Project Definition Study

Factors influencing the commercialisation of defence-related Intellectual Property (IP)

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Introduction

The research topic " Factors enabling or preventing the commercialisation of defence-related IP" is broad and deep. This became increasingly obvious during the development of the Research Proposal for this research.

The Proposal identified Six Key Questions which this research should set out to answer. Depending on the approach taken, answering these questions could involve studying and measuring up to 120 Key Research Parameters relevant to the topic, far more than could reasonably be covered in the time available to complete this research.

It was suggested that a Project Definition Study (PDS) should be undertaken to validate these questions and, in so doing, refine the Key Research Parameters and reduce these to a more manageable number. This would allow time and resources to be focused on issues which go directly to the Key Questions. It would also focus the research on issues which could be examined in sufficient depth to make a genuine contribution to knowledge of the topic, instead of trying to address too many issues and running the risk of treating them in a cursory, superficial way.

The PDS took the form of a questionnaire circulated to 21 individuals with deep knowledge and long experience of different aspects of the research topic. The questionnaire (included at Appendix A; interviewees are listed at Appendix B) sought the interviewees' opinions as to whether or not the six key questions were relevant, and why – or why not?

The Key Questions

The Fundamental Hypotheses which this research sets out to prove or disprove are these:

- There are certain specific factors which enable or inhibit the successful commercialization of defence-related R&D in Australia.
- These factors can be identified and measured and can be used to create a model, or a more general set of pre-conditions, for the successful commercialization of defence-related R&D.

These hypotheses form two of the six Key Questions identified in the research proposal. The other four questions address the essential context and background to the topic and the justification for undertaking this research.

The six Key Questions identified in the Research Proposal are:

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?
2. What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from Australian R&D?
3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?

4. Can a reasonably accurate "multiplier" be developed from the answers to Questions 1 to 3 which can than be applied to estimate the likely return from Australian defence-related R&D investment?
5. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?
6. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?

The interviewees were asked to respond to the questionnaire in a structured interview with the author and invited to comment on these questions.

While it would have been preferable to interview all of the respondents face to face, this proved impossible owing to their geographical separation – many are based in Canberra, Sydney and Melbourne, presenting physical difficulties and considerable expense in conducting a face to face interview.

Some respondents pre-empted the interview process by filling the questionnaire in and returning it to the author by fax or email. All respondents were happy to discuss their responses, either in the first instance during a telephone or face to face interview, or after submitting a completed questionnaire. However, some did not permit public attribution of their comments in this Study.

This study consists of three sections: A summary of the survey results; a discussion of the comments made by the interviewees and their impact on the Six Key Questions and the Key Research Parameters; and a roadmap for the remainder of the research.

1. Survey Results

Three of the people on the interviewee list were either unavailable or declined to respond to the questionnaire; of those who responded to the questionnaire, it proved impossible to obtain subsequent interviews with two respondents owing to their workload. However, all of the respondents agreed the research was timely and potentially valuable and they all professed a willingness to participate when they were approached initially.

As might be expected, the interviewees' opinions varied on exactly how relevant these questions might be, the variations reflecting differences in their roles, responsibilities and experience within the broader Australian defence R&D community.

Some respondents suggested re-wording a number of the questions, or suggested alternative or additional questions. These responses are discussed in Section 2.

The results:

Question	Relevant	Not Relevant
1. What is Australia's total public and private sector investment in defence-related R&D?	16*	2
2. What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from Australian defence-related R&D?	16*	2*
3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?	17	1*
4. Can a reasonably accurate "multiplier" be developed from the answers to Questions 1 to 3 which can then be applied to estimate the likely return from Australian defence-related R&D investment?	15	3#
5. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?	18	0
6. Is it possible to define a model, or at least a more general set of pre-conditions which is likely to result in successful commercialisation of defence-elated IP?	18	0

* Denotes that a respondent has suggested either another question entirely or a different approach to the question as originally posed. See the Discussion of the questions concerned.
# Denotes that one respondent was unsure whether or not the question is relevant as posed – response counted as 'Not Relevant'

2. Discussion of the Survey Results

Most of the interviewees said all six questions were relevant; a few of them, however, stated or suggested some of the questions were irrelevant, or wrongly focused. Of these, some interviewees proposed more appropriate questions, or approaches, in place of the ones posed by the author; and two suggested additional questions. Without exception they all stated questions 5 and 6 would be difficult to answer satisfactorily, but said considered answers would be very useful to defence policy-makers and defence and industry researchers.

A number of respondents offered cautionary comments regarding definitions, reflecting the differences in their various professional and scientific backgrounds. Definitional issues also reflect the growing convergence between the separate fields of "Defence", "Intelligence" and, for want of a better term, "Homeland Security". The latter two have traditionally been separate functions from defence and, at a government level, are the responsibility of separate departments of state.

Nevertheless, organisations such as DSTO, which is funded from the Defence vote, make an important contribution to Australia's wider intelligence-gathering and Homeland Security capabilities. And certain Australian defence companies undertake R&D and provide defence-related products and services to Australia's non-defence intelligence and homeland security agencies.

Furthermore, the ADF, like defence forces worldwide, employs increasing amounts of so-called Commercial Off The Shelf (COTS) equipment such as computers, software, vehicles and boats.

This creates a potential problem: because of the growing use of COTS equipment and the increasingly blurred distinction between defence and non-defence R&D activities, investment in these areas may be inaccurately reported, while manufacturing and exporting activities in these areas may be under-reported or the available statistics may be unintentionally misleading.

Also, differences between the Australian Bureau of Statistics (ABS) and the Australian Taxation Office (ATO) definitions of R&D, for the purposes of reporting the activity and claiming available tax benefits, respectively, mean that while these two separate sources of government statistics don't actually contradict each other, they don't necessarily support each other, either.

The responses to the questionnaire are discussed below, question by question.

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?
The purpose of this question is to map Australia's defence R&D environment and, so far as available statistics and other data enable, attempt to establish authoritative figures for

Australia's total defence R&D investment and the commercial return derived from that investment.

This in turn will enable Australia's defence R&D and commercialisation performance to be compared in a meaningful way with external benchmarks.

This question drew the most comment from interviewees on definitional issues and, along with Question 2, suggestions that it was the wrong question, or worded incorrectly. It was also suggested by two respondents that this should be broken into two separate, and equally relevant, questions. And one respondent suggested the research should also address an extra question related to this topic.

One defence industry respondent said: "This is actually two (relevant) questions and should be separated."

He said the second question is hard to answer and suggested re-phrasing it, thus: "Please estimate the percentage of your turnover that has resulted from your R&D investment." Aggregating all the industry estimates would then help in determining an overall figure for the commercial return from industry's R&D, though not that derived from defence R&D by DSTO and other non-industry bodies such as CSIRO and some CRCs.

A former senior Defence official also suggested a further question: "What are the conditions which determine whether investment in defence R&D is necessary or likely to be commercially successful?" The latter point is addressed in Questions 5 and 6; the first part of the question bears consideration, though not perhaps under Question 1.

The first goes to the very need for defence R&D and this is determined in part by the Department of Defence and its stated needs for a series of specific capabilities; in part also, it is determined by the private sector and the perceptions of individual companies of the value of R&D in the particular market in which they operate. To a considerable extent this issue is addressed in Question 3.

A former senior ADF officer stated: "The problem for you is whether you will be able to ever glean a meaningful answer, given the commercial and defence security sensitivity to R&D for any capability of substance. You may need to do some studies to illustrate the uncertainties and inconsistencies in reporting R&D activity and investment."

A senior Defence R&D practitioner stated: "Definitional issues – what is "Defence" and what is "R&D"? Does the ABS definition of defence R&D cover grey areas such as homeland security and intelligence, both of which areas DSTO's R&D contributes to?"

The definitional issues can be summarised thus:

- What is "Defence"?
- What is "R&D"?
- What is a "Commercial return"?

Taking each of these in turn:
What is "Defence"? – For the purposes of this research the most convenient definition of "Defence" is that employed by the Australian Bureau of Statistics (ABS) in its annual survey of Australian R&D activities. This provides the only common baseline in Australia for reporting defence R&D by private and public sector organizations and subsequent statistical analysis. This definition has a number of important inclusions and exclusions. Its full definition is:

"Division 1 - Defence, covers R&D directed towards the development of defence or national security, including R&D undertaken for military reasons regardless of their content or whether they have secondary civil applications; and towards the development and testing of military or defence related equipment and materials. It includes nuclear and space R&D undertaken for military purposes. It has only one group.

Group 610100 - Defence has five classes:
610101 - Navy
610102 - Army
610103 - Air force
610104 - Combined operations
610199 - Other

Exclusions:
R&D directed towards:
(a) improving the methods of producing or processing military or defence related equipment and materials is included in the appropriate groups in Division 2 Economic Development, e.g. military transport equipment is included in Group 671100 Transport Equipment;
(b) the development of measurement standards and calibration for defence related products and processes is also included in Division 2 Economic Development, Subdivision 720000 Economic Framework, Group 720500 Measurement Standards and Calibration Services; and
(c) civil oriented projects although funded by defence agencies is included in the appropriate groups in other divisions, e.g. communication is included in Subdivision 700000 Information and Communication Services, Group 700300 Communication Services."

The important inclusions here are R&D into National Security (also often referred to as 'Homeland Security'), and secondary civil applications of R&D conducted for military purposes. 'National Security' includes areas such as intelligence and homeland security, to both of which DSTO makes an important contribution but which are not strictly defence activities.

Examples of 'secondary civil applications' include slim towed sonar arrays used both by the Navy to detect submarines and by the petroleum industry for offshore seismic exploration; and multi-level IT security devices such as the Interactive Link which have

important applications in defence organizations, other government organizations and in the banking and financial services sectors.

The important exclusion in this definition is Communications which is covered under a separate ABS subdivision.

The point was made by one respondent that while non-military applications of defence R&D represent important commercialisation outcomes it must be remembered also that much non-defence R&D has resulted in the adoption by the Australian Defence Force and other armed forces of equipment designed originally for commercial applications. The best example of this is the high-speed aluminium-hulled catamaran ferry, developed by Austal in Fremantle and Incat in Hobart for emerging civilian high-speed ferry market, which has been adopted at various times by the RAN, US Navy, US Marine Corps and US Army.

Nevertheless, this falls outside the terms of reference of this research which is concerned with commercialisation of R&D undertaken specifically or primarily for defence purposes.

What is "R&D"? – The ABS definition of R&D does not quite tally with the definition applied by the Australian Taxation Office (ATO) and AusIndustry for the purpose of claiming the current $125 per cent tax rebate on R&D. The ABS definition of R&D doesn't cover a number of product development activities essential to the commercialisation process which can account for significantly greater investment by a company or government organisation than the original research, and so represent a significant stumbling block for smaller, cash-poor organisations.

Indeed, one defence respondent suggested that ATO [ABS?] definitions of R&D are such that much activity which ought to be considered R&D goes unreported. Nevertheless, the ABS's statistics are the most complete figures available in Australia.

Furthermore, in assessing DSTO's contribution to Australian defence R&D it must be borne in mind that only between 15 and 20 per cent of the work it carries out for its principal client, the Department of Defence, consists of R&D in the classical sense (exact estimates vary). According to a former senior defence scientist, "This question is more difficult than it might appear – "R&D" is a much-abused term. When I was CDS, I tried to avoid using it unless it were clear that a line of scientific investigation was likely to lead to a product that would demonstrate a new and relevant application of science or technology to Australia's defence priorities, or, preferably, a product that sooner or later would enter service.

"In part, I did this because the most important "scientific" need in Defence was (and still is) to know how best to use the technologies developed by others. This is not so self-evident for it not to need to be stated explicitly."

This respondent set out DSTO's position in unambiguous terms: "To my mind, the priorities for Australian Defence R&D (i.e., where there's a clear need for a product to be developed) will continue to be in relatively limited niche areas. When I was CDS, I set up four broad policy guidelines, and I imagine that they are still relevant: where Australia's defence needs are sufficiently different from those of other nations for it to be necessary in effect for us to develop our own solutions; where the security sensitivities are so high that not even our closest allies will share their secrets with us; where our own security concerns are so great that we would prefer not to share with even our closest allies; and where, from time to time, we come up with an idea that is just so good that it would be silly not to take it further. I stress that these were guidelines, not tramlines, and their application still needed judgement. I found them very useful for sorting out what would get worked on and what wouldn't.

"The need for "services and expertise" is much broader than this, and is best summed up in the expression that I used along the lines of "DSTO's job within Defence [is] to give impartial and professional advice on how best to apply science and technology to Australia's defence and security needs." Again, the conceptual framework embodied in these words helped sort out what was a priority and what wasn't, and had the added benefit of focussing DSTO on the people being advised, i.e. 'the customers'.

"Industry too needs access to DSTO's expertise, especially and most obviously when DSTO has passed a concept to industry for its further development. But industry also needs (and gets) access to DSTO from time to time for non-DSTO projects; in my time, the building of the Collins-class submarines was the best example."

The clear implication is that only a small proportion of DSTO's approximately $300 million annual budget is spent on R&D which is explicitly devoted to the development of IP which can be commercialised. Of course, much of the other work carried out by DSTO results in the creation of IP which could also be commercialised, but this is a secondary outcome rather than a driver of the IP in question.

This may become an important issue in assessing Australia's total investment in R&D because DSTO is by far the biggest player in this area.

What is a "Commercial Return"? – Another former senior DSTO scientist stated that this question is not relevant. He said: "The question is of some interest but has little meaning in evaluating the benefits of this total investment, depending on what you mean by commercial return. Do you include smart buyer decisions, smart repairer benefits, lives saved etc?"

The point he and others made repeatedly is that much of the benefit of defence R&D conducted by organizations such as DSTO does not show up in the development and sale of new products or services. It is hard to ascribe a dollar value to scientific advice that prolongs the life of an aircraft, for example, through modifications to the way it is flown, or which enables Australian operators to extract a greater capability from imported equipment than the original manufacturer intended, or which results in the selection of

one candidate for a defence contract over another, or which increases the safety of equipment used daily by members of the Australian Defence Force.

Nevertheless attempts have been made to do this, notably in the classified second volume of the Trenberth Review. The author, Mr Robert Wylie of ACIL Tasman, studied six technologies developed by DSTO and subsequently commercialised. Where possible he recorded gross sales figures for the associated products and services, along with an estimate of their contribution to Australia's national wealth, measured using quite different metrics.

While in some cases the sales were small and of relatively little financial value, the broader economic contribution of the technologies in question was highly significant and illustrated the hidden costs frequently associated with maintaining a state of the art defence capability.

Making similar estimates of economic benefit from other defence R&D commercialisation programs may be considerably more difficult and complex owing to lack of availability of data or definitional differences – this may make meaningful analysis impossible. For that reason, it is proposed that analysis in this research of the commercial return on Australia's defence R&D must focus on commercial outcomes – sales of goods and services, and fees and royalties derived from the licensing of Intellectual Property (IP). Other economic benefits should be considered only where there is hard, well-sourced and properly qualified data.

However, a former DSTO scientist who also worked in the defence industry suggested one useful measure of the commercial return on R&D: "You need to define what is meant by commercial return. It could be useful to correlate R&D success with company profit margins." To the extent that R&D investment has a positive impact on company turnover and profit margins it should be possible, using historical data, to determine whether a correlation exists between the R&D investment of Australian defence companies and their growth and profit margins. It should be possible also to compare these with overseas defence companies to establish whether or not Australia exceeds or falls short of international benchmarks, and whether this is reflected in the corporate performance of Australia's defence industry.

In summary, the question is undoubtedly relevant to this research. In answering it however, efforts must focus on three key things:
- measuring Australia's gross investment in defence R&D in both the public and private sectors, based on ABS statistics and surveys and questionnaires completed by Australian defence companies.
- measuring identifiable commercial returns – essentially the proceeds of sales of products and services derived directly from the IP in question.
- identifying and settling definitions and measures of "defence", "R&D" and "commercial return" which enable meaningful comparison between Australia's performance and that of other countries, and between the performance of Australia's defence sector and that of other non-defence sectors.

Responses to this question by Australian defence companies will also provide data to help establish whether or not private sector investment in defence R&D and commercialisation has had a measurable effect on the competitiveness of the companies making this investment. This in turn will help provide an answer to Question 3.

2. What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from Australian R&D?

This question is in some respects an extension of the previous one. Where Question 1 sought to identify Australia's current investment in defence R&D, and the commercial return it derives, this question seeks to establish whether or not Australia's defence R&D investment is commensurate with anticipated customer demand.

It was pointed out by several respondents that in some respects this is a meaningless question because while the domestic market is defined largely by the Defence Capability Plan – in effect the Department of Defence's 10-year shopping list, with quite detailed costings – estimates of the gross export market and the non-defence market for products and services derived from defence R&D are almost impossible to quantify.

Furthermore, to summarize the views of many respondents, access by Australian companies to the export market is constrained artificially by a number of things: first of all, some technologies or products may be too sensitive to receive Australian Federal government export approval; secondly, some products and technologies developed jointly with allies such as the United States may be subject to those allies' export controls; thirdly, access to and success in an export market are to a considerable extent determined by political and strategic factors outside the control of most private sector exporters; and finally, it is the accepted rule throughout the global defence industry that to have any chance of winning an export sale to a foreign government the product or service in question must first have been sold successfully to the exporter's own government.

A former senior ADF officer pointed out that estimates of the size of the defence market, both domestically and overseas, can be something of a theoretical abstraction because gaining access to those markets can be difficult: "Barriers to commercialisation are very high – the Australian market is very small and the commercial risk involved in tackling this market demands deep pockets."

A former senior DSTO scientist said: "The non-Defence sector is probably too hard to quantify. Where the ADF… demand is concerned, the Defence Capability Plan provides guidance on those items of Major Capital Equipment (MCE) which are unlikely to be imported, or which an overseas prime contractor may wish to source from within Australia. This in turn provides the basis for an estimate of local defence industry demand.

"Export demand is much harder to quantify accurately, though where Global Supply Chains (GSC) are concerned, it can be presumed that local firms will achieve greatest leverage where there is an implicit or explicit commitment by the ADF to acquire the equipment in questions. While breaking into GSCs is much harder without the promise of a local sale, price, quality and unique technology can open doors – see, for example, Austal's role in the General Dynamics-led proposal for the Littoral Combat Ship (LCS) program for the US Navy: the RAN is highly unlikely to acquire the LCS."

A senior DMO official with extensive experience as a serving officer in the ADF and managing director of an Australian defence company said the question is irrelevant, but added: "Better question: 'What is the relevance of Australian R&D to the ADF, Australian industry, export customers and the non-defence sector?'

"The real question is – how much do I invest in R&D to meet my future requirements? To revitalise and later replace existing IP?"

As always, it is impossible to address this issue without considering the position of DSTO which is the biggest player in Australian defence R&D. Another former senior DSTO scientist, in answering Question 1, pointed out deliberate constraints on DSTO's involvement in developing products and services. In responding to Question 2 he added, "How will the future be different from the past? This is not clear, though much will not change. Possible differences could be that Australia would be involved in more international development projects, both for "foreign policy" purposes (e.g. helping to keep our relations with the US in good shape), and for the purpose of making sure that we can better support an equipment once it enters service with the ADF and can adapt it to our needs. The associated criteria need more thought."

So, while at first glance the relevance of the question may appear limited, a couple of issues make it (possibly re-phrased slightly) more relevant.

One industry respondent stated that if a meaningful answer could be obtained, "This [question] would probably show the importance of exports in sustaining the industry base and R&D investment."

Another defence industry respondent suggested that "Estimated future demand" is the wrong term in this context: a more relevant question would perhaps be, "What is the accessible market?"

He also said: "I would suggest a modification: 'What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise that you intend to fulfill via an investment in R&D?' This could be expressed in terms of either a percentage increase in turnover or a dollar value."

He acknowledged this would limit responses to companies only and wouldn't give an answer that's relevant to the wider defence R&D community in Australia. However, it

would provide an industry estimate of the potentially accessible domestic and export defence markets and the non-defence export markets.

That word ‘accessible’ is important.

In June 2005 at the Defence + Industry 2005 Conference in Canberra, Mr. Lucio di Bartolomeo, the managing director of one of Australia’s biggest defence companies, ADI Ltd, stated that in his view the *accessible* domestic market for Australian defence companies amounted to between 30 and 40 per cent of Defence’s annual capital investment budget, or about $1 - $1.2 billion a year. The remainder of this budget is spent on imported equipment.

This in turn suggests that the real domestic market for defence products is considerably smaller than the $52 billion which defence currently plans to spend on the major capital equipment projects contained in the 2004-14 edition of the DCP.

Quantifying the accessible export market is difficult.

The circular argument goes that Australian companies shouldn’t try to compete at home or abroad against imported products developed by overseas manufacturers who enjoy natural advantages in, for example, the benefits of scale afforded by the size of their domestic market (and relative lack of access by foreign competitors) and the amount of money available for R&D, either privately funded or from government sources.

In that case, the argument runs, Australian firms should target niche markets of direct benefit to the ADF; products and services developed for these niche markets should be attractive to export customers operating in similar physical and operational environments, and Australian firms would face few, if any, direct competitors.

This argument, though logical, is also limiting. It almost seeks to exclude Australian companies from the majority of the domestic market and therefore from the export market as well. But the skill base resident within Australia’s defence industry means that local firms can and often do compete or collaborate with foreign companies in the development, manufacture and delivery of high-technology products, components and services.

There was a reference earlier to Global Supply Chains (GSC); these are a mechanism whereby an overseas prime contractor sources components and sub-assemblies on a best-value basis from a global network of suppliers and sub-contractors.

The best-known example of this is the F-35 Joint Strike Fighter (JSF) program which has seen companies in nine different countries develop products, processes, services and expertise to support the System Development and Demonstration (SDD) phase of the F-35 fighter. When the aircraft enters low-rate and then full production, most of these companies will supply components and sub-assemblies to prime contractor Lockheed Martin in Ft Worth, Texas.

Instead of building a relatively small number of components (often very simple and requiring little or no design or engineering input) under some kind of industrial offsets deal, or assembling a handful of aircraft locally for their own air force, these companies (including 20 Australian firms) will design and manufacture equipment for the entire production run of F-35 aircraft – potentially 6,000 aircraft over 30 years. But they will only secure this work if they are globally competitive in both technical and cost terms.

Other examples include the Eurotorp MU90 Impact lightweight torpedo, for which Thales Underwater Systems in Sydney manufactures components on a sole-source basis; and Hawker de Havilland in both Sydney and Melbourne which designs and manufactures critical, high-technology airframe components for Boeing and Airbus airliners on a sole source basis.

So, rather than try to "guesstimate" the export market for goods and services resulting from Australian defence R&D it may be more helpful to focus on potential GSC opportunities where the prospects for Australian participation may be enhanced by the leverage of a potential ADF purchase of the equipment in question. An example may be the Boeing P-8A Multi-mission Maritime Aircraft (MMA) which is being developed to replace the US Navy's ageing fleet of P-3C Orion patrol aircraft and is a very strong contender to replace the RAAF's fleet of AP-3C Orions.

In the end, the relevance of the question to a significant extent reflects the relevance of the export market to Australia's defence industry.

The export market is important for several reasons: first, in what amounts to a zero-growth defence budgetary environment, local companies will grow either by winning a greater market share or by exporting. Secondly, the spur of competition for export contracts forces companies to become more efficient and competitive – the innovation this entails almost by definition includes investment in product-related R&D.

Thirdly, the export market provides a mechanism for collaboration with technology partners which helps generate new IP which an Australian company may be unable to create by itself.

In summary, while in some ways this question is irrelevant as originally posed, some aspects of it may throw a helpful light on the health, resilience and medium term (10-15 years) prospects of Australia's defence industry.

It is proposed that the question be re-worded thus: **Is Australia's public and private sector investment in defence R&D commensurate with the anticipated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from that R&D?** And that research focus on three principal aims:

- identifying and where possible putting a dollar value on opportunities for Australian defence companies in the DCP, in order to quantify, even if only in a broad sense, the size and scope of the directly accessible domestic defence market for goods and services.
- identifying potential export and Global Supply Chain opportunities accessible to Australian companies, including local subsidiaries of overseas prime contractors.
- where possible, identifying realistic opportunities in the non-defence market, both domestically and overseas, for products and services derived from Australian defence R&D.

A properly conservative approach to this research is likely to under-state the size and scope of the domestic and export markets.

Two of the three altered or additional questions suggested by respondents on these topics also bear scrutiny. These are separate though closely related questions:
- How much must I invest in R&D to meet my future requirement to revitalise and later replace existing IP?
- What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise that you intend to fulfill via an investment in R&D?
- What is the relevance of Australian R&D to the ADF, Australian industry, export customers and the non-defence sector?

Answers to the first and second will support this research by providing an informed (though necessarily subjective) assessment by private sector defence companies of both the size of the defence market and the R&D investment plans of the companies concerned.

The third question addresses the value or the contribution of Australian R&D in both a local and global context. Trenberth Vol.2 provides a set of metrics for assessing the contribution to Australia's national prosperity of six key technologies commercialised by DSTO. Similar metrics could be used to assess the value or contribution of at least some of these technologies at a global level – this is not the same as simply measuring export sales.

This third question perhaps belongs in the Appendix to the final thesis; not least because studying Australian non-defence R&D programs to identify examples of domestic and global relevance which can then be compared with other measures of relevance and return on investment, for example, would dilute efforts best devoted to the main research.

All of these 'supplementary' questions should be included in the survey questionnaires.

3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?
This question has its roots in the assumption that defence R&D can and does deliver a measurable benefit to Australia and, by implication, that Australia therefore pays a penalty if it fails to invest sufficiently in defence R&D. It therefore addresses the question

of why defence R&D is necessary in the first place; this in turn addresses both strategic (national) and commercial or business motives.

It also suggests an obvious corollary – that it is possible to over-invest in defence R&D and suffer an opportunity cost from resources diverted wastefully to this area which could have been put to more productive use elsewhere.

The answers to Questions 1 and 2 will provide the refined data necessary to establish whether Australia is over-investing or under-investing in defence R&D.

An insight into the Department of Defence's view of private sector R&D investment was provided by the Chief Executive Officer of the Defence Materiel Organisation, Dr Steve Gumley. He said in a speech to the Australian Strategic Policy Institute (ASPI) lunch on 3 March 2005 in Canberra that he was surprised at the low level of self-funded research and development and innovation in the Australian defence industry, especially given the industry's generally high levels of profitability. He was quoted in The Australian Financial Review on 4 March 2005 as saying, "There are some notable and laudable exceptions in the small-to-medium enterprise community, given their profitability. I would like to see more investment in self-funded innovation research."

It would be difficult, if not impossible, to answer this question without establishing some sort of benchmark against which to measure Australia's performance. Using as a benchmark other countries or market sectors where strategic circumstances and defence market conditions may be quite different is naturally problematic. But there seems little alternative to seeking some kind of external benchmark to assess Australia's defence R&D and commercialisation performance.

So what this question sets out to do is compare Australia's defence R&D investment and commercialisation outcomes, and the resulting commercial benefits to the country and the companies involved, with those of other countries which make a significant investment in defence R&D.

Where relevant and directly comparable figures exist Australia's defence R&D and commercialisation performance should be compared also with its performance in the non-defence sectors, and with non-defence R&D and commercialisation outcomes in other countries.

The answer to this question will consists of several components and is likely to be derived largely by inference. This is where definitional issues are so important – to make a valid comparison the statistics on which the comparisons are based must themselves be based on similar measures.

A former senior DMO official alluded to this in saying: "It would be worth comparing Australia's position with that of Norway in terms of identifying and measuring the effect on the national economy, and of the defence industry, of investing in defence R&D and then exploiting it commercially."

He added that in his opinion, "Australia's defence R&D investment is 'all over the place'," clearly indicating that it needs to be better focused.

A senior defence industry executive responded in similar vein: "In order to identify and measure realistic benchmarks, a comparison could be drawn with Israel which has been very effective in commercialising the results of its private and public sector defence R&D."

A former senior DSTO scientist said: "I'm not sure that this question means too much as posed. Do you actually mean "opportunity cost" here? "Benefits foregone", perhaps, but any such benefits flow only where there is a market for the resultant good or service, even within Defence itself. Perhaps this is the place for me to add that I used to be appalled at the naivety of far too many people who believed that the commercialisation of Defence/DSTO IP would produce wealth beyond measure, with little effort and at no risk."

This respondent correctly identified the fallacy behind some of the commentary surrounding Australia's defence R&D community and the needs of the ADF: it is implied that there is huge unmet ADF demand for Australian-made products, services and expertise. This is not the case. Most of what the ADF needs it can acquire from key suppliers overseas; its greatest continuing demand is for scientific and technical advice on how best to use and exploit the technology embodied in the equipment it acquires from overseas.

However, as many respondents pointed out, under-investing in defence R&D, in both the public and private sector, can have other consequences that don't show up directly on profit and loss accounts or balance sheets, or whose effects may be pernicious and slow to show themselves but ultimately damaging in both a strategic and business sense.

One defence industry respondent made a provocative suggestion: "This is a valid question, but one that should be directed to a senior economist. Interesting tangents may come out: e.g. - failing to invest at all may be better than a large defence R&D investment with a bad export return. Should we instead invest massively in value–adding to our resource industry and moving our coal, gold etc up the value chain? And then spend the resulting cash mountain on defence products developed overseas?"

This suggestion is based on the freely acknowledged truth that Australia has traditionally lacked the strategic and economic imperative to develop its own leading edge defence equipment. Because Australia has had unique and privileged access to the US and UK arsenals for over a century, it has not really needed to invest massive amounts in defence R&D and a strong defence manufacturing base.

This respondent added, therefore: "It also begs the question - would it make much difference to Australia's defence capability if we don't commercialise?"

It has been argued that, with its unparalleled access to the best defence equipment the US and UK can produce, it would be cheaper for Australia to simply buy its defence capability off the shelf and stop wasting money on defence R&D and on trying to manufacture defence equipment in Australia.

So Australian defence R&D commercialisation outcomes need to be evaluated in this light and against the question 'Is this a good commercial opportunity or not?', in the respondent's opinion.

This argument is based on economic rationalist business principles and was not presented as the official position of the company concerned, and is countered by several defence R&D, industry and ADF voices.

The meat of their argument can be summarised thus: Australia can buy just about anything it needs, but it would then sacrifice its independence – Australia would be dependent on a handful of key foreign suppliers: dependency carries within itself the seeds of vulnerability.

A senior DSTO scientist summarised the majority view of the opportunity cost to Australia if it under-invests in defence R&D: "We end up beholden to the market with no control over the price we pay for equipment and the capability we receive. Local production (based on local R&D) leaves us options and some leverage in the market place. The advice that DSTO provides Defence in policy/buyer/user areas is backed by its R&D, so defence R&D is an essential component of defence capability. The long-term consequences of bad decisions can be unexpected and persistent, so good advice is essential."

Industry's viewpoint is nearly identical, according to another defence industry respondent: "Aside from revenue and profit foregone by the companies themselves, Australian companies and public sector organisations risk losing core skills and knowledge which are stimulated and refreshed by R&D and bestow the ability to evaluate others' R&D."

The ADF, defence industry and organisations like DSTO need a constant supply of young, talented engineers and scientists. If such people have no realistic job prospects in the defence area, or perceive that it offers no professional challenges or growth opportunities, they will go to other sectors, or overseas, and so will be lost to Australia's defence community, says a former DSTO and industry scientist: "Among the major developed nations, Australia has one of the highest per capita rates of tertiary education. If we fail to invest in R&D there will be a significant opportunity cost among our highly educated and skilled graduates in science and engineering."

While R&D is important, so also is commercialisation to create a business which sustains the human resources necessary to underpin Australia's defence capabilities.

A former senior DMO official alluded to this in referring to the Department of Defence's Jindalee Operational radar Network (JORN) program and the company which rescued the project and delivered successfully after it encountered severe difficulties, RLM Systems Pty Ltd; lacking the large-scale 'noble' systems design and engineering work necessary to sustain it in its previous form, the company has largely been broken up since delivery of the JORN system in 2004.

"Having a capability such as RLM Systems Pty Ltd, which delivered JORN, is even more important than having JORN itself – if we need to do JORN again we'll now need to reinvent RLM Systems," said the respondent.

One senior DSTO scientist threw a different light on the question: "A different angle to this is: of the needs that Australia has in defence R&D (using the DCP as a reference) – if we had to do all of it ourselves what would be the cost, and what would be the economic benefit in terms of exports, etc?"

His response acknowledges the benefit that Australia derives from its very close defence relationship with the USA and UK and the consequent savings in expenditure on defence R&D and other significant elements of national defence capability. This point is addressed also by a former senior ADF officer who said: "Good question, but it is also linked to what is practicable in Australia. We may have people with the intellectual skills to develop the theories, but (for example) an Aegis [destroyer combat system] replacement is not realistically going to come from Australia within the next century."

As a representative of the defence IP "user community" this respondent added: "I don't want to pay for NREs (Non-Recurring Expenditure) associated with local development. This is one of the barriers to [private sector] R&D investment. So also is DSTO's IP regime." These points will be addressed more closely in examining Question 5.

Another defence industry respondent said: "Again, it's a good question, but not easy to answer. It will be necessary to make some assumptions about the opportunity cost based on historical data on R&D effort."

Another former DMO and ADF officer replied along similar lines, though for slightly different reasons: "Whilst relevant, it's very difficult to quantify because of the possible applications of defence IP outside of the military market."

A former senior DSTO scientist also agreed: "Relevant, but hard to quantify. While comparisons with countries like Canada, Sweden, Singapore and The Netherlands may be illuminating, there are too many 'Yes, but…' factors to consider because the circumstances of each of these nations is quite different and this colours procurement, R&D investment and budgeting policies.

"In the non-Defence area it may be worth studying Canada's space industry to establish some sort of benchmark for return on R&D investment. Other non-Defence R&D areas may throw up some interesting figures which would, in turn, allow a comparison between

Defence and non-defence commercialisation rates, and therefore help estimate opportunity costs in the defence area with a reasonable level of accuracy."

A former senior DSTO scientist simply warned bluntly: "Again, it would be most difficult to get a meaningful measure of this cost."

A senior DMO official responded: "It's a difficult question, but if you mean what will Australian industry miss out on if they do not invest in R&D - they will miss out on being competitive and innovative and become irrelevant."

The general consensus, therefore, is that the question is relevant, but hard to answer – estimates of the difficulties involved range from "difficult" to "almost impossible".

Why is the question important? For two reasons: firstly, it attempts to quantify (however imperfectly) the benefits of conducting defence R&D in Australia and the costs of not carrying out such R&D. This in turn may help challenge long-held assumptions about the costs and benefits of defence R&D and therefore change the basis on which defence R&D and subsequent commercialisation investments are made, in both the private and public sectors. It may also help provide an answer to a subordinate question – how much R&D is enough?

Secondly, because the answer to this question is likely to be derived (at least in part) by inference and from comparison with other countries and other industry sectors, it may also provide a valid basis for comparing the national and private sector resources devoted to defence R&D and commercialisation compared with those devoted to R&D and commercialisation in other sectors and in other countries. And it may show whether or not Australia's defence IP commercialisation outcomes are commensurate with the R&D investment.

So far as the methodology of answering the question is concerned, again there was a consensus that the answer would need to be derived or inferred from comparison of Australia's defence R&D and commercialisation outcomes with those of other countries – Israel, Norway and Canada were all mentioned specifically – and also from comparison with the non-defence high-technology sectors in Australia and overseas. Again, Canada's civilian space industry was named specifically as a potential subject for study.

However, data gathered to answer Question 1 may also help establish whether or not private sector investment in defence R&D and commercialisation has had a measurable effect on the competitiveness of the companies making this investment.

While the financial benefits of defence and non-defence R&D and commercialisation may be relatively easy to measure, where suitable statistics are available, non-financial benefits may be very much harder to measure. These benefits are typically held to include (in no particular order) things like recruitment and retention by bodies such as DSTO of suitably skilled and experienced scientists, engineers and commercial staff; commercial leverage in negotiating with technology and equipment suppliers and partners; and

confidence that the correct purchase and policy decisions are being taken with regard to defence equipment and technology investment.

These and other non-financial benefits can be described as contributing to "competitiveness", though the competitiveness of a nation, or of a company, can be measured many ways and is affected by many more factors which this research doesn't set out to address. However, to the extent that these factors affect the competitiveness of a private sector organisation there may be a measurable correlation between R&D investment and the company's general performance, measured as sales and revenue growth and profitability.

The same may be true of those countries which make a significant commitment to defence R&D which in turn supports a nationally and internationally competitive defence industry. However, the research must take into account strategic imperatives which distort classical market mechanisms: most European countries, for example, have quite large defence industries which are major employers and contribute significantly to the national economy as well as to the nation's technical sophistication.

In many such cases R&D is directed at supporting this industry sector and successful commercialisation, either nationally or in a multi-national partnership, is almost a 'given'. This type of situation can distort assessments of commercialisation models and outcomes, as well as comparisons with Australia's performance, and so the validity of some statistics may need careful scrutiny.

Nevertheless, this question is still relevant; it is tempting to re-phrase it to reflect more accurately the methodology for answering it and the need to infer the answer from comparison of different factors. But the question, as posed, demands its answer in identical terms, and that answer is an essential component of this research, so the question should remain unchanged.

4. Can a reasonably accurate "multiplier" be developed from the answers to Questions 1 to 3 which can than be applied to estimate the likely return from Australian defence-related R&D investment?

This question is based on the assumption that the research will show a meaningful and consistent correlation between R&D investment and commercialisation outcomes.

This is not an assumption shared by many of the respondents – not least because in defence as in other sectors only a minority of R&D programs will result in the development of a successful product or service. Furthermore, as noted earlier, many of the benefits of defence R&D – particularly public sector R&D - do not show up on any corporate bottom line. And finally, defence covers so many different technology domains and industry sectors, with so many varying risk factors, that it would probably be meaningless to aggregate the results of quite different R&D and commercialisation pathways.

This point was made bluntly by a senior DSTO scientist: "Any figures you can gather to construct such a model may be very misleading – case studies which provide useful figures may vary so widely as to make a single coherent model very hard to construct."

Most respondents expressed doubts that a multiplier could be developed without considerable difficulty, suggesting that any multiplier effect identified in this research may be too crude to be meaningful. A former senior DSTO scientist suggested, however, that this could be a useful finding in itself: "A negative answer would be as valuable as a positive one. Anecdotally, the defence sector performs worse than the commercial sector. If, for example, commercial rates of return were up to 1:10 (to cover the cost of failed commercialisation programs), does defence achieve as much even as 1:3? There seems little doubt that Defence needs to do better, perhaps aiming to emulate the pharmaceutical industry which operates at a comparable level of scientific and technological complexity."

Another senior DSTO scientist said: "DSTO has tried to develop models and multipliers – the best source is probably Trenberth Vol. 2. However, the net benefit to Australia [of defence R&D and commercialisation] isn't just commercial dollars but savings to the national treasure – eg aircraft life extension which delays expenditure on aircraft replacement."

Trenberth Vol.2 shows very different levels of commercial return from each of the IP commercialisation projects contained within it. Aggregating and then averaging these results would not provide a useful result. They do, however, underline the validity of the non-commercial criteria used to determine whether and how these technologies should be commercialised, and the national benefit derived as a result.

One defence industry respondent suggested a possible approach: "One way to approach this might be to relate R&D investment to compounded average growth of sales of a specific company over five years." This suggestion has considerable merit: if a statistically significant correlation emerges from examination of the relevant statistics, it may be possible to derive a multiplier effect for defence companies which invest in their own R&D or in commercialising the results of others' R&D.

Furthermore, such a multiplier would also reflect the 'intangibles' flowing from a company's R&D investment: the diffusion through the organisation of knowledge, expertise and confidence which in turn affect the broader measures of a company's competitiveness. As a senior DMO official stated: "The multiplier effect also extends to customer confidence in the company that's winning the work. Innovation, R&D, engineering depth are marketing assists."

This multiplier should also take into account re-use of IP developed originally for one application and then applied to other uses, the industry respondent mentioned earlier continued. "And it should somehow capture the economic value of the resulting prosperity as well as the competitive advantage accruing from the R&D. Given the

definitional issues involved, the ATO (Australian Taxation Office) definition of R&D may need to be the common baseline from which these are estimated."

He also warned that there may be a problem with sample size in Australia's relatively small defence industry sector.

However, another senior DMO official who previously worked in the private sector considers the question irrelevant because available Australian statistics, in both the defence and non-defence sectors, reflect a somewhat distorted R&D investment environment: "I think you need to understand the way R&D costs are applied and attributed to sales. The tax department made us come up with the R&D plan and the auditor made us come up with an amortisation policy to get the R&D off the balance sheet, or we had to write it off. Talk to some industries about how they deal with this. Then you might see the questions in a different light."

Definitional issues arose again. This respondent asked, "Are we talking profit or revenue? Australia will not make vast sums from developing IP. In Australia IP developers need to compete for a sale – in the US companies win the sale and then do the R&D: eg, the System Design and Demonstration (SDD) phase in the Joint Strike Fighter (JSF) and Multi-mission Maritime Aircraft (MMA) projects. The environment in Australia is not good for developing IP for sale. In Australia R&D comes from a company's bottom line; in the US it comes from the project budget which is government funded."

Notwithstanding, Australian federal government departments have tried to develop and apply multipliers as part of the process of evaluating the Australian Industry Involvement (AII) and Strategic Industry Development Activity (SIDA) proposals contained in tenders for major defence acquisition projects. According to one defence industry respondent: "There are multipliers which have been applied to SIDAs (and other types of industrial activity) in the past by Defence as part of their evaluation of the AII proposals in tender responses. The ABS and DITR may also have some easily accessible multipliers – especially in connection with projects such as the Joint Strike Fighter."

Yet another defence industry respondent suggested that it may be helpful to study how similar multipliers have been developed in other industries before attempting to develop one for defence in Australia. Models developed elsewhere may in fact be useful in the defence context but the very significant differences between the defence and non-defence markets, both in Australia and globally, means that non-defence models must be selected carefully before being applied to the defence sector.

While at first glance it may seem difficult to produce an accurate and meaningful answer to this question, it may be worth continuing to explore the topic before abandoning it entirely. Why? Firstly, because responses to Question 3 may produce some data which demonstrate a correlation between private sector R&D input and commercial returns.

Secondly, comparisons of the R&D investment and subsequent commercialisation outcomes of Australia and other nations may provide some hard data on Australia's

performance per dollar of R&D expenditure compared with other countries. In turn, any significant differences may then help inform research into Question 5.

Thirdly, examination of projects such as the JSF may demonstrate sufficiently strong links between R&D investment and the subsequent award of contracts under the SDD and low-rate production phases of the program that some kind of multiplier may be calculated. Defence's New Air Combat Capability (NACC) project office has R&D funds which it can provide to Australian companies seeking to improve their ability to win JSF contracts – this may be a useful, though necessarily small-scale, subject for further analysis.

If nothing else, estimating a meaningful multiplier based on the JSF example may help the Federal government and Australian industry in assessing the risks and potential returns in future, similar projects.

However, the advice of several respondents that the question is either irrelevant or too difficult to answer in a meaningful way tends to suggest that the research need not focus unduly on this topic and that this question could be addressed in a relatively brief way in the appendix to the main thesis.

5. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?

This question, and its answer, lies at the heart of this research. Without exception the respondents stated that this was relevant, many stating it was the most relevant of the six questions addressed in the study.

A former Chief Defence Scientist, Dr Ian Chessell summarised the general position thus: "This is the best and most relevant question. A thorough analysis of the impediments to commercialisation would be of great value. Although many of the reasons are pretty well known an analysis that provided a basis for changes to improve the situation would be most useful."

All of the respondents were or had been players of one kind or another in the defence R&D or commercialisation arena and their responses brought forth a variety of insights and anecdotes worth examining in more detail in the research itself. None of them suggested that Australia over-invests in defence R&D or that its commercialisation performance was so good that this research is unnecessary.

On the other hand, several principal factors inhibiting (or positively discouraging) R&D investment and successful commercialisation were suggested. These include, but are not limited to: the size of Australia's defence market; unsteady domestic demand, compounded by the Department of Defence's monopsony status as the sole domestic customer; the department's lengthy and often cumbersome capability development and acquisition decision-making processes; barriers to entry into export markets; a "not

invented there" syndrome in Canberra which discriminates against local products and technologies; constraints on the export of highly capable and therefore sensitive technologies and products, especially those developed in partnership with allies; conditions imposed by DSTO and the Department of Defence on IP licences and other forms of commercialisation; unequal competition between locally-owned companies and the local subsidiaries of overseas prime contractors who enjoy access to their parent companies' own IP; unwillingness of overseas prime contractors to adopt or market globally products developed by their Australian subsidiaries; and simple lack of business skills on the part of Australian firms

Where Australian companies, working with Defence and DSTO, succeed in developing world-class products, the operational imperative and the commercial market come into open conflict. A former senior DMO official said: "The market for the best stuff is quite limited – the technology which offsets the ADF's lack of numbers offers us a time advantage while others try to catch up. The benefit accrues from NOT selling."

That is, the national bottom line takes precedence over the narrower commercial bottom line.

A senior DMO official who has also worked in the defence industry also pointed to business naivety and lack of commercial skills on the part of many Australian companies: "The answers relate more to the mindset of companies in understanding what is possible once they develop IP. You see there is much more a company must be before it can sell really good IP and commercialise."

Companies need to be financially and structurally sound and well-run, with stable ownership, strong and effective management and robust and effective business and quality assurance processes. "In the end the customer does not buy IP - it buys the whole catastrophe," this respondent stated. "Most companies think they sell just great IP. They think the rest doesn't matter until they fail - and then they wonder why customers don't the buy their IP."

A former senior DSTO scientist echoed these sentiments in saying: "The inhibiters of Commercialisation in Australia are outlined in Questions 1-4 where it is posited that the main problems are attitudinal and the competence of the people in the chain and, to a lesser extent, the absolute size of Australia compared to the US or Europe.

"Market related problems include the low profitability of Australian defence companies where some have not made a profit for years and others exists on bottom lines of 10-12 % which gives little room for investing in even medium term R&D – 5 - 10 % of net profit equals 0.5 - 1% of turnover which doesn't buy much R&D."

The one technological advantage Australia has, he said, is DSTO which has not been sold to commercial interests, as in the UK (the privatised QinetiQ incorporates most of the former Defence Evaluation and Research Agency, DERA, leaving only DSTL, the Defence Science and Technology Laboratory, in government hands) or reduced to

managing external R&D and test & evaluation contracts, as per the US Air Force's research laboratory at Wright Patterson Air Force Base in the US.

The dominant position of DSTO in Australia's defence R&D community is a constant factor, but estimates of the value of its R&D can reflect quite different viewpoints. Having answered Questions 1 to 4 another former senior DSTO scientist echoed a response cited above in stating: "If you accept the arguments I have set out, then it follows that the commercial potential of much if not most government-funded defence R&D will be quite limited. The potential market will in practice be very small, usually comprising only the ADF and at best some key allies (US, UK, NZ). Some examples might help illustrate the point; to whom would we export the Jindalee over the horizon radar, the NULKA anti-ship missile decoy, submarine acoustic tiles or computer security devices?

"Where international collaboration is involved, the international partner can also have a strong influence – even a veto – on potential exports.

"I should add that, when I was CDS, I would encounter all too often the attitude within Defence best summarised by "not invented overseas" [referred to elsewhere in this study as the "Not Invented There" syndrome], that is, a strong predisposition to prefer overseas solutions to anything developed in Australia. This attitude, and the associated obstructionism and lack of imagination, used to make me very angry.

This respondent pointed out also that the international defence market can be particularly corrupt, in several senses of that word: defence is not a perfect market – market forces are often distorted by political and strategic considerations and this is reflected in, for example, pricing structures. In some countries (not Australia) the defence market is characterised by venality and often bribery, disguised as "facilitation payments" and the like.

"Finally," the respondent concluded, "We need to recognise that, when it comes to working in the field of innovative high-technology products, far too much of defence-related industry in Australia simply isn't up to the mark, though there are a few welcome exceptions."

A defence industry respondent suggested another possible line of enquiry based upon the Department of Defence's stated needs of the local industry base, which is principally to be able to support, maintain, adapt and modify the ADF's equipment: "Australia's defence industry is to a considerable extent a service-based rather than product-based industry. Furthermore, Australia is an open market for defence products with no barriers to entry by multi-national or overseas prime contractors who wish to offer imported defence equipment, and therefore no imperative to invest in local R&D and product development."

The former DMO official cited above added this comment: "Finally, why bother? What are the indicators of need, or of success?" He stated the four DSTO guidelines cited in the

response to Question 1 are sensible, as far as they go; he suggested there should be two others also: a unique need, e.g. to deliver or support in operational service a capability such as the F-111, Collins-class submarine, JORN or Laser Airborne Depth Sounder (LADS). And a proper economic and business case should be required to justify any project that replaces, replicates or duplicates equipment that's already available from overseas.

He also urged: "Consider the reverse case – companies like Austal and Incat whose commercial R&D has developed products - fast ferries - which have been applied to defence needs. Australia has a head start here in aluminium ship construction capabilities."

Citing Dr Steve Gumley, CEO of the DMO, as an authority (Gumley 2005) the research should examine some basic questions on industry profitability and motivation to invest in what he terms "self-funded innovation research". Gumley argues that the defence industry in Australia enjoys "profits on investments [that] are proportionately higher for defence companies in Australia than internationally." He speculates that this may be partly the result of traditional patterns of defence business in this country: "Just possibly, Defence has been so compliant in the past to pay for innovation, often dressed up as contract change proposals or funded studies that we have taught the companies this is the way to do things. For the robustness of our industry, I would like to see more R&D being undertaken with export markets in mind."

However, one survey respondent who asked for his comments not to be cited in this Study, said "Expect industry to state unsteady demand". This suggests that, leaving aside the comfort zone created by past contracting practices, the way the defence market functions in Australia may itself be a positive disincentive to significant investment in R&D.

The insights provided by the respondents are valuable but in many cases are subjective. Taken in aggregate, however, they reflect the sometimes-subtle influences of a range of factors which affect decisions to invest in R&D, to attempt to commercialise the results and, eventually, whether or not the commercialisation efforts meet with market success.

6. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?
This is the other question which lies at the heart of this research. No respondent questioned its relevance, though many suggested it would be hard or very hard to answer.

Two respondents suggested that, even if a definitive, complete model cannot be created, establishing a causal link between certain actions and government policy settings and the successful commercialisation of defence-related IP would still be very useful.

A former senior ADF officer responded: "In general there is no reason why it couldn't be developed. Its accuracy and application will flow from how you can show such a model

would correlate with what you uncover as being the current state of affairs and its likely evolution. My instinct says this will be very hard. Having said that, being able to demonstrate that a significant support of advanced R&D by the federal government is likely to make a positive impact on Australia's future circumstances as a nation would be a good thing to do."

A defence industry respondent agreed: "This would be useful to government policymakers, industry and the venture capital community."

A former senior DSTO scientist said: "I think experience would suggest a number of factors that are usually present [in a successful commercialisation] although we do not have a great case basis for such analysis."

That last point was acknowledged by a former senior DMO and ADF official who advised: "Look overseas for models that have worked – or at least processes." The implication was that this research could help identify an overseas model which matches Australia's circumstances and that could be adopted in Australia, with minor variations.

The difficulties in doing this were pointed out by a senior DMO official who has worked in the defence industry. There may not be a single model, either overseas or in Australia, as there may be too many variables that are specific to a given project or industry sector. He said: "Depends on the part the IP plays; is it a small part of a system or project, or is it a major part? It will depend [also] who your customer is – i.e. a Prime or Defence [itself]. Then you can talk about the pre-conditions, which are different for both."

Another defence industry respondent broadened the perspective somewhat when he stated: "There may be different models for different projects – but one constant factor is that Australian defence companies need to win their home market in order to tackle the global market with credibility. There is also a "chicken and egg" situation to address – market pull must be balanced against technology push, and the possibility that supply may generate unforeseen demand, especially with disruptive technologies."

A former senior DSTO scientist said it should be possible to develop a model, but acknowledged much of the 'non-linear', even disruptive, nature of innovation in his response: "Establishing some sort of "road map" which people must follow (especially if customers have an expectation this will deliver results) could stifle mavericks and generally constrain innovation."

The majority of respondents provided examples of factors which could form part of the model; one industry respondent provided an additional question which is of undoubted relevance to the high-technology defence industry generally and addresses part of the topic this research is studying.

He said: "No comment – good question. However, what is the one question I would ask? I think it is this one: Where do you truly think your company will be in ten years time, based on its current known business strategy?

a) Will it (for over 50% of revenue) be a supplier of defence products and services around the globe, based on Australian R&D/products?
b) Will it (for over 50% of revenue) be a supplier of defence products and services, primarily to the ADF, based on Australian R&D/products?
c) Will it (for over 50% of revenue) be a supplier of defence products and services, primarily to the ADF, based on overseas R&D/products?"

This question applies solely to Australian companies and to autonomous subsidiaries of overseas prime contractors. And while perhaps more applicable to Question 2, this response goes to the commercial heart of this research: a successful commercialisation is, by definition, a business success, so many of the factors which make up any future commercialisation model will necessarily be business/commercial factors. While the technology which generates the product or service in question is the very foundation of the whole construct, commercial success will depend on classical business drivers, including: assessments of markets, competitors, viability at different price points, manufacturing challenges, likely return on investment, uniqueness of the technology (and the ease with which it can be emulated or copied), and the prospects for growing the product or service into other applications and markets.

In some cases these are subjective judgements based on the views of the individual or company contemplating a commercialisation venture, and coloured by the technology, product and market under consideration.

But a senior DMO official's response to Question 5 cited elsewhere applies also here: "In the end the customer does not buy IP it buys the whole catastrophe."

In other words, companies must also get the business fundamentals right – in the defence sector particularly, governments and prime contractors are very risk-averse and the stability and health of the supplier is as important as the quality and performance of the product or service.

A former senior DSTO scientist acknowledged the element of risk that is an indivisible part of the innovation and commercialisation process with a warning that no commercialisation model can guarantee success: "In brief, it should be possible to develop a set of factors, a check-list if you like, that need to be considered, or criteria that need to be met, if the chance of success is to be more rather than less. Any approach needs to recognise that, in the business of turning innovation into return to shareholders, success is never guaranteed and that risk is the name of the game."

The factors which contribute to the success of a specific commercialisation project may be too specific to support a more general model. For this reason the research will probably need to focus on identifying the common factors contributing to success – or to failure - of a variety of case studies.

These case studies, in turn, must include a mix of product/service development projects based on original IP and more general company/sector studies focusing on organisations

which have prospered - or not - as a result of conducting defence-related R&D and then commercialising the resulting IP. These same studies will provide the answers to Question 5.

The answer to Question 6 lies at the heart of this research: indeed, is part of the justification for the research. As noted earlier, anecdotal evidence suggests a number of common factors may be present in successful (and perhaps also unsuccessful) commercialisation projects; but anecdotal evidence is insufficiently precise to justify or prohibit R&D investment and commercialisation decisions. This research aims to provide a model based on empirical data, structured interviews and surveys, or to show why such a model cannot be created.

It is quite possible that the factors contributing to successful commercialisation projects are so diverse and project-specific that no reliable model can be created; or that specific models may emerge for different markets, technology domains or industry sectors; or that there is a single model, or set of pre-conditions, for a successful commercialisation of defence-related IP. Arriving satisfactorily at any of these conclusions would be a positive outcome of this research.

3. The Roadmap

This Pilot Study has addressed the original six key questions identified in the research and it must be concluded that one of these, Question 4, is of sufficiently marginal relevance that it could form part of the appendix to the main thesis rather than a central part of that thesis.

Furthermore, a number of additional and alternative questions were suggested which are of sufficient relevance that they should form part of the research.

So there are now five Key Questions, rather than six, and one has been substantially re-worded:

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?
2. Is Australia's public and private sector investment in defence R&D commensurate with the anticipated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from that R&D?
3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?
4. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?
5. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?

The answers to Question 1 to 3 essentially make up Chapter 2 of the Thesis, Questions 4 and 5 go to the heart of the topic, which is dealt with in Chapters 3 to 8.

The Appendix should include a short analysis of the former Question 4:

> "Can a reasonably accurate "multiplier" be developed from the answers to Questions 1 to 3 which can than be applied to estimate the likely return from Australian defence-related R&D investment?"

Almost all of the altered or additional questions suggested by respondents in this pilot study support the aims of this research. Some impact directly on Questions 2, 3 and 4 while others provide an illuminating snapshot of private sector attitudes to defence R&D which may be valuable in themselves as well as helping flesh out the background to this research.

While Chapter 2 of the Thesis is important only inasmuch as it creates the background and context for the research, the lack of recent data on Australian private sector defence R&D means that this Chapter will be important in itself as a record of Australia's defence R&D community at a specific point in time.

All but the first question listed below could be incorporated in the defence R&D survey questionnaire which will be circulated as part of this research. The first question could be answered by analysis of available statistics (some of them gathered from the survey); and the second could be put to both private and public sector researchers.

- What is the relevance of Australian R&D to the ADF, Australian industry, export customers and the non-defence sector?
- What are the conditions which determine whether investment in defence R&D is necessary or likely to be commercially successful?"
- Please estimate the percentage of your current turnover, or recent growth in turnover, that has resulted from your R&D investment.
- How much do you plan to invest in R&D to meet your future requirement to revitalise and later replace existing IP?
- What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise that you intend to fulfil via an investment in R&D?

The last two questions are very similar and should be combined to read:

> "What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise that you intend to fulfil via an investment in R&D? And how much do you intend to invest?"

As well as summarising responses to the questions above, Chapter 6 could also include a summary of industry responses to the following questions:

> Where do you truly think your company will be in ten years time, based on its current known business strategy?
> - Will it (for over 50% of revenue) be a supplier of defence products and services around the globe, based on Australian R&D/products?
> - Will it (for over 50% of revenue) be a supplier of defence products and services, primarily to the ADF, based on Australian R&D/products?
> - Will it (for over 50% of revenue) be a supplier of defence products and services, primarily to the ADF, based on overseas R&D/products?

The section which follows deals with the five Key Research Questions and sets out the methods by which they will be addressed.

The original Research Proposal listed some 120 Key Research Parameters, or Variables, which the Key Research Questions set out to define and measure. That is too many; this Pilot Study was designed to reduce these to a more manageable number capable of being examined in some depth and so making a genuine contribution to knowledge of the topic.

The refined list of Key Research Parameters are grouped according to the key questions this research sets out to answer, and forms part of the Roadmap for each of the five Key Research Questions dealt with below.

Appendix A contains the full, refined list of the Key Research Parameters to be examined in this research. It is clear that many of the variables, and their relationships to each other, can be defined and measured using statistical analysis and a search of the literature. However, many of them particularly those relating to Question 4, will be defined and measured through responses to the survey questionnaire.

Therefore the refined list of Key Research Parameters will be the base upon which the questionnaire and survey are designed and constructed.

The refined list is much shorter than the original – the Parameters omitted are those which, in the light of the Pilot Study results, were self-evidently irrelevant or marginal or which the PDS respondents did not identify, in their experience, as relevant to this research.

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?

The boundaries of this question will be set by clear definitions and measures of "defence", "R&D" and "commercial return" which enable meaningful comparison between Australia's performance and that of other countries, and between the performance of Australia's defence sector and that of other non-defence sectors.

The answer will have two principal components:

1. An estimate of Australia's gross investment in defence R&D in both the public and private sectors, based on ABS and other statistics and on surveys and questionnaires completed by Australian defence companies and public sector R&D organisations.
2. An estimate of identifiable commercial returns – essentially the proceeds of sales of products and services derived directly from the IP in question, based upon ABS and industry association statistics and surveys and questionnaires completed by Australian defence companies and public sector R&D organisations.

Variables requiring definition and measurement	Possible relationships and Questions
• A meaningful definition of R&D expenditure as a proportion of defence budgets and/or turnover of private sector defence firms • A meaningful definition of "Commercialisation" • A meaningful definition of non-Defence R&D expenditure as a proportion of the Commonwealth budget and/or turnover of private sector non-Defence firms • The size of Australia's investment in Defence R&D – public and private sector • The commercial Return on that R&D investment – in public and private sector • RoI and other Returns • Exploitable IP	• Has public sector R&D investment as a proportion of the defence budget changed over the years? • Has private sector defence R&D investment, as a proportion of turnover, changed over the years? • Has the commercial return from this R&D increased or decreased in recent years? • Has the commercial return mirrored fluctuations in public and private sector R&D investment?

2. Is Australia's public and private sector investment in defence R&D commensurate with the anticipated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from that R&D?

Part of the answer to this question will be derived from the answer to Question 1, which seeks to quantify Australia's public and private sector investment in defence R&D. The remainder of the answer will come from research in three principal areas:

1. Identifying and where possible putting a dollar value on opportunities for Australian defence companies in the DCP, in order to quantify, even if only in a broad sense, the size and scope of the directly accessible domestic defence market

for goods and services. The next edition of the DCP, covering the financial years from 2005/06 to 2015/16 is expected to be published in January or February 2006.
2. Identifying potential export and Global Supply Chain opportunities accessible to Australian companies, including local subsidiaries of overseas prime contractors.
3. Where possible, identifying realistic opportunities in the non-defence market, both domestically and overseas, for products and services derived from Australian defence R&D.

In each area the data will be derived from a combination of survey responses, analysis of the DCP and analysis of the major procurement programs likely to be undertaken by key allies such as the USA and UK which resonate with major projects in the DCP.

Assessments of the non-defence market for defence-derived goods and services are likely to be extremely subjective and derived from fragmentary data. Therefore this part of the question may need to be treated separately, perhaps in the Appendix. While it may be tempting to ignore it altogether, there have been some significant commercial applications of defence-related IP so it would be wrong to ignore it.

A properly conservative approach to this research is likely to under-state rather than over-estimate the size and scope of the domestic and export markets.

Determining whether or not Australia's defence R&D investment is commensurate with the anticipated future demand may be problematic. The answer will almost certainly be derived from a combination of subjective assessments by defence companies and R&D organisations in their survey responses, and some form of external benchmarking.

Question 1 will determine how much Australia spends on defence R&D; Question 2 will provide an estimate of the size of the market; Question 3 will provide the external benchmarks which will enable a determination to be made of whether Australia's defence R&D investment is commensurate with reasonable estimates of the size of the market.

Answers to this question will be informed also by survey responses to the two questions suggested by respondents to this Pilot Study:
1. What is the relevance of Australian R&D to the ADF, Australian industry, export customers and the non-defence sector?
2. What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise that you intend to fulfil via an investment in R&D? And how much do you intend to invest?

Variables requiring definition and measurement	**Possible relationships and Questions**
• R&D funding criteria – private sector • R&D funding criteria – public sector • Measures of success in private sector defence R&D	• Has the accessible domestic market for Australian defence companies grown or shrunk in recent years? • Does the presence in Australia of major overseas

• Measures of success in public sector defence R&D • Niche technologies and niche markets • Market Opportunities – defined as potential market or scale of user need?	suppliers represent a new market for local product and expertise – both to supply Australian customers and access export markets? • Does access to an export market or a global supply chain stimulate Defence R&D in the private sector? • Has a similar relationship been observed in the commercial sector? • If Australian companies don't invest in their own R&D do they still seek to license and commercialise DSTO's IP?

3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?

The general consensus among Pilot Study respondents is that the question is relevant, but hard to answer – estimates of the difficulties involved range from "difficult" to "almost impossible".

The answer to this question is likely to be derived (at least in part) or inferred from comparison of Australia's defence R&D and commercialisation outcomes with those of other countries and also from comparison with the non-defence high-technology sectors in Australia and overseas.

Data gathered to answer Question 1 will help establish whether or not private sector investment in defence R&D and commercialisation has had a measurable effect on the competitiveness (measured as sales and revenue growth and profitability) of the companies making this investment.

It must be remembered that the majority of Australian defence companies are either privately or foreign-owned and so under a lesser obligation than publicly listed or government-owned companies to disclose financial information about their business operations, including R&D investment and profit margins. In the absence of publicly available data from a single reliable source, a survey may be the only way to gather such data from the private sector, though these may be only partial disclosures by the organisations concerned.

Much of the refined data to answer this question will be generated in Questions 1 and 2: these will provide figures for Australia's defence R&D investment, the commercial return it derives from this R&D, and estimates of the defence and non-defence markets for the product of this R&D.

It is generally assumed that Australia under-invests in defence R&D and under-performs in commercialisation. While this research may prove that assumption to be false, it is a useful working hypothesis for the purpose of orienting the external benchmarks against which Australia's performance will be compared.

If Australia – and particularly Australia's defence industry – is under-investing in defence R&D and under-performing in commercialisation this should show up in comparisons of the overall performance of Australia's defence industry with those of other countries. The size of the discrepancy can be used as a measure of the opportunity cost borne by Australia arising from its failure to invest sufficiently in defence R&D and commercialisation.

Therefore, it is proposed that a search of available statistics be undertaken to produce as reliable an estimate as possible of the defence R&D and commercialisation outcomes in the following countries: The UK, USA, Canada, Sweden, Singapore, Finland, Israel and Norway.

The statistics should be based on similar definitions and measures to those outlined in Question 1 and should include: public sector defence R&D investment; private sector defence R&D investment; the consolidated annual revenue and profit of the defence industry of the country concerned; the number of people the industry employs directly; and the defence industry's domestic and export sales.

It is understood that the drivers for public and private sector defence R&D investment will differ from country to country; and the international market in defence equipment is not free and unfettered - market forces are often channelled or dammed by political and strategic imperatives. Nevertheless, it is a fact that in a technology-dominated industry sector R&D is an essential component of that sector's health and vitality; measurements of R&D investment and industry performance must still be considered valid.

If comparison of Australia with the external benchmarks named above shows the working hypothesis is false, then it can be posited that Australia is investing adequately in defence R&D and commercialisation, given the size of the market accessible by Australian defence companies.

If the working hypothesis is found to be true, then a measure exists for the cost to Australia of failing to invest sufficiently in Defence R&D.

Variables requiring definition and measurement	**Possible relationships and Questions**
• Australia's Defence and non-Defence R&D and commercialisation performance – public and private sector • Australia's public-private sector defence R&D investment ratio • Overseas public-private sector defence R&D investment ratio • Defining an adequate Return on Australia's Defence R&D • Defence and non-Defence R&D and Commercialisation performance – public and private sector	• Comparison of the RoI from Australian Defence R&D with RoI from non-defence R&D • Has the RoI from Australian defence R&D matched fluctuations in Australia's defence budget and R&D investment over the past few years? • A comparison of Australia's defence R&D and commercialisation record with that of overseas benchmarks • A comparison of Australia's non-Defence R&D and commercialisation record with that of overseas benchmarks

4. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?

This question lies at the heart of the research and its answers will be derived principally from surveys and case studies, supported by analysis of available Australian and overseas government statistics and industry statistics provided in the survey responses.

Chapters 3 to 8 of the Thesis will deal with the process of defining the key research variables and their relationships and then measuring and analysing them. The answers to this question will come mainly from survey responses supported in part by available statistics and the data gathered to answer Questions 1 to 3.

Therefore most of the effort associated with this research will be invested in answering this question. Key goals will be to: identify and define the gaps in knowledge which, if filled, will prove or disprove the hypothesis; identify the key research variables relating to the knowledge gaps, and their relationships; establish a meaningful measure for these variables and ascribe the appropriate weight to them; develop the methodology for constructing the survey and identifying appropriate survey respondents; demonstrate how the survey supports the objectives of the research by helping identify the key variables, their relationships and their relative importance.

Variables requiring definition and measurement	**Possible relationships and Questions**
• Market access and knowledge • Availability of appropriate managerial talent and expertise • Availability of appropriate R&D talent and expertise • Clustering - physical proximity - of IP generators (CSIRO, Universities, CRCs etc) and exploiting companies • Proportion of turnover or budget devoted to R&D • Proportion of R&D funding devoted to commercialisation • Motivation and reward mechanisms of the researchers • Competitive Environment • Market Focus of R&D • Commitment of Sponsors to R&D • Project lead times • Product cycle – refreshment rate for market opportunities for high-tech equipment and services	• Is the size of the defence market and ease of market access sufficient to justify private sector Defence R&D? • Has defence-related R&D been commercialised more successfully in defence or non-defence markets? • Does non-Defence R&D deliver a quicker RoI than Defence R&D? • Time to Market: do lengthy acquisition project lead times inhibit investment in time-sensitive defence technology? • As the defence business environment becomes more competitive does Time to Market reduce? • What effect does Defence's lengthy project lead times have on the funding pressures experienced by private sector companies attempting to commercialise new IP? • Does the relatively small defence market, with slower product cycles and lengthy project lead times, inhibit public and private sector R&D or depress commercial returns compared with the commercial arena? • Do the size of the defence budget and the proportion allocated to R&D affect commercialisation outcomes? • Influence on local Defence R&D investment and

	commercialisation of Australian Industry Involvement (AII), DIIREC incubators/venture capital/grants etc • Does the level of transparency (or lack of it) within an organisation such as Defence inhibit decision-making on R&D investment and commercialisation? • Do barriers to entry into the Defence market drive Australian defence companies and R&D agencies into niche technology or market areas? • Is the scale of public sector Defence R&D investment a function of operational needs or simply of the available budget? What historical trends are visible? • Does the proportion of the defence budget devoted to R&D affect commercialisation outcomes? • Is the return on R&D investment a function of the effort and resources devoted to commercialisation activities, or to more fundamental technology-related factors? • Is the likelihood of a successful commercialisation outcome enhanced by the financial health and quality of management of the company involved? • Does increasing investment in R&D deliver a proportionate increase in the RoI, or is there a threshold at which this begins to rise (or fall)? • Does the presence and involvement of a strong Tertiary Education sector enhance commercialisation outcomes? • Technology Readiness Level of the IP being commercialised – does lower technological risk mean a greater likelihood of financial backing and therefore of commercial success? • The influence of financial and other reward mechanisms on the motivation of the researchers and commercialisers • Does the clustering of research organisations and companies enhance commercialisation outcomes? • Does a partnership/alliance with the end user increase the chances of successful commercialisation? • Has market education resulted in the increased commitment of sponsors to R&D? • Does collaboration between public and private sector R&D organisations deliver a better or worse commercialisation outcome than the efforts of either private or public sector organisations by themselves? • Do local investment by, or partnerships with, multi-nationals provide technology access and/or an avenue to exports? • Do Defence R&D outcomes benefit from having a clear measure of success up-front? • What makes IP exploitable, or not, in a commercial sense?

	• Does the relatively high level of defence imports inhibit local Defence R&D? • Do high barriers to entry into the defence market inhibit private sector Defence R&D generally? • Does the high cost of developing leading edge equipment drive companies into partnership with government-funded R&D agencies? • Defence seeks to standardise equipment and standards so far as possible – it buys relatively few products/services but in very high numbers. Does this purchasing pattern match the commercial world or does it represent a less open and diversified marketplace?

5. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?
It is clearly impossible to answer this question until the analysis of the survey results and case studies is complete. The answer to this question will form Chapter 8 of the Thesis. It may be possible to define a model, or the research may show this is impossible to achieve with any credibility and consistency. Either way, the research will have delivered a helpful result

ENDS

APPENDIX A – Key Research Parameters

The subject of this research - Factors enabling or preventing the commercialisation of defence-related intellectual property (IP) – does not appear at first glance to lend itself to conventional statistical analysis. Cultural and political factors and the operations of monopsony markets are not easily measured and the links between cause and effect are not always visible or direct.

It is therefore necessary to establish a credible statistical basis for analysis of these and other factors. To achieve this I have sought to break down the research topic into sub-elements which can be tackled discretely; to identify variables which can be defined and measured accurately; and to identify relationships between these variables and other factors which it might be possible to observe and measure.

These Key Research Parameters are listed below and grouped according to the key questions this research sets out to answer. It is clear that many of variables, and their relationships to each other, can be defined and measured using statistical analysis and a search of the literature. However, many of them particularly those relating to Question 4, will be defined and measured through responses to the survey questionnaire.

Therefore this list of the Key Research Parameters will be the base upon which the questionnaire and survey are designed and constructed.

Comparison with the original Research Proposal shows this current list of Key Research Parameters is much shorter – the Parameters which have been omitted are those which, in the light of the Pilot Study results, were self-evidently irrelevant or marginal or which the PDS respondents did not identify, in their experience, as relevant to this research.

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?

Variables requiring definition and measurement	Possible relationships and Questions
• A meaningful definition of R&D expenditure as a proportion of defence budgets and/or turnover of private sector defence firms • A meaningful definition of "Commercialisation" • A meaningful definition of non-Defence R&D expenditure as a proportion of the Commonwealth budget and/or turnover of private sector non-Defence firms • The size of Australia's investment in Defence R&D – public and private sector • The commercial Return on that R&D investment – in public and private sector • RoI and other Returns	• Has public sector R&D investment as a proportion of the defence budget changed over the years? • Has private sector defence R&D investment, as a proportion of turnover, changed over the years? • Has the commercial return from this R&D increased or decreased in recent years? • Has the commercial return mirrored fluctuations in public and private sector R&D investment?

• Exploitable IP	

2. Is Australia's public and private sector investment in defence R&D commensurate with the anticipated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from that R&D?

Variables requiring definition and measurement	Possible relationships and Questions
• R&D funding criteria – private sector • R&D funding criteria – public sector • Measures of success in private sector defence R&D • Measures of success in public sector defence R&D • Niche technologies and niche markets • Market Opportunities – defined as potential market or scale of user need?	• Has the accessible domestic market for Australian defence companies grown or shrunk in recent years? • Does the presence in Australia of major overseas suppliers represent a new market for local product and expertise – both to supply Australian customers and access export markets? • Does access to an export market or a global supply chain stimulate Defence R&D in the private sector? • Has a similar relationship been observed in the commercial sector? • If Australian companies don't invest in their own R&D do they still seek to license and commercialise DSTO's IP?

3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?

Variables requiring definition and measurement	Possible relationships and Questions
• Australia's Defence and non-Defence R&D and commercialisation performance – public and private sector • Australia's public-private sector defence R&D investment ratio • Overseas public-private sector defence R&D investment ratio • Defining an adequate Return on Australia's Defence R&D • Defence and non-Defence R&D and Commercialisation performance – public and private sector	• Comparison of the RoI from Australian Defence R&D with RoI from non-defence R&D • Has the RoI from Australian defence R&D matched fluctuations in Australia's defence budget and R&D investment over the past few years? • A comparison of Australia's defence R&D and commercialisation record with that of overseas benchmarks • A comparison of Australia's non-Defence R&D and commercialisation record with that of overseas benchmarks

4. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?

Variables requiring definition and	Possible relationships and Questions

measurement	
• Market access and knowledge • Availability of appropriate managerial talent and expertise • Availability of appropriate R&D talent and expertise • Clustering - physical proximity - of IP generators (CSIRO, Universities, CRCs etc) and exploiting companies • Proportion of turnover or budget devoted to R&D • Proportion of R&D funding devoted to commercialisation • Motivation and reward mechanisms of the researchers • Competitive Environment • Market Focus of R&D • Commitment of Sponsors to R&D • Project lead times • Product cycle – refreshment rate for market opportunities for high-tech equipment and services	• Is the size of the defence market and ease of market access sufficient to justify private sector Defence R&D? • Has defence-related R&D been commercialised more successfully in defence or non-defence markets? • Does non-Defence R&D deliver a quicker RoI than Defence R&D? • Time to Market: do lengthy acquisition project lead times inhibit investment in time-sensitive defence technology? • As the defence business environment becomes more competitive does Time to Market reduce? • What effect does Defence's lengthy project lead times have on the funding pressures experienced by private sector companies attempting to commercialise new IP? • Does the relatively small defence market, with slower product cycles and lengthy project lead times, inhibit public and private sector R&D or depress commercial returns compared with the commercial arena? • Do the size of the defence budget and the proportion allocated to R&D affect commercialisation outcomes? • Influence on local Defence R&D investment and commercialisation of Australian Industry Involvement (AII), DIIREC incubators/venture capital/grants etc • Does the level of transparency (or lack of it) within an organisation such as Defence inhibit decision-making on R&D investment and commercialisation? • Do barriers to entry into the Defence market drive Australian defence companies and R&D agencies into niche technology or market areas? • Is the scale of public sector Defence R&D investment a function of operational needs or simply of the available budget? What historical trends are visible? • Does the proportion of the defence budget devoted to R&D affect commercialisation outcomes? • Is the return on R&D investment a function of the effort and resources devoted to commercialisation activities, or to more fundamental technology-related factors? • Is the likelihood of a successful commercialisation outcome enhanced by the financial health and quality of management of the company involved? • Does increasing investment in R&D deliver a proportionate increase in the RoI, or is there a threshold at which this begins to rise (or fall)? • Does the presence and involvement of a strong Tertiary Education sector enhance

	commercialisation outcomes? • Technology Readiness Level of the IP being commercialised – does lower technological risk mean a greater likelihood of financial backing and therefore of commercial success? • The influence of financial and other reward mechanisms on the motivation of the researchers and commercialisers • Does the clustering of research organisations and companies enhance commercialisation outcomes? • Does a partnership/alliance with the end user increase the chances of successful commercialisation? • Has market education resulted in the increased commitment of sponsors to R&D? • Does collaboration between public and private sector R&D organisations deliver a better or worse commercialisation outcome than the efforts of either private or public sector organisations by themselves? • Do local investment by, or partnerships with, multi-nationals provide technology access and/or an avenue to exports? • Do Defence R&D outcomes benefit from having a clear measure of success up-front? • What makes IP exploitable, or not, in a commercial sense? • Does the relatively high level of defence imports inhibit local Defence R&D? • Do high barriers to entry into the defence market inhibit private sector Defence R&D generally? • Does the high cost of developing leading edge equipment drive companies into partnership with government-funded R&D agencies? • Defence seeks to standardise equipment and standards so far as possible – it buys relatively few products/services but in very high numbers. Does this purchasing pattern match the commercial world or does it represent a less open and diversified marketplace?

5. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?

APPENDIX B – Project Definition Study Questionnaire

GREGOR FERGUSON

3/4 West Terrace Kensington Gardens SA 5068
Tel: (08) 8331 1060 Mob: 0414 803 717
email: gregor@chariot.net.au

Education Centre for Innovation and Commercialisation (ECIC)
University of Adelaide

8 February 2005

Dear ,

Ph.D Thesis – "Factors enabling or preventing the commercialisation of defence-related Intellectual Property (IP)"

I have just begun research for a Ph.D on the commercialisation of defence-related R&D. In order to refine and validate the six key questions the research sets out to answer, I would be most grateful for a few minutes of your time.

The six basic questions are attached. I would be most grateful if you could take a moment to tell me whether you think these are the right questions and, if you can spare a moment or two more, why – or why not? The questionnaire is simple and self-explanatory. I'll follow up with a 'phone call in a couple of days to either set up a face to face meeting or go through the questionnaire over the telephone.

If you're unable to speak to me either over the 'phone or in person I'd still be most grateful if you would take a moment to fill in the questionnaire and return it to me by post or fax, indicating whether or not you are willing to be named in my thesis as a respondent, and to have all or part of your response quoted.

I hope this research will provide some benefit to Australia's broader defence community – I'm not aware of any previous academic research carried out along these lines so your participation is important and I'm most grateful for your time and insight.

You may know me as the editor of "Australian Defence Magazine". Please be assured this research is quite separate from my journalistic activities. Questionnaire responses and the names of respondents will not be published, either in my thesis or in any other publication, without the written permission of the respondents. The same applies to data gathered in subsequent interviews and surveys.

Sincerely –

Gregor Ferguson

QUESTIONNAIRE 1/05

Commercialising Defence-Related IP

Introduction
I am currently researching a Ph.D on R&D commercialisation at the University of Adelaide's Education Centre for Innovation and Commercialisation (ECIC). My research topic is " Factors enabling or preventing the commercialisation of defence-related IP".

The first step in the research process is to ensure I'm asking the right questions – in order to validate the basis for my research I would be most grateful if you could take a few minutes to answer the questionnaire below, either in a face to face interview with myself, over the telephone or in writing. Responses will be treated in the strictest confidence. Individual responses will not be identified publicly without your written permission.

Many thanks for participating in this survey.

If unable to take part in a face to face or telephone interview, please E-mail, Fax or Post your questionnaire responses to:

Gregor Ferguson,
3/4 West Terrace,
Kensington Gardens,
SA 5095

Fax: (08) 8343 8577
Email: gregor@chariot.net.au

The Six Key Research Questions

The objectives of my proposed research will be met if the research succeeds in answering Six Key Questions. Please indicate whether or not you agree these are the right questions; please feel free to comment.

Your name: ……

Current Position:…….

May I publish all or part of your comments? YES ❑ NO ❑

May I publish your name in my thesis? YES ❑ NO ❑

1. What is Australia's total public and private sector investment in defence-related R&D? And what is the commercial return derived from this?

Relevant? YES ❑

NO ❑

Comment:

2. What is the estimated future demand from the ADF, Australian industry, export customers and the non-defence sector for products, services and expertise derived from Australian R&D?

Relevant? YES ❑

NO ❑

Comment:

3. What is the opportunity cost to the Australian economy of failing to invest sufficiently in defence R&D and commercialise the resulting IP?

Relevant? YES ❑

NO ❑

Comment:

4. Can a reasonably accurate "multiplier" be developed from the answers to Questions 1 to 3 which can than be applied to estimate the likely return from Australian defence-related R&D investment?

Relevant? YES ❑

NO ❑

Comment:

5. What are the strategic, technological and market-related factors which enable or inhibit the commercialisation of IP developed as a result of defence-related R&D in Australia?

Relevant? YES ❑

NO ❑

Comment:

6. Is it possible to define a model, or at least a more general set of pre-conditions, which is likely to result in successful commercialisation of defence-related IP?

Relevant? YES ❑

NO ❑

Comment:

APPENDIX C – Project Definition Study Interviewees

Name	Occupation (At time of Interview)	Date of Interview
Dr Roger Lough,	Chief Defence Scientist, DSTO	29 July 2005
Dr Ken Anderson,	First Assistant Secretary, Science Policy, DSTO	1 August 2005
Mr Warren Canning	Head, DSTO Business and Commercialisation Office	
Dr Ian Chessell	Former Chief Defence Scientist, DSTO	29 July 2005
Dr Don Sinnott	Former Chief, Microwave radar Division, DSTO	23 March 2005
Dr Bill Schofield	Former Director, Aeronautical and Maritime Research Laboratory, DSTO	25 February 2005
Dr Richard Brabin-Smith	Former CDS and Deputy Secretary, Strategy, Dept of Defence	7 July 2005
Dr Stephen Gumley	Chief Executive Officer, Defence Materiel Organisation (DMO)	
Mr Peter Croser	Head, DMO Industry Division	8 February 2005
LTGEN David Hurley	Head of Capability Development Group, Dept of Defence	24 February 2005
Air Chief Marshal Angus Houston	Chief of the Defence Force	Unavailable for Interview
VADM (Ret'd) David Shackleton	Former Chief of Navy	8 July 2005
Mr Michael Roche	Former Under Secretary Defence Materiel, DMO	8 July 2005
Mr Martin Jones	R&D Manager, Tenix Defence Pty Ltd	7 July 2005
Dr Roger Creaser	Former Chief, Maritime Operations Division, DSTO and Former Chief Scientist, ADI Ltd.	3 August 2005
Ms Susan Anderson	R&D Manager, BAE Systems Australia Ltd	
Mr Lindsay Pears	Chief Strategist, Boeing Australia Ltd	8 July 2005
Mr John O'Callaghan	Executive Officer, Australia Industry Group (AIG) Defence Unit	
Mr Paul Fisher	Director, Defence Business Unit, Australian Business Ltd (ABL)	29 July 2005
Mr David Gaul	President, CEA Technologies Pty Ltd	8 July 2005
RADM (Ret'd) Kevin Scarce	Former Chief Executive, Defence Unit, & Chair Defence Industry Advisory Board, SA Department of Trade and Economic Development; former Acting Under Secretary Defence Materiel, DMO	