Anticipating Tomorrow's Defence Needs

A Century of Australian Defence Science

DSTO

DEFENCE SCIENCE & TECHNOLOGY

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Anticipating Tomorrow's Defence Needs

A Century of Australian Defence Science

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Acronyms and Abbreviations

ADF	Australian Defence Force
AMAS	Australian Minesweeping and Support System
AMRL	Aeronautical & Maritime Research Laboratory
ARL	Aeronautical Research Laboratories
CDS	Chief Defence Scientist
CSIRO	Commonwealth Scientific & Industrial Research Organisation
DMO	Defence Materiel Organisation
DRCS	Defence Research Centre Salisbury
DRL	Defence Research Laboratories
DSL	Defence Standards Laboratories
DSTO	Defence Science & Technology Organisation
LADS	Laser Airborne Depth Sounder
LRWE	Long Range Weapons Establishment
MRL	Materials Research Laboratories
MSL	Munitions Supply Laboratories
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RANEL	Royal Australian Navy Experimental Laboratories
RANRL	Royal Australian Navy Research Laboratory
S&T	Science and Technology
TTCP	The Technical Cooperation Program

FOREWORD

This book celebrates 100 years of defence science in Australia, beginning with the role of Cecil Napier Hake in investigating the feasibility of establishing a cordite factory in this country. From those early days defence science has undergone many changes, reflecting that the nature of warfare itself has changed radically since Hake developed safety standards for handling cordite and went on to establish the first defence laboratory in Victoria.

There have been many changes since 1907, including significant expansion in the years following WW II. A watershed in the history of defence science occurred during the 1970s when the various defence laboratories were brought together as the Defence Science & Technology Organisation (DSTO) as we know it today. DSTO's reputation has grown and it is now recognised as the government's lead agency providing science and technology support to both the Defence and the wider national security community.

Through the decades of change, one theme has remained constant – that is, the high calibre of our defence scientists and the associated quality of our science. These enduring elements have been the cornerstone of our work, enabling Defence to better accomplish its mission during times of war and peace.

Generations of Australian defence scientists have been responsible for a host of noteworthy achievements which have helped establish our world class reputation, and many of these achievements are highlighted in this book. For a small organisation, we punch well above our weight compared to some of our contemporaries in other parts of the world.

Today we are less interested in specific product development and more focused on finding total solutions. This is because the technology services we deliver demands cross scientific disciplines and span the whole technology life cycle. Our defence scientists today take a systems-based approach that starts with the conceptual work and extends through to engineering and capability support.

More than ever before, DSTO's role is to act as a technology agent for the ADF to help position it to effectively exploit future technologies.

While we have a keen appreciation of the past which has shaped our scientific excellence, established our traditions and formed our present, we are firmly focused on the future. Currently, DSTO is undergoing a Renewal Program that is transforming our programs, business processes and our culture to better meet the challenges of the early 21st century. Understanding the past is key to managing change. Our history shows that DSTO and its predecessors have regularly overcome challenges and rejuvenated themselves to ensure they remained relevant to Australia's defence needs.

The ADF will continue to rely on science and technology to underpin its warfighting capability. Defence scientists will continue to support the ADF with their innovative solutions as they have done during the past 100 years.

This book is a fitting tribute to those endeavours, building on John Wisdom's earlier account on the subject.

The history of defence science is one in which all Australians can take pride.

Roger Lough

Chief Defence Scientist

Introduction

The Defence Science and Technology Organisation (DSTO) in 2007 is the product of 100 years of defence science in Australia and the largest government research agency after the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Several books have already been written about Australian defence science. The chief ones among them include John Wisdom's *Defence Science: A History of Defence Science in Australia*; Peter Morton's history of the Joint Project, *Fire Across the Desert: Woomera and the Anglo–Australian Joint Project 1946–1980*; A.T. Ross' *Armed and Ready: the Industrial Development and Defence of Australia 1900–1945*; D.P. Mellor's history of defence science during World War II, *The Role of Science and Industry*; and the collection edited by Frank Cain, *Arming the Nation: A History of Defence Science and Technology in Australia*. There are many other works.

There are also published histories of major establishments that form DSTO. They include Dennis Smith's history of the laboratories at Maribyrnong, *To Explore and Exploit the Unknown, A History of Defence Science at Maribyrnong 1922–2004*; the histories of the Aeronautical Research Laboratories at Fishermans Bend, J.Y. Mann's, *Aeronautical Research Laboratory 1939–1989: 50 Years of Research and Development for Australia's Defence*, and Dr Gordon Long's *The Leading Edge: Sixty Years of Aeronautical Research & Development for Australia's Defence, 1939–1999*. In addition, there is the RANEL Association's *Secret Science at Sea: the RAN Experimental Laboratory 1956–1987*, and my own *Pyrmont People: 50 Years of Defence Science in Sydney, 1956–2006*.

This book competes with none of these, but draws upon all of them to recount the development of DSTO and Australian defence science with an emphasis on people and institutions rather than on projects. I did not have the expertise or the time to include and comment in detail about individual projects. Nevertheless, key projects are highlighted where they underscore the development and changing nature of Australian defence science in accordance with changing Defence needs and policies. Those involved with the work of DSTO and its predecessors continue to document key projects and activities as far as national security allows. For example, scientists are currently involved in writing the history of the Nulka active decoy system, while Alexander Biggs has a website with a detailed story of the early days of the Joint Project.

It must be said that defence science in Australia has not been exclusively the preserve of DSTO and its predecessors. For instance, the Aircraft Research and Development Unit never became part of the organisation, and increasingly there is defence science being undertaken in universities and in some companies. The nature of the project did not permit extensive treatment of these. Still, the story is internally consistent. It remains comprehensive but not necessarily exhaustive. No written history can be totally exhaustive, and while in no way excusing shoddy work, historians can take some comfort in the view of noted Australian historian Sir Keith Hancock who wrote:

> *The history we write will contain flaws. Other historians will expose them. We ourselves shall rectify some of them. [But] the advancement of knowledge will be achieved in the process of questioning, answering and debating.*[1]

I have made a concerted effort to minimise the number of acronyms used. However, it seems unnecessarily pedantic and wasteful of space not to use DSTO when referring to the Defence Science and Technology Organisation, or CSIRO when referring to the Commonwealth Scientific and Industrial Research Organisation, and it is far easier to refer to TTCP than The Technical Cooperation Program. Similarly, the acronyms for the various establishments; for example Weapons Research Establishment (WRE), Defence Standards Laboratories (DSL), and Aeronautical Research Laboratories (ARL) and those acronyms appropriate for their predecessors and successors have been used.

Acknowledgements

Any author owes a debt of gratitude to those who assist in bringing a book to publication. As the explanation given above suggests, historians, in particular, depend on a great deal of goodwill and assistance in their efforts to retrieve information and interpretations about the past. Those who provided information by means of interviews are listed under ‘Notes on sources’, and their assistance is gratefully acknowledged here.

Others provided particular assistance during the course of this project. Peter Dempsey, a long-time employee at DSTO in Edinburgh, South Australia provided access to his collection of historical material and commented on an early draft of the history; Andrew Lawrence provided access to material collected by his father, Tom Lawrence; Oliver Raymond provided copies of documents, Departmental Science Instruction No. 1/85, a paper on the DSTO Program Planning, Management and Review Program, and a paper by Professor Tom Fink delivered to a Commonwealth Defence Science Organisation Conference in Brighton, United Kingdom, on 17 May 1985.

June Donovan undertook research into various projects mentioned in the history and commented on an early draft of the history. Former Chief Defence Scientist Dr Richard Brabin-Smith provided invaluable advice on several iterations of the manuscript. Jimmy Hafesjee facilitated the history and managed the production. Penny Cook edited the first draft.

The assistance of all is appreciated and acknowledged.

Peter Donovan

DSTO MISSION

The Defence Science & Technology Organisation is the Australian government's lead agency charged with applying science and technology to protect and defend Australia and its national interests. It delivers expert, impartial advice and innovative solutions for Defence and other elements of national security.

DSTO VISION

To be a world leader in defence science and technology – indispensable in transforming the Australian Defence Force and Australia's national security.

To achieve its mission and vision, DSTO:

- Provide scientific and technical support to current defence operations
- Investigates future technologies for defence and national security applications
- Ensures Australia is a smart buyer and user of defence equipment
- Develops new defence and national security capabilities
- Enhances existing capabilities by increasing performance and safety, and reducing the cost of ownership of defence assets
- Works collaboratively with other agencies to strengthen national security
- Assists industry to better support defence capability needs.

CHAPTER 1

Australia's first defence scientist: 1907–1919

The history of defence in Australia extends back to the 19th century when each colony established its own defence force and when munitions and ordnance were generally sourced from England. However, as early as 1874 or 1875 dynamite was manufactured in Australia: Australian Lithofracteur began manufacturing at Deer Park, beyond suburban Melbourne;[1] these Australian Explosives and Chemical Company works were later acquired by Nobel-Dynamite Trust Limited in 1897.[2] Meanwhile, in 1878, the Saltwater Gunpowder Magazine was built at Footscray in suburban Melbourne; the Colonial Ammunition Company Ltd built an ammunition factory on the site in 1889.[3]

The defence of Australia took on a new dimension following the federation of the several colonies on 1 January 1901, with defence responsibilities being assumed by the new Commonwealth government. Indeed, the Commonwealth Department of Defence was established on 1 March 1901 under Sir John Forrest as Minister for Defence. The civil administration of the former Victorian Defence Department became the nucleus of the Commonwealth department with Captain Robert Collins as the inaugural secretary.[4]

Thereafter the history of Australia's defence is one of the Commonwealth assuming ever-greater powers in that area. Fundamental to this history was the push for greater self-sufficiency in munitions and ordnance. As early as 14 March 1901, Collins submitted a report outlining the need for a central arsenal: another report only three months later suggested the need for the Commonwealth to take complete responsibility for the manufacture of munitions. Little was done immediately, with the new department focused on establishing procedures. However, Inspector-General Major-General J.C. Hoad,[5] in a report dated 28 February 1908, spoke of the government already having taken the decision to establish small arms and cordite factories. He wrote of the need for the new nation to be 'independent of overseas supplies for the whole of its Warlike Stores, including guns and ammunition'. He indicated that guns, carriages and limbers ordered in November 1904 were not delivered until March 1906.[6]

Fundamental to this push for greater independence in defence materiel was the need for the recruitment of scientists and the development of defence science to establish and maintain standards. War materials had to be manufactured within strict tolerances and in conformity with similar articles made throughout the Empire. Consequently, there was a need for strict attention to dimensional standards and an understanding of instruments and practices for checking gauges and tools in order to meet these standards.

The first tentative step in the Commonwealth government's commitment to defence science was the instruction to Cecil Napier Hake on 15 April 1907 to proceed to England to gather information and make recommendations concerning the establishment of a cordite factory in Australia. He was also instructed to enquire about the manufacture and storage of cordite following publicity about recent explosions at arsenals in India and at Woolwich in England.

❮ *Cecil Napier Hake (1848-1924), Australia's first defence scientist.*

Hake had been born in England on 15 May 1848. He was educated at King's College in London and later studied at the Royal College of Chemistry under the German chemist, August Wilhelm von Hofmann. He worked as a chemist for Leister and Townsend of Stassfurt, Germany, from 1866 and became manager of the Stassfurt Chemical Company in 1876, and manager of the Douglas Salt Mine and Chemical Works at Westereglen, near Stassfurt, in 1884. He later returned to England to practise as a consultant at Westminster until 1891. Hake migrated to Victoria to take the position of Inspector of Explosives in that colony in 1892 and to be a member of the Testing Board appointed to inspect and test ammunition produced by the Colonial Ammunition Factory. His expertise in explosives led the Commonwealth Department of Defence to consult him and seek his advice from time to time while he was still working for the government of Victoria and consolidating that state's position as the centre of munitions manufacture in Australia.

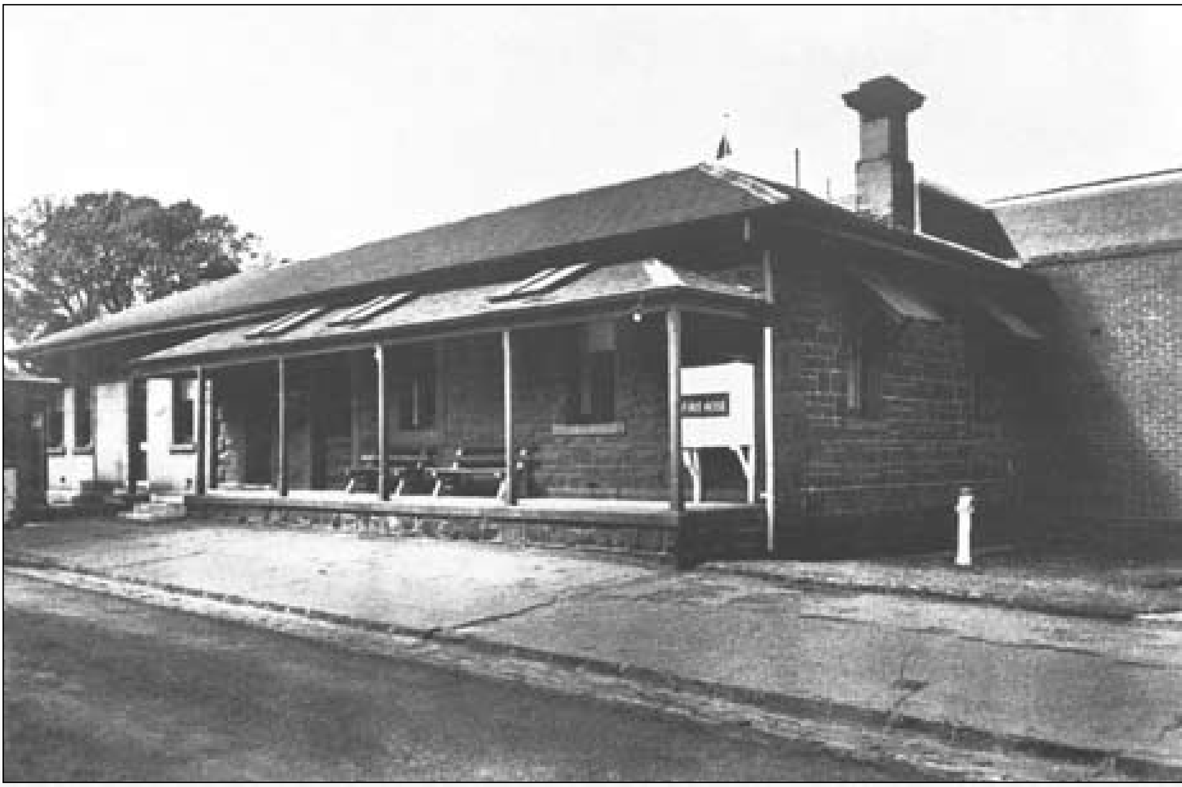
The question of Australia's preparedness to defend itself continued to exercise the new Defence Department. For instance, on 12 February 1904 it asked Hake to comment on the manner in which cordite supplies might be supplemented in the event of an emergency.[7] He reported that a cordite factory was unwarranted given Australian demand at the time, and that the Nobel company's Deer Park factory could be adapted to produce cordite within three months. But the issue was revisited following the appointment of Thomas Ewing as Minister for Defence in January 1907 and Hake was asked to proceed to England to acquire all possible information on the manufacture of cordite. In accordance with his instructions, Hake departed for England on 23 April 1907, with Engineer-Commander William Clarkson of the Royal Australian Navy who was instructed to study issues concerned with establishing a small arms factory. Hake visited the Royal Gunpowder Factory at Waltham Abbey and had extensive interviews with Colonel Sir Frederick L. Nathan, the Superintendent. His report dated 18 October 1907 recommended a factory with an annual output of 150 tonnes of cordite.[8] He also recommended the need for the appointment of an Inspector of Cordite in accordance with his instruction to research the storage of cordite. This recommendation was independent of that to establish a cordite factory because it involved an inspector to oversee the preservation, safety and storage of all explosives; those imported as well as those produced locally.

While in England, Hake met Arthur Edgar Leighton[9], a chemical engineer born in Christchurch, Surrey, England, on 17 June 1873. Leighton had been assistant manager of the Indian government's newly constructed explosives factory at Aravunkadu since 1903. Hake recommended that Leighton be appointed to design and manage the future cordite factory he recommended should be built by the Commonwealth government.

Hake continued to advise the Commonwealth government after his return to Australia, as issues warranted.[10] As he indicated, he undertook works of 'a varied character, such as examination of Service explosives, investigations of many complex problems connected with ammunition, &c., inquiries into accidents with explosives, and much consultative work of a confidential nature connected with proposals for the establishment of a Cordite factory locally, and other matters.'[11]

Hake took on the additional responsibility of Victoria's Chief Inspector of Explosives in June 1908. However, he became gravely ill in early 1909, and in September of that year, after his recovery, resigned from the state's service to take the position as Chemical Adviser on the permanent staff of the Department of Defence on 16 September 1909.[12] His responsibilities were 'to initiate and supervise all arrangements connected with the erection and management of the Cordite Factory, &c.; to organise and carry out a proper system of periodical inspection and testing of cordite, and to advise generally on the preservation, supply, and storage of all Service explosives throughout the Commonwealth.'[13]

Hake's assistant, Marcus Bell, was appointed 'Assistant Explosives Expert to the Department of Defence' from 1 July 1908.[14] Bell had been born at Kew, Victoria, on 7 January 1881. He had been educated at the University of Melbourne and was in England at his own expense at the time of Hake's visit in order to study military explosives in England. He evidently assisted Hake while in England, before being appointed assistant to him as Chief Inspector of Explosives of Victoria on his return. The two worked from the premises of the Victorian Explosives Department Library in Flinders Lane, Melbourne, under an arrangement with the Victorian government. In August 1908, soon after Bell's appointment, the two embarked on an inspection of cordite stores in New South Wales and Queensland: Hake let Bell visit those in South Australia, Western Australia, Tasmania and Victoria.



The site of the Chemical Adviser's Laboratory in the guard house at Victoria Barracks, c. 1916.

In accordance with Hake's recommendation, plans were implemented for the establishment of the government's cordite factory, with 103 hectares of land for the purpose being appropriated by an Act of Parliament on 4 July 1908: this was the site of the disused Maribyrnong racecourse about 11 kilometres from the Melbourne General Post Office and was also suggested by Hake. It was an admirable site, being bounded on three sides by the Maribyrnong River, and on the fourth side by the site that would later become the Government Ordnance Factory.

Leighton was recruited in accordance with Hake's suggestion, and appointed manager of the cordite factory on 29 January 1909: he took up his duties in Melbourne on 17 February 1909.[15] His first duties were to design the factory to suit the site, to travel to England to acquaint himself with the latest advances in the manufacturing and storage of cordite, and to recruit an experienced foreman for the factory: Ernest George Monk, from Waltham Abbey.

Hake travelled to England again in 1910 to select and order plant for the proposed cordite factory. Noel Kendric Stevens Brodribb,[16] who was instructed to undertake training in the manufacture of cordite, accompanied him. Brodribb, born at Kew, Victoria on 27 December 1885, had studied assaying at the Working Men's College in Melbourne and had developed an early interest in explosives and weapons. He had been Assistant Chemist in the Victorian government laboratories from 1909 and had been appointed chemist for the government's proposed cordite factory at Maribyrnong on 4 October 1909.

Tenders for construction of the cordite factory were let on 9 March 1910 and Leighton had the first sample of cordite pressed on 7 June 1912. By 30 June 1912 the factory employed 40 men and seven boys assisted by one chemist—Brodribb, who was promoted to assistant manager—and junior chemist Arthur Albert Topp, who had previously worked as a chemist with the Mount Lyell Mining Company in Victoria, the Chillagoe Mining and Railway Company in Queensland, and with the Victorian Mines Department. In the nine months from 22 September 1911 to 30 June 1912, the two chemists completed 122 analyses and conducted 27 heat tests. Robert James Craig was appointed a chemist at the factory on 1 June 1914 and by 1 July 1917 additional staff included John Robert Swan Cochrane and A.G. Hall.[17]

Meanwhile, the Chemical Adviser's Laboratory was established in a bluestone guardhouse at Victoria Barracks in Melbourne and opened in September 1910, in accordance with Hake's recommendation for an Inspector of Cordite independent of the cordite factory: the guardhouse had been used most recently as a magazine for small arms ammunition. The purpose of the laboratory was to test stocks of explosives and determine their state of preservation. Considered one of Australia's 'earliest science-dedicated laboratories', it was certainly the nation's first defence science laboratory.[18]

Hake resigned his position as Chemical Adviser to the Department of Defence from 1 April 1911, after having become the Commonwealth's first defence scientist, and established the nation's first defence science laboratory. John Jensen suggests he resigned in order not to conflict with Leighton in his role of assisting with the development of the cordite factory:

> *Without intending in any way to minimise the great services rendered over the years by Mr Hake, the facts are that whereas Mr Leighton was an experienced Chemical Engineer and Factory Manager, Mr Hake, although a notable figure in the Chemistry profession, did not have Mr Leighton's practical experience, and once the latter had returned from England, there was no field for two 'Captains' to be in charge of the construction of the factory. Mr Hake therefore gracefully relinquished his responsibilities in connection with the factory and left the field solely to Mr Leighton.*[19]

Hake had married an Australian, Elizabeth Carstairs Simson, in Melbourne in 1895, but prospects remained better in England and he returned there and worked as an analytical and consulting chemist for a time before retiring to the Mediterranean: he died in Monaco in 1925. Hake's legacy was a significant one, with his initiative being carried forward by those whose appointments he had recommended, particularly that of Arthur Leighton, and to a lesser extent, that of his assistant and successor, Marcus Bell. Indeed, John Jensen, who joined the Victorian Ordnance Stores as a messenger on 20 June 1900, and ultimately became head of the Commonwealth's Munitions Branch, considered Hake—along with Captain Robert Collins, head of the Victorian Defence Department, and Captain John Whitney, founder of the Colonial Ammunition Company works—to be 'the foundation in 1900 upon which the vast [munitions] structure of 1939–1945 was built.'[20]

After Hake

Marcus Bell succeeded Hake as Chemical Adviser to the Commonwealth government on 1 April 1911. He had as his assistant Gustav Adolph Ampt, BSc, who had been appointed to the position on 7 February 1911 and who had travelled to England for training; John T. McCormick MSc was appointed to the laboratory on 1 July 1911.

The early work of the laboratory was routine but it was occasionally asked to report on particular issues. Such an issue occurred following an explosion in a New South Wales coal mine in 1912. The laboratory was asked to report on the quality of the explosives used.

Australia's early defence scientists were chemists appointed to oversee chemicals used in the production of explosives and ammunition and to advise on the safe storage of explosives. Not all were associated with the Chemical Adviser's Laboratory in Melbourne. A small arms factory was built at Lithgow in New South Wales following the recommendation of Engineer-Commander William Clarkson who had accompanied Hake to England in 1907. Land was acquired in 1908, and construction began in early 1910 in accordance with the tender won by the Pratt and Whitney Company of the United States. Governor-General Lord Denman formally opened the factory on 8 June 1912. The need for an associated laboratory soon became apparent because of the need to analyse steel and other materials and because of the undue delay in having to send materials to Melbourne. Marcus Bell endorsed the recommendation for a laboratory and urged that a chemist be appointed permanently. H.A. Wilson joined the staff on 1 July 1915.[21]

An Australian arsenal

Australia's participation in World War I hastened the development of Australian defence science with the need to oversee the production of munitions and to analyse materials associated with this. Australia's defence production was associated with the manufacture of small arms, explosives, clothing and associated supplies in six government factories employing about 2500 people. The Maribyrnong complex underwent a major expansion to ensure Australia's self-reliance in munitions production and afterwards became the Commonwealth's main factory for explosives and munitions production.

The expansion at Maribyrnong meant a complementary expansion in the demands made on the analytical section of the Chemical Adviser's Laboratory in particular. Curtailment of supplies from overseas meant the cordite factory was required to source or produce locally the glycerine, acetone, cellulose and methanol necessary for cordite production once imported supplies were no longer available after the outbreak of World War I.[22] Scientific expertise was required to ensure this was suitable for munitions production. Extra work included the

The pioneers (L-R): Robert Summers, John McCormick, Marcus Bell, Alfred Dawkins, 1924.

preparation of specifications for the manufacture of shell steel and of a high explosive shell, and an investigation into the manufacture of trinitrotoluene.[23]

Others joined the laboratory as demand for its services grew. Robert Ernest Summers joined the staff by 1 July 1915. A young Alfred Ernest Dawkins joined the Department of Defence as a chemist at the Chemical Adviser's Branch in 1915. He had been born in Adelaide and graduated from the University of Adelaide in 1913 with a BSc with first class honours.[24]

The pressure on the Chemical Adviser's staff—Ampt, McCormick, Summers and Dawkins—was the greater because Marcus Bell was increasingly called upon as a departmental consultant and to serve as a member of the Federal Munitions Committee and the Directors of Munitions Committee.

In addition, Bell was appointed a member of the committee tasked with advising on the development of an Australian arsenal. The Australian government anticipated manufacturing guns and shells in Australia and once more considered building an arsenal, this to be at Tuggeranong, south of Canberra in the Federal Capital Territory. The committee sought guidance from defence experts in England only to be told that no one could be spared for this purpose, nor should anything be done to jeopardise war production in England by sourcing plant from America. However, the government was advised to seek information from India. The government appointed a Munitions Committee to pursue the idea in 1915. It comprised Colonel Percy Thomas Owen, Director General of Works; B.T. McKay, Works Manager for Walkers Ltd, Maryborough, Queensland; Professor Henry Payne; Major Henry Brook Lawrence Gipps; and Marcus Bell. The committee visited India in July 1915. Bell also took on the extra responsibility of Director of Munitions in Australia in 1916 after his return.

Meanwhile, the committee endorsed proposals for an arsenal. The government concurred and, in July 1916, appointed Leighton as General Manager of the Commonwealth Arsenal, though he was working in England at the time, with Major Alexander James Gibson[25] appointed acting General Manager of the arsenal organisation in Melbourne.

Leighton had travelled to England via India in 1915 to gather current information to assist with the extension of the cordite factory and the need to manufacture big gun cordite. 'He was not long there before the Ministry of Munitions applied for his services to assist with the manufacture of Munitions'.[26] The Australian government agreed and Leighton became associated with the construction of many major factories in Great Britain, and served on the management board of the Gretna Factory. Brodribb was appointed manager of the cordite factory in succession to Leighton from 1 February 1917,[27] and later Chief Chemical Engineer in the Commonwealth Arsenal.

Leighton used his position in England to transfer the latest developments in defence science to Australia in anticipation of the construction of the arsenal. During the course of his secondment, and with an eye to training men for positions in the arsenal, Leighton initiated a scheme for attracting more than 100 Australian chemists and engineers to England to work in the munitions program so they might later transfer their skills to Australia. As early as 6 July 1915 Leighton sought the services of two chemists already experienced in the manufacture of guncotton and nitroglycerine to be sent to England, with three others to be trained at the cordite factory for three months, then sent to England to be employed in the explosives factories then being built.[28] Dr McKenzie, chemistry lecturer at the Royal Military College, Duntroon, and Robert James Craig from the staff of the Chief Inspector of Explosives in Victoria were selected, with Craig sailing for England on 10 August 1915 and McKenzie sailing for India on 16 November 1915. C.P. Callister, A.F. Parkin and Robert Summers were selected for training and departed for England in early December.

The chemists drawn from all Australian states were a few of the 5500 Australian civilians—other scientists, engineers, tradesmen and labourers—who were sent to England under various schemes to assist with industrial war work in Britain during World War I.[29]

The scientists included Robert Summers and William Oswald Stubbs who studied ammunition and explosives production; Clement Blazey who studied non-ferrous metallurgy; William Ralph Jewell, iron and steel metallurgy; C.P. Callister, chemical and trench warfare; Norman Abraham Esserman, physics, optics and metrology; William Joseph Kelly, technical records. Chemical engineers Arthur Topp, then assistant manager of the cordite factory, and H.E.B. Scriven gained experience in explosives manufacture and filling. Lieutenant-Colonel Henry Gipps visited England in order to study the organisation of the Munitions Inspection Branch, and John Jensen studied the organisation and administration of the Ministry of Munitions. Several mechanical engineers including Arthur Samuel Ford, James Harold Wrigley, William Fowler, Frank Cecil Spiller, Maurice Michael O'Loughlin, F.T. Small and T.L. Sherman also worked in areas of small arms, gun ammunition production and aircraft manufacture.[30]

The scheme was an extensive and intensive one. The Australians studied in virtually all areas of science with a bearing on defence as they existed in 1918. Most information was garnered

A group of early metallurgists at the Munitions Supply Laboratories (L-R): G.L. McCandie, E.G. Thurlby, A.A. Robertson, H.R. Williams, A.J. Roennfeldt, E. Ridge, 1929.

from British institutions such as the research department of the Royal Arsenal at Woolwich, the National Physical Laboratory at Teddington and the inspections departments of the Navy, Army, and the fledgling Air Corps. Several supplemented this work with courses in key educational institutions and terms in commercial laboratories.[31]

All who participated in the scheme joined the Australian Commonwealth Arsenal, which also had a coordinating branch in London. Several returned home via the United States in order to gather additional experience and information.[32] Many of the scientists, on returning home, joined others such as John McCormick, Alfred Dawkins, Percival Robert Weldon and Eric Loxton Sayce, all of whom rose to senior positions in the Munitions Supply Laboratories.[33]

Leighton personally encouraged several of those whom he believed would later be leading scientists in Australia. For instance, in 1918, Leighton had spoken to Norman Esserman of the need for Australia to have its own optics industry. Acting on this advice, Esserman studied the theory and design of optical instruments at the Northampton Institute and at the Department of Applied Optics at Imperial College London, the first such department to be established outside Germany.[34] Esserman also had the opportunity to study aspects of metrology associated with war production at the National Physical Laboratory and, during the course of his return to Australia to take a position at the Chemical Adviser's Laboratory, spent time at the National Bureau of Standards in Washington.[35]

Marcus Bell, first appointed to the Chemical Adviser's Laboratory on 1.4.1911.

Marcus Bell was another to take advantage of Leighton's initiatives. He had been identified as a key addition to the proposed arsenal staff and was appointed Superintendent of Laboratories on 1 January 1917[36] and told that he would become responsible for all scientific and research endeavour within the Department of Defence. He sailed for England in February that year to acquaint himself with scientific research associated with war developments and the design and construction of appropriate laboratories in which to undertake this work. Bell remained in England until August 1918 and returned to Australia via the United States in order to garner additional information there. On the basis of his investigations, and discussions with Leighton while in England, he drew plans for the creation of four laboratories to undertake general chemical research and research in metallurgy, physics and explosives.[37]

Meanwhile, in Australia, an administrative structure was established in the Commonwealth Arsenal that included the Lithgow Small Arms Factory, the Maribyrnong Cordite Factory and the Chemical Adviser's Branch at Victoria Barracks.[38] Key personnel in Australia supporting the Leighton initiative and creation of the Commonwealth Arsenal included Lieutenant-Colonel S. Henry Barraclough,[39] Professor of Mechanical Engineering at Sydney University from 1915 to 1942; Major Alexander James Gibson, Professor of Engineering at the University of Queensland; and Frederick Russell Ratcliffe, manager of the Small Arms Factory.

Construction of the Australian arsenal did not proceed during World War I because of practical difficulties, and it was postponed in November 1918 after the conclusion of the war. The Australian government reasoned that it could obtain better advice based on the experiences gained by the allies during the war, especially the expertise of Leighton, and also obtain surplus equipment being dismantled in England.[40] However, from a defence science point of view, the idea was already a success with the recruitment of a cohort of scientists trained in the most up-to-date technologies with the latest scientific information and eager to put this to good effect.

CHAPTER 2

Between wars: 1919–1939

World War I had demonstrated the importance of science in seeking to gain technological advantage in warfare. The Australian government had been quick to appreciate this and to take advantage of its Empire links to foster the transfer of technologies from the United Kingdom to Australia. The return of peace provided the opportunity to consolidate and extend these initiatives. Defence science in Australia continued to be primarily identified with munitions production, but it also had wider implications. Indeed, during the period after World War I there developed a broader push to enhance the role of science in industry and agriculture. This led to the development of a second key research organisation, the Council for Scientific and Industrial Research that, for a time, also became involved in defence science.

Arthur Leighton, General Manager of the Commonwealth Arsenal, remained a zealot in the interest of science. He left England to return to Australia on 8 February 1919 after placing orders for plant and equipment for the various explosives and munitions factories and the research laboratories: John Jensen remained in England to manage issues associated with the arsenal. Leighton returned to Melbourne on 24 March 1919 after an absence of nearly four years and became chairman of the Board of Factory Administration, created on 1 September 1920.

At the government's request Leighton submitted a report on 27 May 1919 in which he reviewed the issue of munitions supply in Australia. He recommended the extension of existing Defence factories rather than proceeding with the Tuggeranong project. He also stressed the significance of science in the production of war materials and urged the enhancement of associated scientific laboratories. He wrote:

> *This section (the Research Department) is of primary importance and unless it is established on sound lines as regards staff and equipment, the manufacture of munitions in Australia will fail. A nucleus staff has been at work for some years in the Chemical Adviser's Department and has played an important part in securing supplies of satisfactory quality. It has been handicapped by want of accommodation and its present equipment is inadequate to meet demands. In its present rooms at Victoria Barracks the Department is cramped, and is a menace to the safety of adjoining buildings, and experimental work on the scale which is demanded by the needs of the Army and Navy is out of the question. I propose to build a laboratory that will be capable of dealing with the problems of manufacture and inspection that the Defence Department is called upon to face. The present staff is capable of dealing with all Chemical problems, but expansion both of staff and accommodation is required for the Metallurgical and Physical sections of Research. The Department has now in England five Australian University Graduates and the completion of their training will find us with a Research Staff capable of dealing soundly with all our problems of material and process.*[1]

‹ *Engineering workshop, early 1920s.*

The government accepted Leighton's recommendations towards the end of 1919, though demands for the scaling back of defence expenditure meant the timeframe for the proposed program was extended.[2]

The role of the Commonwealth Arsenal then became one of expanding and developing government defence factories. Those scientists who had worked and studied in England joined the staff of the Superintendent of Laboratories in the Research Department of the Department of Defence and came under the General Manager of the Commonwealth Arsenal in 1919.

Munitions Supply Board

Leighton's 1919 report recommended a new arrangement to oversee defence materiel production. The government accepted the recommendations and established the Munitions Supply Board as a statutory body on 13 August 1921. The Board assumed the responsibilities of the former Board of Factory Administration and comprised the same personnel, namely, Leighton as the Controller-General of Munitions Supply, Colonel Thomas John Thomas, the Financial Secretary of the Department of Defence, Mathew Michael Maguire, the Assistant Secretary of the Department of Defence, and Secretary John Jensen.[3] The statutory functions of the Board were:

(a) Provision of such armament, arms, ammunition, equipment, supplies and stores of all kinds as may be demanded by the responsible authorities and approved by the Minister;

(b) Research and design;

(c) Inspection and examination of supplies obtained in Australia other than food, forage and fuel supplies, up to the point of issue to the Service;

(d) Administration of manufacturing establishments established or to be established under Section 63 of the Act and placed under the control of the Minister of State for Defence.[4]

Leighton remained Controller-General of munitions supply from 1921 to November 1937.[5]

The agency previously called the Commonwealth Arsenal became known as the Munitions Supply Branch on 24 August 1921 when it became the administrative arm of the Munitions Supply Board and assumed control of the government factories from the Board of Factory Administration.[6] The Munitions Supply Branch within the Department of Defence comprised Chemical Engineering, General Engineering and Small Arms, with a supporting scientific support laboratory and inspection branch.

The objectives of the Board were:

(a) The establishment of scientific and technical staffs, with the necessary laboratory equipment, for the investigation, from the munitions stand-point, of the resources of Australia in the way of materials, and the study and development of manufacturing processes, so that in time of war there will be a centre from which such information can be rapidly distributed.

(b) The erection of factories for the production of articles of munitions either not obtainable from commercial sources or required in peace time in such small quantities as to render the encouragement of private enterprise uneconomical or undesirable.

(c) The preparation of a scheme for the organisation of the whole industry of the country in time of war.[7]

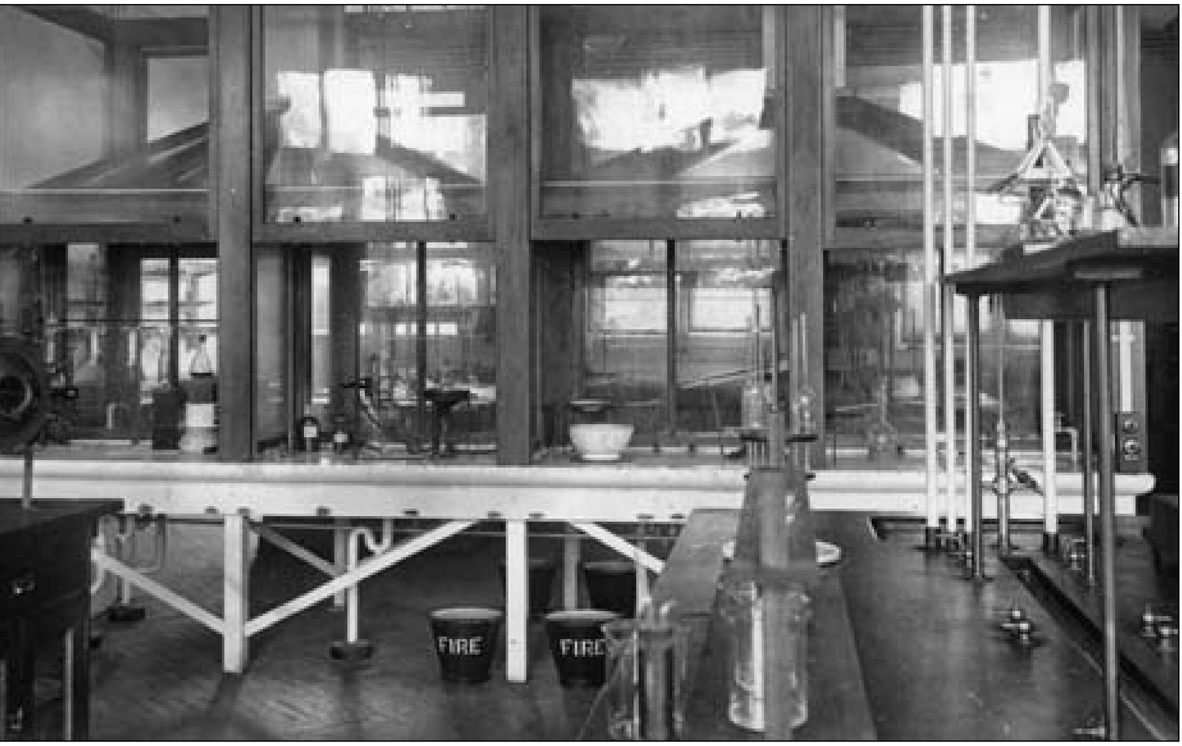
A feature of Leighton's 1919 report was a recommendation that the government should construct a new research laboratory equipped for chemical, physical and metallurgical work to help munitions factories and industry over initial technical difficulties in building a munitions industry and to ensure that production conformed with strict British military specifications.

The government concurred and called tenders for construction of the new laboratory on 10 June 1920. F.E. Shillabeer won the tender, and construction commenced on 20 August 1920 on a new purpose-built laboratory at Maribyrnong close to the cordite factory. Meanwhile, staff and equipment crowded into the one-time Chemical Adviser's Laboratory originally established in Victoria Barracks, Melbourne. The crowded conditions meant that William Jewell was temporarily located at the Lithgow Small Arms Factory and Clement Blazey at the Footscray Ammunition Factory, enabling both to gain first-hand understanding of issues with which they were to contend. The first of the scientific staff moved to their new facility early on 31 March 1922.

The new facilities at Maribyrnong permitted implementation of the more formal structure devised by Superintendent of Laboratories Marcus Bell in consultation with Leighton while in London. Blazey, Esserman and Jewell were made permanent employees in 1920 after their return to Australia and were already marked for senior positions. They were among those appointed to take charge of the five separate sections that formed the basis of the new organisation. The sections were Explosives managed by Robert Summers; General Chemical, Alfred Dawkins; Non-ferrous Metallurgy, Clement Blazey; Ferrous Metallurgy, William Jewell; and Physics, Norman Esserman. The several section heads reported initially through John McCormick the Assistant Superintendent. By 30 June 1922, permanent laboratory staff comprised a superintendent (Bell), an assistant superintendent (McCormick), four chemists, a physicist, three assistant chemists and a clerk: in addition there were temporary staff comprising an assistant physicist, an assistant chemist, a laboratory assistant and three clerks.[8]

The first task was to settle into the new laboratory and install the new equipment purchased in England by Leighton and Jensen. This had already been shipped to Australia and awaited completion of the buildings. Urgent family concerns meant that Norman Esserman sought 12 months leave of absence in April 1922. There was no other qualified physicist in the organisation. However, a young Eric Sayce, then working in the laboratory of the Footscray Ammunition Factory, had been identified as a scientist of potential and was considered qualified for the task; he was asked to report to the Maribyrnong laboratory. He supervised the installation of the equipment and had it completed when Esserman returned on 12 February 1923. Sayce remained and enjoyed a long career with the laboratory.[9]

The new facility comprised the main laboratory buildings with two small auxiliary buildings to house electrical controls and fan for the fume exhaust system. There was an acids and solvent store, another for pressure bar tests on explosives, chambers for climate storage of cordite and a locker magazine. In addition, there were two experimental timber-seasoning kilns.[10] The new



General chemical laboratory in the early 1920s.

facilities and staff meant the Maribyrnong laboratory was among the most sophisticated in the British Empire at the time.

The laboratory became an integral part of the Munitions Supply Board, with the research function being interpreted very liberally. The laboratory investigated issues faced by the Board's own factories, but also those of other industries engaged in defence production. It provided advice to the Naval, Military and Air Boards about storage and use of war materiel and instructed Service personnel in its the proper handling. In addition, the laboratory fulfilled a role as a repository of technical information with staff being made available to advise other government agencies.

The variety and quantity of work undertaken by staff was enhanced by the acquisition and installation of new equipment. While research work focused on explosives and chemicals used in the munitions industry it had become increasingly specialised and was undertaken in separate areas that concentrated on explosives and ammunition, general chemical, metallurgical, physical and scientific information.

During 1922 the laboratory undertook work for the Navy Department, the Air Board, Military branches, the Contract and Supply Board as well as inspecting material for the various factories. Results of much of the work of the scientists were recorded in a series of technical papers. For instance, 'A paper relating to Metallographic Testing of Steel, with particular application to rifle production has been prepared. The paper discusses the methods of examination of carbon steels and the interpretation of results of examination, with examples drawn from experience at the Small Arms Factory.'[11]

The functions of the laboratory, as outlined in 1923, were:

(a) to determine by experiment the procedure to be followed in adapting Australian raw material to the production of new munitions, and the subsequent maintenance of a proper standard of manufacture;

(b) to promote by investigation the production of Defence supplies by the civil industries; and

(c) to study the problems of modern munitions production especially in the two fields of high explosives and chemical warfare.[12]

Staff grew slowly from 17 in 1922 to 80 in 1937.[13]

The research laboratory became known as the Munitions Supply Board Research Laboratories in 1924[14] and undoubtedly comprised Australia's leading and largest dedicated research establishment. Meanwhile, the early idea of an Australian arsenal was essentially realised with the steady growth of the Maribyrnong munitions factory, the acquisition of the Colonial Ammunition Factory in 1927 and the establishment of an ordnance factory in 1928.[15]

Commonwealth Institute of Science and Industry

Applied science continued to be regarded as important within Australia's burgeoning munitions industries, but it became increasingly recognised for the contributions it could make to broader economic and industrial fields. This marked a significant shift in attitude towards science in Australia.

Traditionally, the teaching and acquisition of a broad education, rather than independent scientific research, had been the priority of tertiary teaching institutions in Great Britain and similar institutions in Australia prior to World War I. However, the growing economic strength of industrial nations such as the United States and Germany had demonstrated the benefits to be derived from harnessing, encouraging and coordinating applied scientific research.

The British government had already recognised this and established a Department of Scientific and Industrial Research in 1915 to direct scientific research in the interests of industrial development. The nationalist fervour associated with World War I prompted Prime Minister William 'Billy' Hughes to propose a similar organisation for Australia. His idea was to have a 'national laboratory' that would undertake and coordinate major research in support of agriculture and industry. An Advisory Council of Science and Industry was appointed in 1916 to prepare a plan and propose legislation. It comprised 20 members that included scientists and state and business representatives. The Science and Industry Bill went before Federal Parliament in September 1918, but suffered such opposition that it was withdrawn in 1919. The initiative failed to secure the support of the states and was not accompanied by significant funding for scientific research.[16]

Still, the idea survived. An amended Bill went before Parliament in 1920 and finally received Royal Assent. The Commonwealth Institute of Science and Industry was established in 1921 with the physicist and former Commonwealth statistician, Sir George Knibbs,[17] appointed director. Once again, a failure to establish a precise role for the organisation and match the initiative with additional scientific research funds meant it achieved little.[18]

Even so, the concept of a national scientific organisation persisted and gained a sense of purpose with endeavours to strengthen trade links within the British Empire and encourage Empire self-sufficiency following Imperial Conferences in 1920 and 1923. The United Kingdom established the Empire Marketing Board in 1926 with a budget that included provision for industrial research grants to be made available to research agencies within the Empire. The general Empire economic initiatives and the availability of access to research funds prompted Australia's Bruce-Page government to reorganise the Institute of Science and Industry and create a new organisation following passage of the Science and Industry Research Act in 1926. The new Council for Scientific and Industrial Research (CSIR), established on 22 June 1926, was to be a coordinating body working in association with state institutions.[19]

Prime Minister Stanley Bruce outlined the objectives of the new organisation when proposing the legislation, namely:

> *[N]ot to create a great new centralised institute of research, but, for the benefit of both the primary and secondary industries, to bring about co-operation between existing agencies and to enlist the aid of the pure scientist, the universities, and every other agency at present handling scientific questions.*[20]

The Council comprised nine members: an executive committee of three—Chairman George Julius,[21] a consulting engineer, inventor of the automatic totalisator and businessman; William Newbigin,[22] an engineering executive; and David Rivett, a physical chemist who was appointed chief executive officer and chairman of the six state committees.[23]

The Council's immediate work was to focus on research in agricultural and industrial areas, rather than that of defence. However, in 1926 Harold Patrick Breen,[24] the Council's assistant secretary, was commissioned to undertake a survey of Australia's potential for manufacturing armaments. The survey was never completed as envisaged, but sufficient data were gathered to indicate the potential for the Council to encompass defence issues as well. Indeed, the increasing likelihood of renewed war during the late 1930s led to Noel Brodbribb, a chemist, being appointed to update and complete the Breen survey in 1937. As a consequence, the government established the Advisory Board on Industrial Organisation in March 1938 under chairman Essington Lewis,[25] managing director of BHP from 1926 to 1938 and chief general manager to 1950. The committee agreed that 24 armament factories be established.

Defence Committee

Meanwhile, the government established a Defence Committee on 8 March 1929 comprising the chiefs of the three armed Services and the Secretary of the Department of Defence. Its functions were to advise the minister on defence policy as a whole; the coordination of the operations and requirements of the Naval, Military and Air Boards; the coordination of the operations of the Munitions Supply Board in relation to the requirements of the several Services; financial requirements of the defence policy and the allocation to the respective Services of the funds made available; coordination of civil aviation with defence requirements; and all matters of policy or of principle affecting the organisation and distribution of such Air Forces as may be established. It was charged with consulting the Controller-General of Munitions Supply on matters affecting the Munitions Supply Board, and the Controller of Civil Aviation over civil aviation issues. The functions and personnel of the committee were later enhanced, but its essential functions remained the same.[26]

The Munitions Supply Laboratories continued to be the Commonwealth's premier defence research facility. The laboratories broadened their scope in accordance with new demands made upon them. For instance, as an acknowledged expert in optics, Norman Esserman had oversight of the repair of optical instruments used by the Services and 'designed modifications of certain short-base range-finders, and worked on the problem of fitting graticules to binoculars'.[27]

The laboratories also became involved in the study of gas and anti-gas equipment during the 1920s because of concerns aroused by the use of gas during World War I. The Australian government believed it required an understanding of chemical warfare and established a Chemical Warfare Board in 1924 with Percival Weldon as its secretary. He was sent to England in 1927 to study the manufacture of respirators and, in 1929 soon after his return, a facility was established at the Munitions Supply Laboratories to study gas and anti-gas equipment. There was such a small call on industry for the manufacture of respirators that this was undertaken at the laboratories, initially by assembling respirators from products sourced from England and China.[28]

The broadening areas of research and an increase in munitions production during the 1930s put heavy demands on the laboratories and required a staff expansion from 34 in 1932 to 93 by 30 June 1938[29] and 192 only 12 months later: the latter figure included 17 women.[30]

Marcus Bell continued as superintendent of the laboratories until his sudden death on 3 June 1934 when he was succeeded by John McCormick, with Alfred Dawkins, formerly a head of the General Chemistry Division being promoted to Assistant Superintendent.[31]

As work expanded so too did the range of professional staff employed. The first scientists were chemists or physicists, but increasingly metallurgists and engineers were employed. All those recruited were university graduates or those holding approved diplomas that guaranteed a minimum academic qualification.

The academic standards of the laboratories were jealously guarded and fostered, with scientists keen to remain abreast of scientific trends overseas. Indeed, in 1921 Alfred Dawkins had been awarded an 1851 Exhibition Research Scholarship and was given 12 months leave without pay to study at University College, London, and afterwards to gather information on subjects referred to him by colleagues in Australia: he undertook special research into the radiological examination of war materiel. Dawkins was the first of a succession of scientists to broaden their experience in England in the period after World War I. Assistant Superintendent John McCormick followed from 1922 to 1924 to study metallurgical issues associated with the manufacture of 18-pounder ammunition and 'to make specific inquiries in certain directions and to acquaint himself with the latest development and advances of research in the production of war materiel.'[32] Percival Robert Weldon had leave from 1925 to 1927 to address issues associated with chemical defence. Eric Sayce followed from 1927 to 1929. There was a hiatus during the worst days of the Depression, but Ernest George Thurlby re-established the tradition from 1935 to 1936 when he visited England to study the metallurgy of materials used in gun production.[33]

The laboratories engaged in collaborative research from a very early period. From 1927 to 1931, for instance, they worked with the British Chemical Defence Research Department in evaluating a satisfactory rubber mix for gas masks. They also collaborated with the same British agency in an investigation of the stability of various types of bleaching powder for use in decontaminating areas affected by mustard gas.[34]

The laboratories underwent continual expansion and reorganisation under Leighton's general encouragement. For example, the heavy demands on Esserman's Physics section led to Leighton establishing a separate Metrology section on 1 September 1936. By arrangement with the Standards Association of Australia, the standards of length held at the laboratories were accepted as the national standards for Australia before the National Standards Laboratory was established in accordance with a Cabinet directive in 1938. Continuing industrial development in Australia meant there was a need to establish absolute standards of measurement to assist with the testing and accuracy of fine measurements. Eric Sayce took charge of this new section, and went on to become assistant superintendent of the laboratories from 1939 to 1952 after Norman Esserman left to become chief of the CSIR's Division of Metrology.[35] As many as 1100 tests were made in the year 1936–37 representing a 100 per cent increase on the previous year.

The laboratories' work focused on the needs of the Services but increasingly it undertook work for other government institutions and even industry, when consultant facilities were unavailable. The laboratories charged for these consulting works.

New demands were matched by new facilities. For example, a new laboratory for chemical defence work had been built and occupied in 1928. The following year another small building was completed for cordite preparation and testing, and an additional timber-seasoning kiln was built. A new airconditioned calorimetric laboratory was built and equipped in 1935 for the explosives and ammunition section. This permitted determination of the calorific value of new types of cordite to be conducted at the same time as their manufacture in the explosives factory.

By 1938 the laboratories had seven specialist sections - general chemistry, explosives and ammunition, timber, metallurgy, metrology, chemical defence, and physics (including optics and electrical). Examination of explosives remained a key role to ensure that samples conformed to Service specifications. The explosives and ammunition section conducted 1298 examinations in the 12 months to 30 June 1938. The metallurgy section carried out 1074 analyses and tests.

The physics section carried out as many as 4115 tests. The section also designed and built a machine for testing a batch of springs for the Civil Aviation Board. It reconditioned and repaired many varieties of optical instruments and conducted courses in optics for Army and Navy servicemen. The workshops also built other new equipment including a high temperature thermometer-testing bath, a canister-filling machine and equipment for conducting oxidation tests on lubricating oils.

Another section of the laboratories focused on research into Australian timbers and their suitability for Service requirements. Much of this research had direct applications within the broader timber industry and was warmly received by those involved. Associated research investigated insect attack on ammunition boxes and research into aircraft glues and the efficiency of bakelite varnish as a timber sealant.

The Chemical Defence section was involved with the assembly of anti-gas respirators and testing of components and various types of protective clothing. A new respirator assembly building was established in the late 1930s.[36]

In his report on the activities of the Munitions Supply Board to the end of June 1937, and perhaps with an eye to his retirement five months later, Leighton proclaimed 'the second stage of development of Munitions Supply in Australia is closed.' He explained, 'The first stage ended in 1918 at the termination of the war with a consciousness that the experiment, opened in 1908, whereby Australia undertook to manufacture some important types of munitions, had been successful and had been of material importance in the defence of the country.' The second stage, according to Leighton, began with his 1919 report and the efforts to establish the munitions supply organisation.[37]

The development of the Munitions Supply Board and its establishments, particularly the Munitions Supply Laboratories, meant that Australia was admirably placed to meet the military and industrial challenges of World War II. Noel Brodribb succeeded Leighton as Controller-General of Munitions Supply, and John Jensen, the Board's secretary since its inception, was appointed Controller of Munitions in 1937 and two years later became Assistant Secretary of the Departments of Supply and Munitions. These appointments ensured a continuity of policy.

CHAPTER 3

War and peace: 1939–1947

Science took on an enhanced role in the service of national defence during World War II. This was evident in Australia but even more so among the industrialised nations which saw a host of innovations including radar, jet propulsion, rocketry and the harnessing of nuclear energy.

While these innovations occurred overseas Australia became an industrialised nation as a consequence of the war, with rapid developments in the manufacture of machine and precision tools, largely to foster the war effort. Much of the push was in the area of science, with the CSIR becoming a major centre of defence science. The venture of the CSIR into defence science occurred primarily because the Australian armed Services—unlike their counterparts in the United Kingdom—had no culture of science. Meanwhile Australian scientists continued to work within the Department of Defence and in the production of chemicals required for the expanded munitions industry.

Department of Supply and Development

There occurred a major change in administrative arrangements in 1939—Jensen considered it 'a turning point' in the history of Australia's munitions industry—when significant defence agencies, including the Munitions Supply Laboratories under John McCormick, ceased to be part of the Department of Defence and were transferred to a new Department of Supply and Development established on 26 April 1939, though it did not begin operations until 17 June 1939 following Royal Assent to the Supply and Development Act.[1] This arrangement followed the British example of having defence support industries in a separate Ministry of Supply.

Optical glass blanks being shaped for preparing lenses and prisms, c.1947.

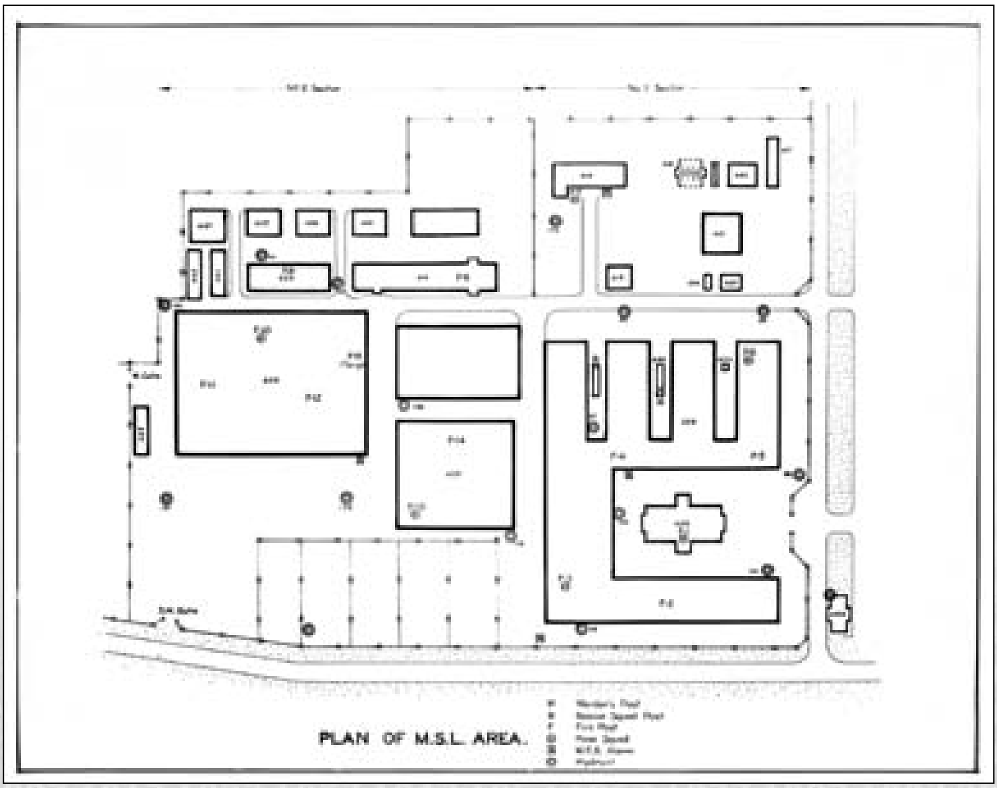
Other Department of Defence agencies transferred to the new Department of Supply and Development included the Drawing Office, the Ordnance Factory managed by Maurice Michael O'Loughlin, the Explosives Factory (Arthur Topp), the Ammunition Factory (James Harold Wrigley), Small Arms Factory (Arthur Samuel Ford) and the Clothing Factory at South Melbourne.[2] The Explosives Factory, Ordnance Factory and the Munitions Supply Laboratories were all at Maribyrnong. The latter included the Chemical Defence Equipment Laboratory and the Artillery Instrument and Optical Equipment Factory.[3] Aircraft production also became a responsibility of the new department—until June 1941.

‹ Women staff in the metallurgy section, Munitions Supply Laboratories.

Soon afterwards, when separate departments of the Navy, Army and Air Force were established in November 1939, the Department of Defence was renamed the Department of Defence Coordination, though it reverted to the Department of Defence in April 1942.

Arthur Leighton had retired as Controller-General of Munitions Supply and Chairman of the Munitions Supply Board on 1 November 1937 under regulations concerning his age, though he was appointed a consultative member of the Board the following day. Noel Brodribb, Chief Chemical Engineer in the Department of Defence and Manager of the Ordnance Factory from 1921, succeeded him as Controller-General of Munitions and Chairman of the board after recently returning from 16 months in England studying developments in munitions production.[4] Michael O'Loughlin, previously Works Manager of the Ordnance Factory, succeeded Brodribb as manager of the factory from 11 November 1937.

Leighton, though officially retired, continued to provide valuable service and innovative science in the areas of defence. He served briefly as Controller-General again from May 1938 to June 1939 while Brodribb undertook special duties as Inspector-General of Works and Supplies in the Department of Defence. In 1940 Essington Lewis, Director-General of Munitions, appointed him as a consultant on explosives and gave him charge of all explosives factories and others producing chemicals, and authority to liaise with those in the chemical industry. His original research led to the use of fibres from *pinus radiata* in the manufacture of cordite in place of imported cotton, thereby making the country more self-sufficient. He also introduced a wet process for making cordite that was safer than the accepted dry process; and he supervised the search for an alternative source of glycerine using sugar as the raw material.[5] Leighton continued in this consultancy role until 1946.



Munitions Supply Laboratories, Maribyrnong, site plan, pre-1948.

Wartime respirator manufactured at Munitions Supply Laboratories, 1940.

Organisational re-arrangements continued. A Department of Munitions was separated from the Department of Supply and Development on 15 June 1940 to take responsibility for munitions, aircraft production and all Commonwealth factories other than the clothing factory, while the Department of Supply and Development retained responsibility for filling all other government needs. A separate unit, formed within the Department of Munitions, became an independent Department of Aircraft Production established in June 1941.[6]

These reorganisations led to the Department of Supply and Development becoming responsible for shipping administration on 17 October 1942 when it was renamed Department of Supply and Shipping. By 1943 the government had 49 Commonwealth factories providing munitions and government laboratories employing more than 1000 scientists.

The Munitions Supply Laboratories continued to play an important role during this period. This was reflected in staff numbers that grew from 80 in 1937 to 200 in 1939 to peak at 934 in 1944. Demands on staff increased greatly.

By the time World War II had been declared, scientists at the Munitions Supply Laboratories at Maribyrnong were well advanced in developing an Australian respirator. Indeed, more than half a million respirators were manufactured at Maribyrnong in six months in 1940. In all, more than 500 people were employed at Maribyrnong and some 750,000 respirators were manufactured from locally sourced materials before the project was shut down by mid-1944. Gas warfare never became a reality during World War II but it was imperative from a government point of view that precautions were taken to protect its citizens.[7]

The Munitions Supply Laboratories at Maribyrnong played a major role in pioneering the optical glass industry in Australia after establishing glass-making facilities to manufacture lens assemblies in 1938. Indeed, it was the only organisation in Australia possessing any skills in optical technology at the outbreak of World War II. Prior to this time, any optical equipment needed to provide optical sighting for defence weapons manufactured in Australia had been imported from Britain. However, supplies from Britain ceased once the Germans triumphed in France and the Battle of Britain began. Australia found itself in dire circumstances in providing optics for its expanding wartime munitions manufacture. The country had no industry manufacturing optical equipment or even any local supply of optical quality glass, apart from the Munitions Supply Laboratories that was by then engaged in some instrument design. Joseph Frederick McNeil had been sent to England for training and had been able to send back information and recruits. Following his return in early 1941 he became head of the optics laboratory and able to provide expert ‘advice on and actual design of optical systems’.

Establishing an optics industry had become a priority. In June 1940 Laurence Hartnett, Managing Director of General Motors Holden and appointed by Prime Minister Robert Menzies as Director of Ordnance Production in the Munitions Department (1940–45), called a meeting to discuss production of optical sighting equipment in Australia. Eric Sayce and H.J. (Jim) Frost of the Munitions Supply Laboratories were two of those invited to attend. As a result of that meeting, the Optical Munitions Panel was established to assist in creating an optics industry, with Sayce becoming a member of the Panel.

Despite enormous challenges, the Optical Instruments and Munitions Panel succeeded in its endeavours through the collaborations of the Munitions Supply Laboratories, the Physics Departments of the Universities of Melbourne, Sydney, Adelaide, Hobart and Western Australia, and the Commonwealth Solar Observatory. The Munitions Supply Laboratories developed Australia's best equipped optics laboratory and workshop and played a leading role in the war effort as John Wisdom noted:

> *The scope of expert support provided by the Laboratories staff including actual creative design, was wide ranging. They provided advice to inexperienced firms contracted by the Ordnance Production Directorate; they experimented on improved means of producing the mechanical components of optical systems such as substituting die-castings for fabricated steel components; they evolved production procedures for lenses, prisms and mirrors and produced complex equipments; they carried out initial assemblies of newly produced components at the prototype stage; they simplified designs and assessed the merits of alternative solutions to new optical munitions requirements; they tested submitted equipments both before and after production was approved and generally provided that essential lubricant without which the wheels of the optical industry could not turn.*[8]

As many as 43 different types of optical instruments—numbering more than 26,000 individual objects—were made for the war effort in Australia. At war's end, however, the government decided that an optical industry was not viable and withdrew its support despite the enormous industrial and scientific successes achieved. Still, some optical research continued in universities, the CSIR and the Munitions Supply Laboratories. The skills acquired by staff at the Munitions Supply Laboratories provided a foundation for the metrology work that continued, for optical work associated with the later Anglo-Australian Joint Project in South Australia, and for important work associated with laser research that commenced in the early 1960s.[9]

Demands on the Munitions Supply Laboratories grew with the proliferation of explosives and munitions factories, several of them beyond Victoria. Consequently, Joseph Frederick McNeil was called upon to establish the Explosives and Ammunition Section of the New South Wales branch of the Munitions Supply Laboratories at the Villawood Explosives Factory and at Lidcombe in 1942. The laboratory transferred to Alexandria in 1947.

The period of World War II witnessed major technological developments in Australia that were reflected in the functions of the laboratories. By 1948 the functions included investigation of manufacturing processes, investigations relating to Service stores and equipment, maintenance of accuracy of instruments used to control the manufacture of munitions and aircraft, analysis and testing of conformity with specifications, preparation of specifications,

Senior staff, Munitions Supply Laboratories, 1947. Standing (L-R): Ernest Thurlby, Jim Frost, W.J. Wark, A.J. Roennfeldt, E.A. Goode. Seated (L-R): Eric Sayce, Alfred Dawkins, John McCormick, Percival Weldon, Robert Summers.

Entrance to Munitions Supply Laboratories,1946.

Workers in the metallurgy section, Munitions Supply Laboratories, c. 1942.

design and construction of instruments for laboratory and Service use, plus long-term and fundamental research on such subjects as the functioning of explosives, the mechanical properties of metals and design of optical systems.

Council for Scientific and Industrial Research

Defence science was no longer the sole province of the Munitions Supply Laboratories once the CSIR established a Division of Aeronautics in 1939 and began aeronautical research at Fishermans Bend.

The government had established an aircraft factory in Melbourne in 1936 as part of an endeavour to increase local production of motor engines and to foster industrial technology. The need for the backing of scientific research became evident and a CSIR report completed in February 1937 recommended the building of facilities for aircraft and engine testing and complementary research laboratories to support aircraft and engine manufacture in Australia. Soon afterwards, the government invited Henry Egerton Wimperis, the retiring Director of Scientific Research for the British Air Ministry, to make suitable recommendations to enable Australia to embark on aeronautical research. He submitted his report to Parliament on 21 December 1937. In addition to recommending the creation of an aeronautical research facility, he recommended the establishment of a Chair of Aeronautics at the University of Sydney and the formation of an Australian Advisory Committee on Aeronautics. The government acted upon the report and acquired a 10-hectare site at Fishermans Bend in suburban Melbourne, close to the Commonwealth Aircraft Corporation, for the laboratory.

The research laboratory came into existence on 26 January 1939 when the CSIR established its Division of Aeronautics and appointed Lawrence Percival Coombes as its chief. Coombes, born on 9 April 1899 in Madras, India, had been educated in England and interrupted engineering studies at the University of London to serve as a fighter pilot in World War I. He completed his engineering degree after the war and, four years later, as a graduate apprentice and engineer, joined the Royal Aircraft Establishment at Farnborough. He became a scientific officer in 1925 with the Marine Aircraft Establishment at Felixstowe where he engaged in research on seaplanes and flying boats. He had returned to Farnborough when he applied for the Melbourne position.

Coombes succeeded in gathering a team of competent people for the laboratory. They included Howard Arthur Wills, Dr G.N. Patterson, Dr M.W. (Don) Woods, Thomas Fulton Coleman Lawrence, John B. (Jack) Dance, and David Walter Eaton. All were to play major roles in the development of aeronautical science in Australia.

The early laboratory work was to concentrate on aircraft design, structures, materials and power plants and Coombes proposed four key sections, Aerodynamics, Structures and Materials, Engines and Fuels, and Instruments, with supporting sections.[10]

Lawrence Percival Coombes, first chief of Division of Aeronautics, 1939-49 and superintendent of Aeronautical Research Laboratories, 1949–1964.

Building work commenced at Fishermans Bend in August 1939, only a month before the beginning of World War II. The first buildings were occupied in April 1940, with nine professional officers and seven support staff working there.[11]

Early work was hampered by difficulty in obtaining equipment ordered from overseas, though scientists were able to use the University of Melbourne wind tunnel, and metallurgical research was undertaken in the Munitions Supply Laboratories. Nevertheless, fatigue testing machines were installed in 1941 and an engine test plant in June the same year. Early work was associated with addressing problems in the embryonic aircraft manufacturing industry.[12]

Tom Lawrence, one of the first recruits, played a major part in the design and construction of the wind tunnel that became fundamental to much of the laboratory's early work. He had been born at Yass, New South Wales, on 26 November 1915 and had completed his schooling at Sydney Boys' High School before proceeding to Sydney University where he obtained a BSc in 1935, and first class honours in Civil Engineering in 1937. Even then he was interested in aeronautics and took courses in Fluid Mechanics. While still a student he entered a Citizens Air Force Flying Training Course and was commissioned as a Pilot Officer. After graduating he registered his interest in a job with the University Appointments Board in the field of aeronautics and immediately received a job offer as an assistant research officer in the engineering school at Melbourne University, where he spent time designing a wind tunnel to replace the Eiffel Type open return wind tunnel. From here he joined the CSIR Division of Aeronautics on 1 January 1940.[13] The new wind tunnel began operating on 5 December 1941, only two days before the Japanese attack on Pearl Harbor in Hawaii.[14] In 1944 Lawrence spent a year in research at Sydney University in the School of Aeronautical Engineering and in 1945 became Acting Head of the Aerodynamics Section of the Division of Aeronautics.

CSIR involvement in the physical sciences broadened because of war demands. It became involved in a variety of projects allied to aerodynamic studies such as the study of airflow for dehydrating food, structural analyses of elevated water tanks and ventilating fans in mines and factories. Indeed, the laboratory developed expertise in fan design.[15] Far more important, however, was its involvement in the local development of radar, which involved scientists at the leading edge of technology and greatly enhanced CSIR's reputation.[16] The laboratory was fully committed to defence projects as the war drew to a close.[17]

Salisbury Explosives Factory

The demands of war had repercussions throughout Australia, with the need to manufacture and supply munitions for its armed forces affecting Australians long before the Japanese entered the war in late 1941. The work of the Munitions Supply Laboratories increased as additional munitions factories were built because of increased demands for explosives and munitions. The Maribyrnong factory could not be expanded to meet the increased demand, so a factory was built at Albion in Victoria in 1939 for the mass production of trinitrotoluene and cordite used to manufacture explosive components, stabiliser carbamate and small quantities of fuse powders. Another explosives factory opened at Ballarat in October 1941. Others were established at Villawood (1941) near Sydney and at Mulwala on 1 December 1943. Munitions factories were also established at Finsbury and Hendon in South Australia along with a major explosives factory at Salisbury.

Above and below: Women working at the Salisbury Explosives Factory on the production of munitions, early 1940s.

Premier Sir Thomas Playford, ever eager to secure new industry for South Australia, lobbied intensely for the complex to be built near Adelaide and offered the Federal government numerous incentives to do so, including provision of land, water, roads and other services. Immediately following the Federal government decision in June 1940 to build the factory at Salisbury, upwards of 2023 hectares of farmland were acquired for the purpose—1486 hectares for the factory and 531 hectares for magazines. Construction began on the factory in November 1940. It was a remarkable endeavour and the largest building project undertaken in South Australia to that time. When completed, the complex included as many as 1405 buildings in the factory areas and 95 in the magazine areas. In order to service these buildings 66 kilometres of roads, 55 kilometres of gritless cleanways for moving explosive materials between buildings, and 21 kilometres of railways were constructed. The complex was operational within 12 months of the commencement of site works, with production commencing in the Percussion Cap Section in November 1941: production had begun in all sections except the Pyrotechnic Section during the first half of 1942.

Once the complex was completed it provided work for as many as 6400 people in early 1943 with three shifts ensuring work was undertaken continuously. This was a remarkable achievement given the necessity for recruiting and training a virtual army of staff, from managers, chemists, engineers and production supervisors to foremen and process workers: only 12 of the 116 technical and management staff had had experience in explosives and ammunition filling prior to September 1939. The size of the labour pool in Adelaide meant there was always a difficulty in recruiting sufficient labour as production at the factory increased, and it was essentially for this reason that later factories were built at Villawood and St Marys in New South Wales, close to sources of labour, although less preferable for strategic reasons.

Aerial view of the Salisbury Explosives Factory looking to the south. The main Adelaide-Gawler railway line is to the far left.

The production of explosives peaked in March 1943 though continued until August 1945 when hostilities ceased. Soon afterwards the factory was downgraded to a 'care and maintenance' footing with only 300 people remaining to clean and decontaminate the site. The science undertaken on the site during the war was simply that required to ensure the specified quality of chemicals used and explosives produced. However, afterwards it became the site of much of Australia's most innovative defence science.

Anglo-Australian Joint Project

Defence science in Australia took a monumental step forward after World War II with the inauguration of the Anglo-Australian Joint Project for the development of guided weapons. Indeed, Alan Butement—later Chief Scientist in the Department of Supply—believed 'Defence Science really commenced in Australia following the agreement by Cabinet in November, 1946, to set up a joint United Kingdom-Australian Long Range Weapons Organisation.'[18] This Joint Project became the basis for the third of the three key defence science establishments that were to form the core of the Australian Defence Scientific Service: it was the one most exclusively focused on defence issues at the time.

Central to the project was the need for a land proving range. Canada and Australia were the only two British Empire countries with sufficient territory for such a range, 1600 kilometres long and 300 kilometres wide at the target. Inspection of alternatives early in 1946 suggested that a strip of arid land north-west of Mount Eba Station in South Australia was suitable as a rocket range for testing long range weapons. Having determined the location of the range, the one-time explosives factory at Salisbury was offered as a potential technical establishment base. It was readily adapted for the new use that was to bring huge benefits to Australia for the following 30 years and helped South Australia become a centre of high technology research and development.

The Joint Project Agreement was formalised on 1 April 1947, and the first of the Joint Project staff took up residence on the Salisbury site, beginning preparatory work on the project that year. Thereafter that part of the complex that formed the southeastern portion of the original factory, and which was required for the guided weapons project, became known as the Long Range Weapons Establishment. It was formally transferred to the Joint Project on 29 March 1949.


Albert Percival Rowe.

The Long Range Weapons Establishment, under the direction of Chief Scientist Albert Percival Rowe[19] consisted of three units: the Long Range Weapons Organisation, Salisbury, where the laboratories and administration were headquartered; the Long Range Weapons Organisation Range, Woomera, where tests were to be conducted; and the Long Range Weapons Organisation Air Component, based at the wartime aerodrome at Mallala, 60 kilometres north of Adelaide, which provided air transport between Adelaide and Woomera.

Albert Percival Rowe had been born on 23 March 1898 at Launceston, Cornwall, England. He had attended the Portsmouth Dockyard School and studied physics at the Imperial College of Science and Technology at the University of London from where he graduated with a BSc Hons in 1922. That year he was appointed scientific officer under Henry Egerton Wimperis at the Air Ministry Research Laboratory where he worked on aerial navigation problems and effects of underwater explosions on ship structures. At the same time he undertook a postgraduate course in aerodynamics under Leonard Bairstow. In 1924, Wimperis was appointed first Director of Scientific Research to the Air Ministry and took Rowe with him to headquarters. He joined a defence science unit of the Air Ministry, and lectured part time (1927–37) at the Imperial College of Science and Technology.

From 1935 Rowe was secretary of the Committee for the Scientific Survey of Air Defence which had the task of evaluating research in radio direction finding. In 1938 he succeeded Sir Robert Watson-Watt as head of the Radar Research Station at Bawdsey, though he had no specific acquaintance with radar. From 1938 to October 1945 Rowe was Chief Superintendent of what, from 1941, was known as the Telecommunications Research Establishment. Rowe was appointed a Commander of the British Empire in 1942. From October 1945 to October 1946 he was responsible to the Controller of the Navy for all research and development carried out under Admiralty control and was Scientific Adviser to the Board of Admiralty, though was forced to resign from these positions because of ill health. In October 1946 he joined the Ministry of Supply as Chief Scientific Officer, Long Range Weapons Research Organisation Australia, with the idea that the climate would be conducive to his health.[20]

Early administrative responsibility for the Joint Project was complex. Australian responsibility was ultimately invested in Cabinet, but exercised through the Departments of Defence and Munitions. Overall direction was provided by the Combined United Kingdom-Australia Committee that convened in London: local administration was exercised by the Long Range Weapons Board of Administration that met in Melbourne and was initially chaired by Noel Brodribb, the Controller-General of the Department of Munitions. The Department of Munitions with which the Department of Aircraft Production had amalgamated, was absorbed into that of the newly reconstituted Department of Supply and Development on 6 April 1948 and meant that that department became ultimately responsible for day-to-day administration. The several units at Salisbury became part of a single Long Range Weapons Establishment in October 1948.[21]

Those associated with the Joint Project were able to adapt the many factory buildings at Salisbury to the new use with a minimum of alteration. The large number and size of the many process buildings meant they were readily adapted to new uses as offices, laboratories and workshops. Consequently, no significant new buildings were required for project purposes until 1952 when a contract was signed for the construction of a wind tunnel.

Young Australian scientists experienced a boom time, comparable to the period during World War I when their predecessors gained postgraduate training in England. The Joint Project recruited virtually as many young graduate scientists as were available and sent them to England for induction and training. George Barlow was typical. He had been born in Melbourne and educated at Wesley College and the University of Melbourne where he graduated with a BSc in 1944 and an MSc in physics in 1947. He responded to a call for science graduates for the Joint Project in 1947 and was one of the first group of 16 to be sent by flying boat to Britain in 1948 for training. Barlow was first posted to the Guided Weapons Department of the Royal Aircraft Establishment at Farnborough where he formed part of a research team developing and designing analogue computer circuits. He later spent several months at the Telecommunications Research Establishment at Malvern, Worcestershire, and at Cambridge and Manchester universities studying digital computing. When he returned to Australia in August 1950 he joined the Long Range Weapons Establishment at Salisbury where became involved in designing automatic equipment for guided missiles.[22]

Scientific Advisory Committee

Meanwhile, the lessons drawn from the conduct of the war and the inauguration of the Joint Project highlighted the need for coordinated advice to government on defence science. Consequently, on 18 December 1945, the War Cabinet approved the creation of a Scientific Advisory Committee as part of the higher machinery of the Defence Department. Prime Minister Joseph Benjamin Chifley announced the decision two days later and charged the Defence Committee, in conjunction with Sir David Rivett, Chairman of the CSIR, and Noel Brodribb, Controller-General of Munitions Supply, to make recommendations relating to the constitution and detailed functions of the new committee.

The functions of the committee were broadly to advise the Defence Committee and Chiefs of Staff Committee on the scientific aspects of defence policy, including the scientific and research needs and activities of the Service and Supply groups of the department and to monitor scientific developments having either direct or indirect bearing upon national defence.[23]

The committee was appointed on 31 July 1947 under Chairman Albert Percival Rowe who became full-time Defence Scientific Adviser, on loan from the United Kingdom Ministry of Supply. His appointment followed the recommendation of Sir Henry Tizard, Chairman of the Defence Science Policy Committee in the United Kingdom, and the negotiation of a 12-month loan of Rowe from the United Kingdom Ministry of Supply.

Other committee members were Dr Frederick William George White, Executive Officer, Council for Scientific and Industrial Research; Professor Leslie H. Martin, Professor of Physics, University of Melbourne; Professor Ernst Johannes Hartung, Professor of Chemistry, University of Melbourne; Professor Arthur Veryan Stephens, Professor of Aeronautical Engineering, University of Sydney; and Professor Frank Macfarlane Burnet, Director, Walter and Eliza Hall Institute of Research in Pathology and Medicine.

Rowe was essentially the predecessor of what became the Chief Defence Scientist, but his tenure was brief. He resigned his position with the Joint Project and as Defence Scientific Adviser from 30 April 1948 to become the first full-time vice-chancellor of the University of Adelaide. He retired from this position on 1 May 1958 and returned to England where he died on 25 May 1976.

The inaugural committee achieved little, and Rowe's tenure as chair was tempestuous. During the course of his tenure he criticised the Prime Minister, the Minister for Defence, the chiefs of staff and Services, the permanent head, the CSIR, members of the Defence Scientific Advisory Committee and the chairman of the New Weapons and Equipment Development Committee, indeed all with whom he had to deal. Each of his criticisms was rebuffed and he in turn was criticised by others. Sir Ben Lockspeiser, Chief Scientist of the British Ministry of Supply, described Rowe as 'a supreme egotist' and was quoted as saying he:

> *[W]as surprised at Mr. Rowe's selection by Sir David Rivett for this reason as Mr. Rowe is an administrator of a scientific establishment or Vice Chancellor of a University, rather than a scientist with high qualifications … we would never get anything out of Mr. Rowe in the solution of scientific problems, as he did not possess the requisite scientific ability. At the Telecommunications Research Establishment at Malvern, at which Mr. Rowe was the administrative head, the work was done by a team of very able scientists.*[24]

After Rowe's resignation, the Defence Research and Development Policy Committee that had been established on 12 November 1948 assumed the Defence Scientific Advisory Committee functions, as well as those of the New Weapons and Equipment Development Committee that had been responsible to the Defence Committee. The new committee's functions were 'to advise the Defence Committee on matters connected with the formulation of scientific policy in the defence field, including the machinery and major projects for research and development'.

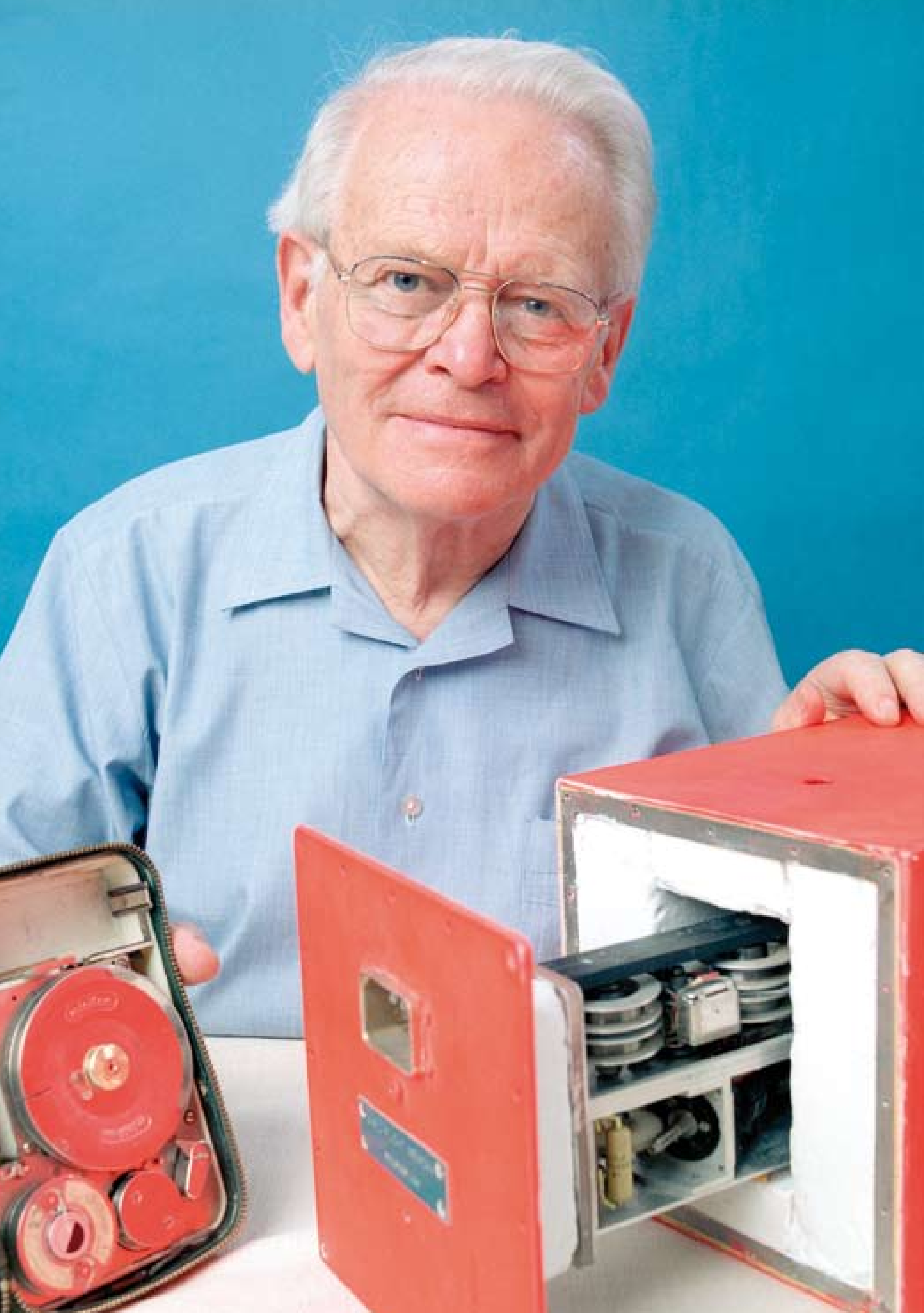
The government sought a successor for Rowe, and advice on the matter from Sir Henry Tizard in the United Kingdom. The government's wish was to appoint an Australian to the position, though there was general agreement that there was none suited to the position in a full-time capacity. Moreover, 'in view of the great importance of developments in atomic warfare, it is considered that a physicist would be the most suitable appointee.'[25]

Pioneer scientists associated with the Anglo-Australian Joint Project being welcomed in Melbourne by Brigadier Coffey, March 1947. L-R: Alan Butement, Chuck Bayly, John Caddy, Brigadier Coffey, Robert Pye, N.H. Fresson, Sidney Hunwicks.

Professor Leslie Harold Martin succeeded Rowe as Defence Scientific Adviser and Chairman of the Defence Research and Development Policy Committee on 12 November 1948, though he took on the role of Defence Scientific Adviser in a part-time capacity only. Leslie Martin had been born on 21 December 1900 in Melbourne and educated at the University of Melbourne where he graduated with BSc in 1921 and MSc in 1923. He obtained an 1851 Exhibition Scholarship and a Rockefeller Fellowship that enabled him to undertake further study at the Cavendish Laboratory, Cambridge where he completed a PhD in 1927. He returned to Australia as Senior Lecturer in Natural Philosophy at the University of Melbourne from 1927 to 1937, was Associate Professor from 1937 to 1945 and Professor of Physics from 1945.

Other members of the inaugural Defence Research and Development Policy Committee were: Major-General Leslie Ellis Beavis, Department of Defence representative; Captain Galfrey George Ormond Gatacre, Deputy Chief of the Naval Staff; Lieutenant-General Sydney Fairbairn Rowell, Vice Chief of the General Staff; Air Commodore Frederick Rudolph William Scherger, Deputy Chief of the Air Staff; William Alan Butement, Chief Scientist, Department of Supply and Development; Noel Brodribb, Controller-General of Munitions Supply; Professor Frank Macfarlane Burnet, Biological Scientist; and Professor Ernst Johannes Hartung, Physical Scientist. The Committee could co-opt other members as required. By 1950, it had sub-committees responsible for armament, atomic warfare, chemical and biological warfare, clothing and general stores, engineer equipment, food research, medical research, and telecommunications.[26] Its purpose was 'to advise the Defence Committee on matters connected with the formulation of scientific policy in the Defence field, including the machinery and major projects for research and development.'[27]

Developments during World War II had ensured that Australia had become an industrial nation with a diversified science base to sustain new technologies in many fields. Inauguration of the Joint Project, migration to Australia of experienced British defence scientists and training of young Australian scientists in England ensured that Australian defence scientists were at the forefront of scientific endeavour and at the beginning of an extended period of immense scientific achievement.



CHAPTER 4

Blue skies: 1950s

The end of World War II marked the beginning of the so-called Cold War and the uneasy balance of power between the western and Soviet Union political blocs. Stability, precarious at times, was maintained by the mutual possession of nuclear weapons and the means of delivering them over long distances. Striving for and maintaining a strategic advantage remained paramount.

It was a time when nations lived in fear of the proliferation of atom and hydrogen bombs. Defence Scientific Adviser Sir Leslie Martin was quoted in the *Melbourne Herald*, of 29 March 1954, as being worried about the hydrogen bomb. 'Professor Martin said he began to get "a bit worried" after reading a report by the chairman of the Joint Congressional Atomic Energy Commission, Mr Cole, on the first H-bomb explosion in November 1952.'

The great power rivalry led governments to go to extraordinary lengths to safeguard information about the work of their own scientists while seeking to learn about their opponents. Nevertheless, a measure of trust was required among allies to permit the sharing of information of strategic value in accordance with stringent agreements. This introduced the notion of strict security for scientists working within the defence industry. These Cold War suspicions and the heightened need for security in defence matters led to restructuring of the CSIR and the transfer of its Division of Aeronautics on 10 February 1949 to the Department of Supply where it became the Aeronautical Research Laboratories (ARL), with the former sections being known as divisions.

View of the engineering workshops, Defence Standards Laboratories, Maribyrnong, mid-1950s.

David Rivett, director of the CSIR, had always remained a 'pure scientist', wedded to the idea of scientific autonomy, and consistently fought pressures to impose secrecy and greater security measures within his organisation. He constantly championed the need for his scientists to undertake their work without political restraint. Indeed, when the plans for the Long Range Weapons project were incubating he had flatly refused to make available the radiophysics laboratory at Sydney University or to have CSIR undertake any military work whatsoever.[1]

Rivett's attitude apparently aroused suspicions among British agencies and raised the spectre of the United States excluding Australia from information exchange, particularly any concerning atomic research, thereby compromising research under the Joint Project. Rowe, as Chairman of the Scientific Advisory Committee, certainly raised the issue of an apparent lack of

‹ Dr David Warren with prototype of black box flight recorder.

trust the defence agencies in the United Kingdom and the United States felt towards the CSIR. He wrote of Rivett:

> *I like Rivett and I think most people do. I was however, given the job of starting your defence science organisation; I found a serious obstacle, and I brought the existence of this obstacle to the notice of those concerned, i.e. the Defence Department and the Defence Committee. It was most unpalatable to criticise a scientific colleague, but it had to be done in the interests of the job. I had to make it clear that the world regards Rivett as No.1 Australian Government scientist and that, in these difficult times, his declared view on secrecy—or perhaps it is better to say the Anglo–Saxon world's interpretation of them—are incompatible with his position unless it is known to all that C.S.I.R. holds no secrets. It now holds loads of secret documents.*[2]

Others believed Rowe's comments were exaggerated, but the government addressed the issue by divesting the CSIR of defence related research—namely the Division of Aeronautics—and transferring it to the Department of Supply and Development and bringing the division's scientists under the provisions of the Public Service Act. Enabling legislation went before Parliament in March 1949, passed quickly, and was proclaimed on 19 May 1949, establishing the new Commonwealth Scientific and Industrial Research Organisation (CSIRO). The new arrangements enabled the bulk of CSIRO scientists to focus on agricultural and industrial research and continue to exercise scientific freedom and free inquiry. Rivett could not support the changes and retired before the new legislation was proclaimed.[3]

In the meantime, the secrecy debate had an impact on the early careers of the group of young Australian scientists recruited in 1949 to become part of the Joint Project team and sent to England for training. They were not permitted to train in the same defence establishments as their predecessors. Instead they trained at other research institutions, and on return to Australia joined research establishments in Melbourne rather than the Joint Project.[4] The secrecy issue was soon resolved and many of these scientists later became involved in Joint Project work.

The CSIR's divestment of the Division of Aeronautics research brought all Australian defence science activities within the Commonwealth public service and the Department of Supply and Development, with appropriate secrecy provisions. It also represented the first consolidation of Australian defence research and development activities under one manager, William Alan Stewart Butement. A member of the Defence Research and Development Policy Committee, Butement had been Rowe's deputy in the Joint Project and succeeded him as Chief Scientific Officer and Chief Superintendent of the Long Range Weapons Establishment in 1947. Butement was later appointed to the new position of Chief Scientist within the Department of Supply and Development that was created on 14 April 1949.[5]

Butement—'Butey' as he was affectionately called by friends and colleagues—was originally a New Zealander, born at Masterton on 18 August 1904, but moved with his family in 1912 to Sydney where he lived briefly before his father, a doctor, relocated to England so he could enlist in the armed Services. Young Butement completed his schooling in England and proceeded to University College, London, where he completed his BSc in 1926. He joined the British War Office's Signals Experimental Establishment at Woolwich in 1928. There he engaged in radar research and, with a colleague, is credited with being the first—in the United Kingdom, at least—to demonstrate the feasibility of radar. Later research gained him credit for development of switched beam radar that improved radar accuracy. He remained at Woolwich until 1938 when he took the position of Senior Scientific Officer at the Bawdsey Research Station in Christchurch, Hampshire where he continued his radar research, working with Robert Watson-Watt, Henry Tizard and W. Eastwood. He later worked on the development of a radio fuse that combined a receiver, transmitter and aerial that could be enclosed in the nose of a shell and detonate when close to an aircraft, thereby greatly increasing the shell's effectiveness. The device was a major contribution to the war effort and an American company that produced the fuse garnered a fortune, but neither Butement nor the United Kingdom profited because the United Kingdom had traded British intellectual property for 24 American destroyers under lend-lease arrangements. In 1946 Butement became Assistant Director of Scientific Research in the unit formed by Lieutenant-General John Evetts who was charged with planning for the Joint Project in Australia. He returned to Australia in 1947 to assist with setting up the Long Range Weapons Establishment at Salisbury, South Australia.[6]

Australian research

The rapid build-up of scientific personnel at Salisbury was assisted by the decision of the Australian government in December 1948 to adopt a policy of having Australian scientists undertake independent defence research and development in association with the work being conducted under the Joint Project arrangements at the Long Range Weapons Establishment in Salisbury.[7] This followed a recommendation of Sir Henry Tizard, Chief Scientist of the United Kingdom Ministry of Defence, made in 1947, that Australian scientists should be involved in such research.

Alan Butement was appointed to lead this research, with his functions as Chief Scientist being similar to those of the incumbent in the Ministry of Supply in the United Kingdom. That position was 'responsible for the execution of research and development in connection with Service requirements.'[8] Butement was succeeded as Acting Chief Superintendent of the Long Range Weapons Establishment by Robert W. Pye, another of the 11 scientists to form the original Long Range Weapons Organisation, Australia.

Butement became a good leader, though had an off-putting manner that took some time for colleagues to appreciate. He was first and foremost a scientist and a man of ideas. His ideas were invariably simple in principle, but difficult to implement, with others generally being charged with differentiating wheat from chaff. Henry d'Assumpcao, a young scientist at the time, recalled an occasion when Sir Robert Cockburn, an acknowledged expert on electronic warfare, visited Salisbury and listened to Butement propounding an idea. 'Butey', he said, 'you have just enough knowledge: any less and you could not have thought of it; any more and you would have said that it could not be done.' This propensity of Butement's to generate ideas prompted the quip by d'Assumpcao that 'A think of Butey is a chore forever.'[9]

In December 1949 the Minister for Defence, in accordance with the recommendation of the Defence Research and Development Policy Committee and the Defence Committee, endorsed proposals for the establishment of three research facilities at Salisbury to undertake defence research on projects endorsed by the Department of Defence. The new research facilities were the Electronics Laboratory, Propulsion Laboratory and High Speed Aerodynamics Laboratory.

The new laboratories were established during 1951 in vacant buildings alongside the Long Range Weapons Establishment at Salisbury with staff from the Aeronautical Research

Laboratories in Melbourne becoming the core of the new High Speed Aerodynamics Laboratory and staff from the Maribyrnong-based Defence Research Laboratories, also in Melbourne, forming the core of the new Propulsion Research Laboratory. At the same time an Electronics Research Laboratory was established to research guidance and control systems. This meant that there were two research streams based at Salisbury, one devoted to the Joint Project, the other focused on Australian projects, though the work of the Joint Project dominated the site both in terms of the funding available and the profile of work undertaken.

Australian Defence Scientific Service

Though all part of one Research and Development Division of the same department, the three key defence research establishments—the Munitions Supply Laboratories (renamed the Defence Research Laboratories in 1948), the Aeronautical Research Laboratories, and later, the Australian reseach laboratories at Salisbury—remained separate entities. The first step to unifying Australia's defence science agencies occurred when the Australian Defence Scientific Service was established within the Research and Development Division of the Department of Supply and Development in 1950.

This initiative followed a report by Butement dated 23 October 1950 that detailed difficulties in recruiting suitable scientists for defence purposes. At that time defence scientists worked either with the Joint United Kingdom-Australian Long Range Weapons Project or on Australian initiated projects in the Defence Research Laboratories or the Aeronautical Research Laboratories. Unfortunately, Butement found as many scientists leaving as were joining the agencies for which he was responsible. In part this was because of discrepancies between the conditions of those recruited through the Munitions Department, those recruited through CSIR and those joining the agencies later, with salary scales in the various laboratories 'unrelated to one another, and in some, no differentiation in category is made between those possessing the highest qualifications and those with less or none.'[10]

Butement proposed setting up 'the Australian Defence Scientific Service ... constituted in a manner generally similar to the Scientific Civil Service of the Ministry of Supply and the Royal Naval Scientific Service.' The new organisation was to include the Long Range Weapons Establishment, the Aeronautical Research Laboratories and the Defence Research Laboratories along with other laboratories being set up for defence research and development. His plan made provision for varying degrees of qualification and experience within three broad categories, namely, Scientific Officer, Experimental Officer, and Experimental Assistant, with various levels under each.

The Defence Research and Defence Policy Committee endorsed Butement's idea at its meeting on 6 December 1950, and its recommendation was further endorsed by the Defence Committee on 14 December 1950.

Meanwhile, there occurred another reorganisation of the department that included the research establishments. The Department of Supply and Development was abolished on 17 March 1950 and its functions passed to the Department of Supply, the Department of Fuel, Shipping and Transport, and the Department of National Development.[11] The Department of Supply became responsible for supporting Australia's armed Services in defence production, research and development, purchasing, transport and storage. A separate Department of Defence Production was established in 1951, but continued only until May 1958 when its activities returned to the Department of Supply. This departmental restructuring had no impact on the work being undertaken in the several defence laboratories.

Far from mollifying his scientists, Butement's proposal stirred another issue that had rankled with those at Fishermans Bend. His proposal raised issues concerning the nature of research within the department and provided these scientists with the opportunity to vent their displeasure at having been transferred to the Department of Supply and brought under provisions of the Public Service Act. A letter to Butement of 7 June 1951 and signed by 36 scientists at the Aeronautical Research Laboratories is quoted in full because it highlights a key feature of the culture that continued to characterise the defence science laboratories for many years, particularly those at Fishermans Bend:

> *In view of the proposed division of the Department of Supply we think the time appropriate to bring to your attention the feelings of senior officers of these laboratories with regard to the present control of the Research and Development Branch.*
>
> *We are in the unique position of having experienced both the C.S.I.R. method of administration and that employed by the Department of Supply and respectfully suggest that our opinions may be helpful to you.*
>
> *Briefly, the C.S.I.R. might be described as a Commission for Research, controlled both scientifically and administratively by men who are scientists, whereas the Research and Development Branch is merely an appendage to a very large organisation set up for the completely different functions of supply for the Services.*
>
> *The massive organisation inevitably required for these latter purposes has shown itself to be incapable of coping with the rapidly changing demands of scientific research. This has led to a fatal slowing down of our work compared with progress made by the Division under C.S.I.R. administration, even though the ratio of clerical and scientific staff has increased many fold.*
>
> *As you know, research can only be carried out at a lively tempo. The continual unnecessary delays which we now experience in obtaining staff, equipment and services lead to a frustration which inhibits the conception and development of new ideas. Many glaring examples could be quoted, but it is more the cumulative effect of the multitude of cases both large and small which has led to our present attitude of mind. A continuance of this unsatisfactory state must lead either to nervous breakdown due to frustration or to its acceptance with the consequent killing of all enthusiasm.*
>
> *Rather than accept either of these unattractive fates most of the senior scientists of these laboratories have been forced reluctantly to be on the look-out for suitable employment outside the Department. That the losses of such staff have not been greater is largely due to the very specialised nature of their experience and the limited market in Australia for such specialists.*

Under the C.S.I.R. regime the sense of achievement, coupled with pride in and loyalty to the Division, precluded any such thought from the minds of most of the staff. It is our conviction that the enthusiasm and esprit de corps which existed in these laboratories until two years ago can be recaptured only when the work is directed by a compact, autonomous organisation under the control of scientists and completely divorced from any department having functions other than research and development. In the present circumstances this would be achieved most readily by converting the Research and Development Branch into an independent body.

To summarise our thoughts in metaphor it could be said that organisation for research requires the agility of a monkey while the functions of Supply need the strength of an elephant. We believe the difference to be as fundamental as this and hope that, if you do not already agree with this point of view, we can convince you of its validity, either by means of this letter or in discussion with you; and that, further, you will find it possible to bring this point of view before those in whose power it lies to bring about such changes.

Yours faithfully, ...[12]

Butement was sympathetic to the idea and submitted a proposal to Jack Edwin Stawell Stevens, the departmental secretary, and through him to the chairman of the Public Service Board. He received understanding but little support.[13] Minister Howard Beale opposed the idea and alluded to 'Cabinet's present strong inclination to resist any further creation of organisations within the Public Service.' He recommended instead concentrating on measures to address the frustrations 'by simplifying procedure for appointment of scientific staff and decentralisation generally.'[14]

Here matters remained, though the frustration continued and bedevilled the organisation for decades.

Long Range Weapons Establishment (LRWE)

The frustrations encountered by scientists at Fishermans Bend do not seem to have been shared by those at Salisbury where the functions of the Long Range Weapons Establishment and those of the Australian laboratories—amalgamated as the Weapons Research Establishment (WRE) from 1955—underwent continuous expansion for two decades after its foundation as extra funds became available for defence science. The appropriation for Defence Research and Development grew from £6.4 million in 1950–51 to £10.9 million in 1956–57.[15]

This period was a particularly optimistic one for scientists associated with the Joint Project. One group of scientists included those from Britain who were at the forefront of their disciplines and who revelled in the notion of being engaged in such challenging research. They included R.J. (Bob) Dippy who had been identified with developing the first accurate radio navigation system; E.G. (Taffy) Bowen who was considered the primary developer of airborne radar; and Alan Oxford who had taken out a patent on pulse code modulation that paved the way for development of the analogue-to-digital converter. The other group included the young

Drawing Office, Long Range Weapons Establishment, Salisbury, pre-1955.

Australian scientists eager to learn what they could. All were broadly focused on research and development trials to gather scientific information for the design of prototype missiles, and evaluation trials to measure the performance of weapons systems. They were involved with a broad range of projects, all at the frontiers of science. High altitude parachute testing by the Royal Aircraft Establishment began in December 1947. Trials on rocket test vehicles began in December 1949 and continued for seven years. There were experiments with vertical take-off vehicles from 1952 to 1956. Various units were organised as required, such as bomb ballistics, air projects, mathematical services, missile projects and optical and mechanical instrumentation.

Projects using the Skylark rocket for the study of the upper atmosphere began in 1957 and continued for 22 years. Skylark, developed by the Royal Aircraft Establishment, Farnborough, was one of the world's most successful sounding rockets. The Royal Aircraft Establishment and the British Aircraft Corporation assembled the instrumented heads in Britain; the rocket was tested at Salisbury and first launched from Woomera on 13 February 1957. The British Science Research Council sponsored the Skylark program at Woomera with physicists from most United Kingdom universities taking part along with others from the Universities of Adelaide and Tasmania. Salisbury scientists were responsible for assembly, launching and refurbishing operations, and range instrumentation at Woomera between 1957 and 1969. Experiments carried out on the Skylark rockets resulted in a wealth of knowledge about the upper atmosphere: as many as 242 firing trials and 15 non-firing trials of Skylark were conducted between 1957 and 1978. Skylark ceased to fly under the Joint Project in 1979, but a Skylark launch was undertaken on 25 August 1987 when studies were undertaken into Supernova SN 1987A in the Large Magellan Cloud.[16]

The Blue Steel project began in 1957. Blue Steel was intended as a supersonic air-to-ground cruise missile capable of carrying a nuclear warhead and being launched in any weather by Britain's V-Bombers. Much development work for Blue Steel was undertaken at Woomera and at Salisbury. The Woomera trials program continued until October 1964, and the program ceased in 1965.[17]

Blue Steel cruise missile on display at the Woomera Missile Park.

Jindivik aircraft stationed at Evetts Field, Woomera.

Testing of the Black Knight ballistic missile began in 1958. Black Knight was the largest and most powerful rocket built in Britain to this time, and was used to develop a nose cone and components for Blue Streak. The first test took place on 7 September 1958. A total of 22 firings of Black Knight took place from Woomera before the program ceased in November 1965. Black Knight was also used in the projects Gaslight and Dazzle to launch re-entry vehicles and propel them back into the atmosphere to study a number of phenomena.[18]

A project that captured attention and greatly enhanced the reputation of Australian scientists and aeronautical engineers was the development of Jindivik, a subsonic unmanned jet-propelled target aircraft designed to measure missile performance and built at the Government Aircraft Factory at Fishermans Bend. Jindivik was a metal low-wing cantilever monoplane, 7 metres long with a 5.8 metre wingspan and powered by an Armstrong-Siddeley Viper jet engine giving it a maximum speed of Mach 0.85 and a ceiling of 40,000 feet.

A small team began the design and development of Jindivik prototypes in 1948 making the Jindivik project contemporaneous with the development of the Anglo-Australia Joint Project. Ian Fleming, chief designer at the Government Aircraft Factory, Fishermans Bend, supported by the Aeronautical Research Laboratories, headed the team that undertook the design work and initial development of Jindivik. The Aeronautical Research Laboratories' pioneering expertise in flutter and vibration analysis was successfully applied to the project with almost all wind tunnel testing being carried out at Fishermans Bend. The Royal Aircraft Establishment in Great Britain and the Long Range Weapons Establishment/Weapons Research Establishment played crucial roles in developing the control equipment and instrumentation, and in project planning, although this latter role was assumed by the Royal Australian Air Force and later still by civilian contractors.

Two aircraft were designed initially: a manned version called Pika and the unmanned radio-controlled Jindivik. Only two of the manned Pika were built to prove the basic Jindivik design and its electronic guidance and control systems. They were flown between 1950 and 1954.

The first successful Jindivik test occurred on 28 August 1952 from Evetts Field near Woomera. Five people at ground level flew the Jindivik target aircraft into position for trials. Once the Jindivik reached operational altitude, it could be used to tow small targets on a wire cable that was reeled out, sometimes streaming thousands of metres behind the aircraft. This target became the object of missiles fired towards it, thus saving the Jindivik, which could be returned to the landing strip by the ground crew and re-used for further target trials. The first firing trial using the Jindivik Mk1 as a target took place at Range E, Woomera, on 1 October 1954. Mk2, Mk3A and Mk3B Jindiviks were later designed and developed, and continued in service at Woomera until 27 June 1975.

Other pioneering work was associated with the Jindivik development. The aircraft carried Weapons Research Establishment Target Recorder (WRETAR) cameras with fish-eye lenses to gather information about missile behaviour. Bob Bonnell designed the camera that was very compact, and contained a lens designed by Frank Dixon, with a field of view exceeding 180 degrees. WRETAR was one of a series of cameras designed and made at this time by engineers at Salisbury for use in trials during the Anglo-Australia Joint Project conducted at Woomera. This made it possible to use two cameras in each wing pod of the Jindivik where previously four cameras in each wing pod had to be used. The WRETAR camera system became the standard miss-distance measuring system for Jindivik and other target aircraft.

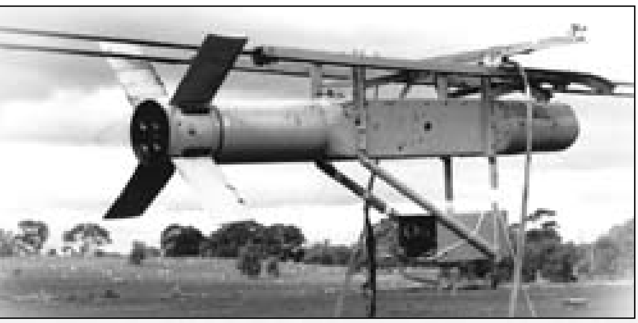
Jindivik technology was sold overseas and thereby helped raise Australia's profile in international defence markets. The first use of Jindivik overseas occurred in 1957 when the Royal Swedish Air Force purchased ten Mk2 Jindiviks. In 1960, the aircraft was introduced into the United Kingdom: it first flew in the United States in 1962, and in 1967 the Royal Australian Navy adopted the Jindivik for target service at the Jervis Bay Missile Range. One Australian Navy Jindivik set a record of 324 flights between 1952 and 1977.[19]

Australian initiatives

The early work of the new Australian research laboratories, part of the fledgling Research and Development Branch of the Department of Supply and Development, commenced with Butement's recommendation that Australian scientists seek to develop a guided weapon for use in anti-tank and anti-aircraft roles. Already, in August 1950, preliminary work had begun on an Australian-designed wire-guided missile called Project 'E'. This technology formed the basis of what became the Malkara missile that was the first guided weapon system to be introduced into the British Army.[20]

The development of Malkara, a heavy anti-tank wire-guided weapon system, began in 1952 at the Government Aircraft Factory as a collaborative project between the Aeronautical Research Laboratories and Long Range Weapons Establishment. J.M. (Murray) Evans, a research scientist specialising in stability and control of flight vehicles at the ARL, was appointed Project Officer and Chief Designer, though the concept was credited to Alan Butement.

Malkara was a stubby rocket, 1.8 metres in length and 20 centimetres in diameter, weighing 98 kilograms. The rocket was propelled by a solid fuel motor that was one of the first rocket motors developed in Australia after being designed at the Propulsion Research Laboratory at the Long Range Weapons Establishment. A 'pilot' steered the rocket by sight to a target using a joystick to transmit signals down a thin cable that was paid out as it flew. A gyroscope automatically corrected any tendency to roll. The early versions of Malkara had an effective range of between 450 metres and 1800 metres, with a flight time of about 15 seconds. Later versions had twice this range.



Early test version of the Malkara anti-tank wire-guided weapon system.

Woomera trials led to the British Army ordering 150 missiles for evaluation and, following successful trials in the United Kingdom, an additional 1000 in August 1959. Malkara production continued until 1964, and the experience gained in its development was later used in the design and development of the Ikara anti-submarine weapon.[21]

Other non-Joint Project work included upper atmosphere research carried out for British civil science purposes using solid fuel rockets built in the United Kingdom. This was simply opportunistic work to take advantage of the Woomera facilities, but was useful in training Australian scientists.

Long Tom, the first successful Australian sounding rocket, ready for launch at Woomera.

The High Altitude Temperature and High Altitude Density vehicles were superseded by smaller Australian-developed sounding rockets known as Kookaburra and Cockatoo in the 1960s. Kookaburra was used in an international experiment in March 1970 when a series of firings was carried out simultaneously with Britain and India in order to obtain a comparative assessment of atmospheric temperature and ozone levels.

The first locally designed and developed sounding rocket—the Long Tom rocket—was named after Tom Lawrence, a pioneer of the upper atmosphere research program. Lawrence had left the department in 1946 when he became Technical Superintendent of ANA Pty Ltd and in 1948 he was organising secretary of the first meeting of the Commonwealth Advisory Aeronautical Research Council in Australia. He travelled to England and gained a job as Principal Scientific Officer with the Royal Aircraft Establishment (1948–52) and had charge of the Aerodynamics Department engaged in transonic research. He returned to Australia in 1953 and joined the High Speed Aerodynamics Laboratory as Principal Scientific Officer. The following year he was promoted to Superintending Scientist and became engaged in upper atmosphere research. In 1958 he became assistant to Arthur Wills, Deputy Controller of the Weapons Research Establishment, and was appointed Deputy Director (Trials) in 1963.[22]

The Long Tom was originally an instrumentation test vehicle adapted for carrying equipment used for research into atmospheric conditions. It was first launched in October 1957; only ten weeks after the decision had been taken to make the rocket. Other locally developed rockets used during the sounding program included Lorikeet and Corella. Between 1960 and 1976, when the program ceased, more than 400 sounding rockets were fired from Woomera.[23]

Scientists involved in non-Joint Project research largely chose the projects on which to work, in contrast to those working on the Joint Project where the work was closely directed. Development of Malkara was Butement's idea, rather than a directive from the Services. Similarly, Ralph Cartwright, who had transferred from the Aeronautical Research Laboratories to Salisbury in 1955, embarked on operational research largely on his own initiative—though with the approbation of his superior—after undertaking *ad hoc* work at the behest of the Army Scientific Adviser, largely associated with advising on new equipment. One of Cartwright's first projects was to determine whether there was a need for Australia to invest in first generation night vision equipment or to await later developments. This small contribution grew into a team of scientists, as the benefits of such operational analysis became evident.[24]

Other work followed from projects being undertaken, perhaps the most significant being development of mathematical modelling. The Systems Assessment Division of WRE had been particularly concerned over the evaluation of weapons, with the early work being undertaken by means of actual weapon trials. The trials became more and more complex as the sophistication

Manipulation of 3" U.P. rockets on the storage rack during the first trial held at the Interim Range, Woomera, 22.3.1949.

of weapons increased and they became correspondingly more expensive. This became a concern because Australia met the cost of providing and operating the testing range at Woomera. Lawrence and his colleagues sought a solution in modelling. He explained:

> *The experience of the people in the Division with the RTV1 trials and my experience with aircraft trials, led us to propose what we called a Model Approach to Evaluation Trials. In principle the philosophy was that since the weapon had been designed by man, it must be possible to express in mathematical form, the rules governing every sub-system of the weapon—the aerodynamics, the propulsion, the reaction of the guidance system to the signal from the target, the control system—and of course the atmosphere and gravity; in short a mathematical model of the physical behaviour in flight. That being so, it should be possible to use a computer to solve all of these equations, and their interactions, simultaneously, just as happened during the live firing of a weapon. You could then use flight trials to prove the computer model was correct, and use it to predict performance in all the untrialled conditions.*

There were many sceptics, and the only computers available were two analogue computers, a small locally built machine, the Australian Rocket Test Vehicle Simulator (ARTVS), and the

Australian Guided Weapons Analog Computer (AGWAC), a larger machine built to local specifications and largely to a local design. Lawrence continued:

> *With the enthusiasm of the young, the encouragement of some of the bosses, and the co-operation of some of the staff of the designer/manufacturer, we charged ahead. Along the way, the Model Approach produced a number of unforeseen benefits. First, it meant a considerable enlargement of the analogue computer, and that benefited the Establishment's electronic equipment design and manufacturing capabilities. Secondly, it sharpened the Establishment's data reduction capabilities, because it had an inherent self-checking characteristic. And long before we got to the stage of having a fully validated model that could be used for extrapolation purposes, we had unearthed and explained inconsistencies in behaviour ...*
>
> *In the end, I think everyone was satisfied that the Mathematical Model we had produced—and the mathematics were of course subtly different from what we had started with—gave a good reproduction of the weapon behaviour. It was rewritten for a digital computer—because by then it could be manipulated on any sufficiently powerful computer—and used to predict the behaviour of the weapon in other, non-trialled, conditions.*[25]

The Services were little more than peripherally interested bystanders as far as defence research was concerned at this stage; the preferences of decision makers in the Army and the Air Force, in particular, were to acquire proven technologies from Britain and the United States.[26] The attitude of the Navy was generally more supportive of Australian research scientists because of a longer tradition of naval ship building in Australia.

Salisbury rationalisation

The Australian component of work continued to increase and with it the need for a measure of rationalisation. The Propulsion Research Laboratory and the Electronics Research Laboratory were joined to form the Chemical and Physical Research Laboratories in 1953. Then, on 12 January 1955, all laboratories at Salisbury were amalgamated into one organisation renamed the Weapons Research Establishment, under a single Controller, Harold Brown, answerable to Chief Scientist Alan Butement, and through him to the Minister for Supply.[27] The former Australian research laboratories became the responsibility of Dr Francis Fox, Deputy Controller, Weapons Research and Development. From May 1955, the other key functions were the responsibility of Ron Boswell, Deputy Controller Trials and Instrumentation.

The new arrangements promoted more efficient use of facilities, resources and support services, but also marked a stage in the Australianisation of the Joint Project and the Salisbury facility with Harold Brown—born and bred in Sydney and foundation Professor of Electrical Engineering at the New South Wales Institute of Technology—following a succession of Englishmen.

Restructuring continued from time to time to manage the growing facilities and keep pace with the work. Key functions were initially grouped into two 'wings' in 1956. The Weapons

Research and Development Wing was divided into three divisions: aerodynamics, chemistry and physics, and weapons projects. It worked on Australian defence projects and supplied services to the Joint Project when required. The Trials and Instrumentation Wing included the divisions for techniques, systems assessment, range development and trials. It became responsible for planning, conducting and assessing all trials at Woomera.

These wings were supported by other divisions such as administration and engineering: the latter became a separate wing on 1 January 1958 and undertook construction and manufacturing work for all parts of the establishment. This separate Engineering Wing became a Planning Wing in August 1959 but reverted to being called the Engineering Wing in 1966. A separate Space Physics Wing devolved from the Trials and Instrumentation Wing in 1963: this latter had three divisions, associated with ‘American projects’, systems assessment, and applied physics. The administration division, gradually assumed the status of a wing with responsibility for managing the defence sites at Salisbury and Woomera.[28]

Apprentice Training School, Salisbury. The last apprentices graduated from the school in 1994.

The Weapons Research Establishment set up its own Apprentice Training School in 1953 to train apprentices in 10 trades for the extensive workshops at Salisbury.

There were other agencies at Salisbury also, including staff representing the British government and the British Defence Research and Supply organisation. Generally there was a staff officer attached to each project.

There were also several contractors on the site working for British electronics and aeronautics firms. By the 1960s they included the British Aircraft Corporation, EMI Electronics, Hawker de Havilland, Fairey, Ferranti, Saunders-Roe, Avro, English Electric, Hunting Engineering, Rolls Royce, Sperry Rand, Bristol and Armstrong Whitworth. These firms had generally been given contracts to develop weapons or components. They were concentrated in the area to the north of the Laboratories Area in that part of the former explosives factory that had been used for shell filling and cartridge bundling and assembly. The role of the contractors became increasingly important as they began to manufacture and modify equipment and components, rather than simply act as shipping agents for their parent companies.[29] The virtual co-location of scientists and contractors established a tradition of close collaboration that was to become increasingly significant. A similar close relationship developed in Melbourne between the ARL and the nearby Government Aircraft Factory.

Service Establishments—Army

The various Services established units of their own to undertake specific research during this period. The Army set up several establishments—the Army Design Establishment, the Army Food Research Station and the Tropical Trials Establishment.

The Army Design Establishment had its origins in the Master-General of Ordnance Branch within the Department of Supply. It became a quasi-independent unit when it became known as the Technical Services Establishment on 8 November 1951. At this time it was located at the Albert Park Barracks, but relocated to Raleigh Road, Maribyrnong, in 1953. It was renamed the Army Design Establishment on 12 March 1959 when the unit was transferred to the Department of the Army.

The facility was primarily concerned with development, design and engineering evaluation of a range of equipment and armament used by the Army with field trials being undertaken at a 218.8 hectare facility at Monegeeta, 50 kilometres north of Melbourne. These included trials of the Leopard tank and the evaluation of weapons such as the 105/155 millimetre Howitzers. The unit was also responsible for tropical trials in Australia. Increasingly, there was work undertaken in association with the other Services including evaluation of the Joint Army/RAAF Portable High Power Communication Terminal.[30]

The Army Food Research Station was originally established in Melbourne in 1954 to develop lightweight ration packs, because private industry was reluctant to tender for this work. Facilities in Melbourne were inadequate and a research unit transferred to Scottsdale, 60 kilometres north-east of Launceston, Tasmania, in mid-1954. Research into food compression began in 'The Annex'—a World War II building moved to the site—in July 1954.

Preparation of freeze-dried meals at the Army Food Research Station.

In the succeeding four years three types of ration packs were developed and accepted by the Army—an emergency ration, a one-person 24-hour ration, and a 10-person composite ration. In addition, the unit conducted research into the dehydration of meat, the production of glucose-free egg powder, the production of fat antioxidants, and the compression of dehydrated vegetables. The unit also provided research and development services in food science and nutrition, and produced a range of specialised food products determined by the energy and nutritional requirements of defence personnel under various combat conditions.

The Tropical Trials Establishment could trace its origins back to 1950 when the British government asked the Australian government to conduct tropical trials for the Centurion Tank. The Innisfail and Cloncurry areas of North Queensland were chosen as suitable areas in 1954, but were used only as and when trials were required. Tropical exposure testing of material is still carried out at these sites.

Service Establishments—Navy

The Royal Australian Navy had taken the notion of research further than the Army and had two significant research establishments—the Royal Australian Navy Experimental Laboratory and the Royal Australian Navy Trials and Assessing Unit.

The Royal Australian Navy Experimental Laboratory (RANEL) differed from the Army establishments in that its culture and charter required academic standards for its personnel, akin to the major research laboratories that comprised the Australian Defence Scientific Service.

RANEL was created on 13 February 1956 following the Australian visit in 1954 of Dr W.J. Cook, Chief Scientist of the British Naval Scientific Service. Cook offered the Australian government access to current British research into long-range passive acoustic detection of submarines, provided the Royal Australian Navy recruited suitable scientific staff to test the work locally. A team visited England in August 1954, an Underwater Acoustics Committee was established on 14 February 1955, and an agreement reached whereby the Australian Defence Scientific Service would assist the Royal Australian Navy in assessing the effectiveness of the British system in Australian waters. Later in 1955 the Navy determined that it should be responsible for the work and by year's end had approved the establishment of a civilian facility to undertake the work.

Commander Frank Lord, Royal Australian Navy, became the first superintendent, with Department of Supply scientists, Dr Arthur Pryor, Dr Doug Campbell and Stan Lott comprising the first staff. Lord and his colleagues reported to Ray Gossage, a Senior Principal Scientific Officer in the British Admiralty who had been appointed Scientific Adviser to the Australian Naval Board on 1 February 1955.

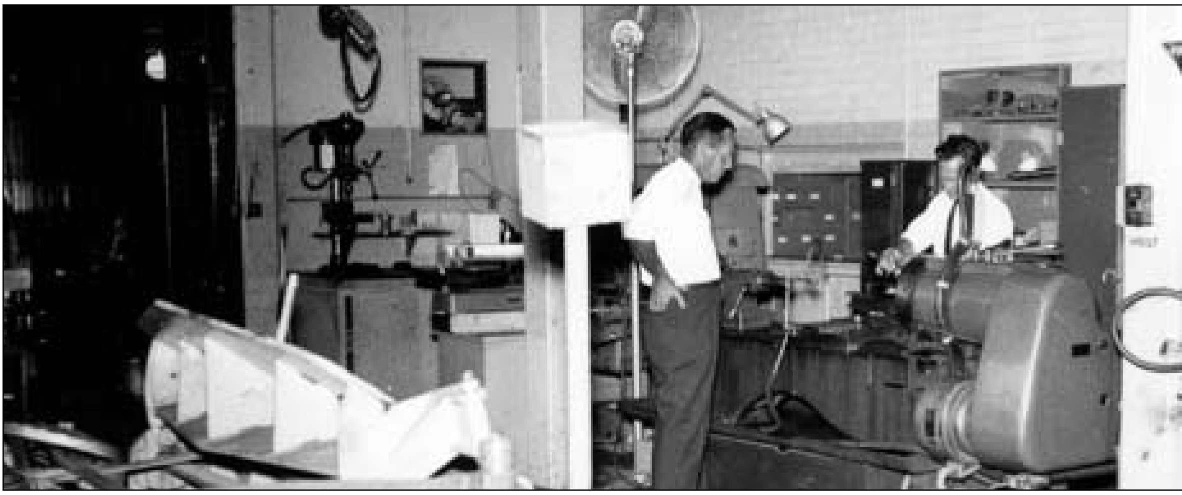
RANEL was housed in two classrooms and an office in the northern building of HMAS *Rushcutter* at Rushcutters Bay, little more than 2 kilometres from Sydney's centre. The laboratory was largely a product of the Cold War, with the emphasis on research focused on defending Australia from Russian submarine infiltration and attack. The earliest research was primarily focused on detecting enemy craft and was largely concerned with sonar and deployment of sensors along the New South Wales coast.

The laboratory retained close links with British research institutions throughout this time. Ray Gossage's immediate successors as Scientific Adviser to the Naval Board also followed from the United Kingdom. They were Peter Ward in 1959 and later Philip Horton. Several British scientists spent time at the laboratory. For instance, Ian Gatenby and Peter Clynick both arrived on three-year secondments in November 1956 to appointments as Senior Scientific Officer.

The British relationship was strengthened after a succession of Australian scientists, beginning with Bill Hunter, were sent to Britain for training. He had joined the Department of the Navy and RANEL in Sydney in 1957 as a scientific officer. Two years later he was seconded to the Admiralty in the United Kingdom and worked at the Underwater Detection Establishment, Portland, and later the Admiralty Research Laboratory in Teddington. Warwick James (Mike) Turner was one of the early Australian scientists to join the laboratory when he did so on 11 November 1957, soon after graduating from Sydney University.

In March 1958 the Royal Australian Navy Scientific Policy Committee recommended that the laboratory's scope be broadened to include all scientific work for the Navy. Staff numbers increased with the broadened scope. The formation of a Mine Countermeasures Group in 1958 represented one aspect of this expansion. The development of a towed underwater glider to enable divers to conduct visual searches of underwater ordnance became one of the group's early projects. This ultimately went into service with clearance divers in 1966.

The Royal Australian Navy Trials and Assessing Unit comprised two basic units; a weapons assessing unit and a trials unit. The unit was based in an office block in North Sydney, with outposts at Watsons Bay and Neutral Bay on Sydney Harbour, and at Jervis Bay on the New South Wales south coast. It was involved in inspections, tests and trials of all ships and testing and assessment of the firing of naval guns, torpedoes, missiles and anti-submarine mortars.



The engineering workshop at Rushcutters Bay. (RANEL Assn)

Aerial view of RANEL at Rushcutters Bay. (RANEL Assn)

Defence Standards Laboratories (DSL)

Alfred Ernest Dawkins, recruited to the Chemical Adviser's Laboratory in 1915, became Superintendent of the Munitions Supply Laboratories in 1947 after having served as assistant superintendent since January 1934, and continued in the role until retiring in 1957. He had an immense influence on the development of the laboratories under their various names—Defence Research Laboratories from 1948 and Defence Standards Laboratories from 1953. He was also active in associated industry organisations. He assisted with the formation of the National Association of Testing Authorities in 1946, became vice-chairman in 1949 and served as chairman for 10 years from 1950. He was also a prominent member of the Australian Chemical Institute.[31]

During Dawkins' time at its head, the laboratories became more exclusively involved in defence work rather than that for industry. The DSL was divided into four divisions, Physics, Organic Chemistry, Physical Chemistry, and Metallurgy: previous functions, such as timber research, were no longer appropriate and other functions dealing with weaponry had been transferred to the WRE or had become the province of the CSIRO. Still, the laboratories continued to act as general consultants to the Services and government agencies.

Moreover, the laboratories had expanded further interstate when a branch was opened at Finsbury in South Australia in 1947. It had been established at the request of state government and industry representatives in order to maintain skills acquired during World War II.[32]

Indeed, one of the DSL's most noteworthy achievements derived from the perceptiveness of two of its South Australian scientists, K.A. (Ken) Metcalfe and R.J. (Bob) Wright who, in 1952, invented the 'wet' electrophotographic process that became the basis of the modern photocopying industry.

The xerography process—literally 'dry writing' from the Greek words *xeros* and *graphos*—was invented by Chester Carlson, a United States patent attorney, in 1935. Metcalfe became interested in Carlson's xerographic process as a possible means of producing industrial radiographs more cheaply and rapidly than on X-ray film. It soon became clear to him and his co-workers that the current dry-powder development could not reproduce the tonal grades and the fine detail required in radiographs of welds and casings.

Metcalfe and Wright's invention of the 'wet' process had many advantages over the dry powder method of development then in use. It was a liquid development process that produced the required improvement in the quality of continuous tone images and also opened up many new applications for the electrophotographic process. Among these were greatly improved resolving powder, production of permanent images without fixing treatments and the ability to produce images in any colour or combination of colours.

The Australian Department of Supply patented the new technology in 13 countries. As well, firms in the United States, England, Japan and Europe were licensed to use the patent, with licence fees and royalty payments being received by the Commonwealth government. More than 90 patents were taken out in Australia and overseas and royalties flowed to the Commonwealth at a rate that was more than twice the operating costs of the South Australian branch of the DSL. Metcalfe and Wright's liquid development of electrophotography became the basis for the development of office photocopying machines.[33]


Dr Francis Fox.

Dr Francis Fox succeeded Dawkins as Chief Superintendent of the laboratories in 1957. He had been born in Westcliff-on-Sea, England in 1910, and educated at Birmingham University where he gained a first class honours BSc in 1932, an MSc in 1933 and a DSc in 1947. After gaining his BSc he worked for two years as an assistant assayer for a mining company in South Africa. He then spent two years with ICI Metals in Birmingham and became Chief Metallurgist at Magnesium Elektron, Manchester in 1938. He became Deputy Director of the British Welding Research Association, London, in 1946, and later, Deputy Technical Manager of the lead processing company H.J. Enthoven Ltd in London. Fox moved to Australia in 1952 as Superintending Scientist of the Department of Supply at its Melbourne Head Office. He went to WRE in 1954 as Acting Senior Superintending Scientist but returned to Melbourne and the DSL in 1957 when he succeeded Dawkins. He became a Commonwealth representative on the Council of the National Association of Testing Authorities in 1957 and later its vice-chairman.[34] He remained in the position until his retirement on 7 August 1970 and continued the metamorphosis from what was essentially a calibrating laboratory to that of an important research institution, so much so that, in 1974, its name changed again to the Materials Research Laboratories.

The laboratories did cutting-edge research. Fox, with Dr John Farrands, began research into the military use of lasers in 1962. This became a major activity of the laboratories. Leslie Mathias, a laser scientist, was recruited from the United Kingdom in 1967 to head a research group involved in the laser research.

Aeronautical Research Laboratories (ARL)

Though not part of the Joint Project, the ARL, in association with other laboratories at Salisbury, became deeply involved in research and development of guided weapons, particularly within its Aircraft Systems Division.[35]

ARL staff were also involved in several innovations in the aviation industry, though not strictly defence projects. Perhaps the most notable was Dr David Warren's invention of the so-called 'black box' flight recorder that was conceived by the inventor without any reference to evident defence applicability.

Warren had seen the world's first miniature tape recorder, the 'Minifon', at a trade fair in 1953 at about the time the world's first jet airliner, the Comet, had suffered a mysterious series of fatal crashes. It occurred to him that everything said in the cockpit of an aircraft until the time of a crash could be recorded on such a machine and afterwards might be useful in explaining the cause of any crash. Warren and his team—Kenneth Fraser, Lane Sear and Dr Walter Boswell—spent the next several years developing the technology and produced a demonstration model of the black box in 1957. Australian aviation authorities were unimpressed and could see no practical use for the device. Their attitude was that the Americans would have already produced such a device if it were considered important. Fortunately, British interest was high after Warren demonstrated the idea there in 1958. The British Ministry of Aviation later announced that such a recorder should be carried on aircraft, at least for recording instrument readings.

H.A. Wills.

However, the next step in acceptance of the invention occurred in Australia following the unexplained crash of a Fokker Friendship aircraft at Mackay in 1960. The judge at the following court of inquiry ordered that flight recorders be fitted to all future Australian aircraft. Consequently, Australia became the first country in the world to make cockpit voice recording mandatory, though the tender for such devices was given to an American company. Since then, with refinements and upgrades, voice-plus-data recording has become mandatory in all major aircraft throughout the world, and has proved invaluable in helping to solve many air disasters and has substantially contributed to aircraft safety worldwide.[36]

Only a little less significant, and another major contribution to aviation safety, was the development of the T-VASIS (Tee-Visual Approach Slope Indicator System) that became the international standard to assist aircraft pilots in the final stages of landing. Ron Cumming and Russ Baxter of the ARL's Human Engineering Group at Fishermans Bend, in association with Bruce Fraser and Dr John Lane of the then Department of Civil Aviation, developed this system.

Development of the T-VASIS began in the mid-1950s at a time when only large aircraft had instrument landing system equipment, which meant pilots of small aircraft relied wholly on visual cues to find the correct approach angle when landing their aircraft. The system was based on a series of light boxes on either side of a runway with various apertures that, taken together, showed a white line if the aircraft approach was correct: too high and the system showed an inverted 'T', too low and the pilot saw an upright 'T' coloured red.

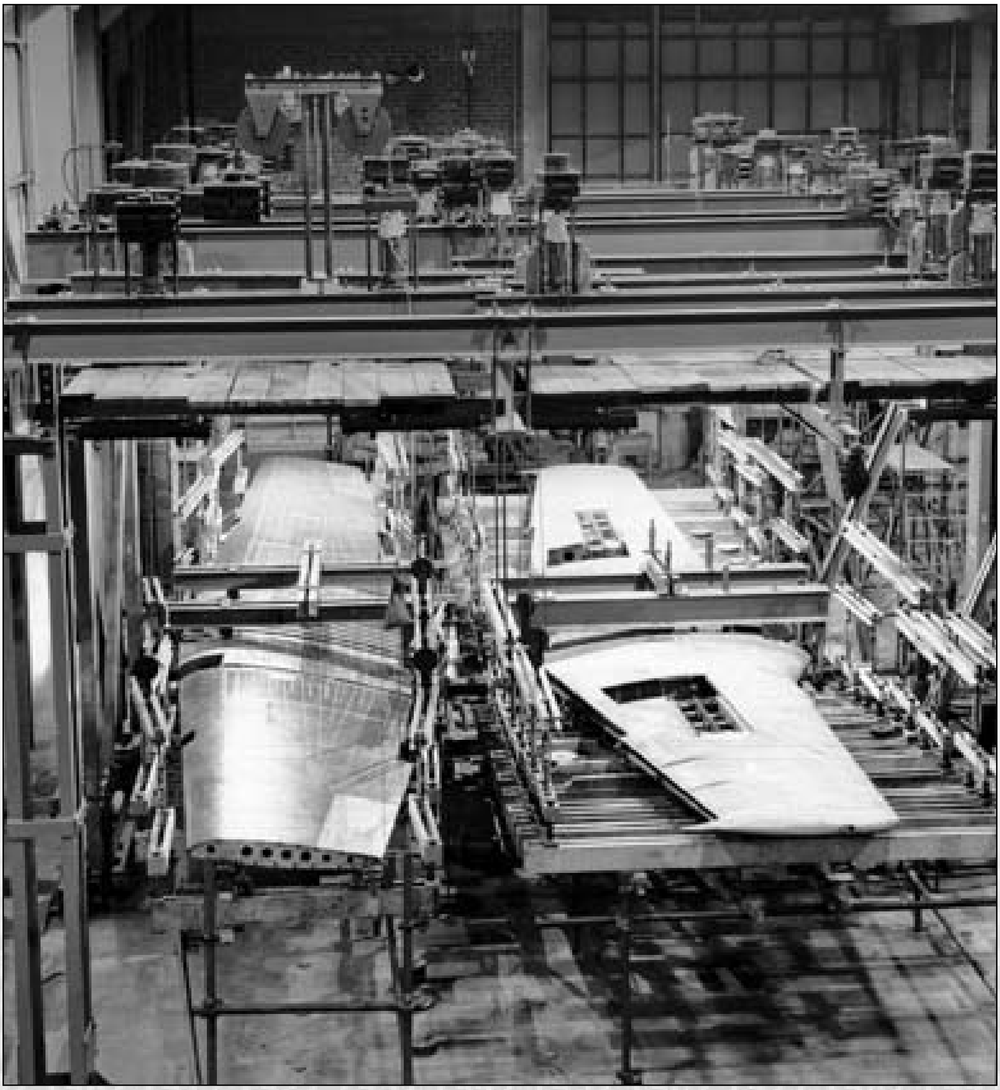
The Department of Civil Aviation adopted the system in Australia after extensive evaluations in Australia and overseas and let the contract to Reinforced Plastics Pty Ltd to manufacture six production units in 1963. The first system was commissioned in Hobart in 1964. Additional units were installed at major airports in Australia during 1966–67 and the system was adopted as the international standard in 1971.[37] Two years later the system was awarded the Diplome d'Honneur by the Federation Aeronautique Internationale.

The particular work for which the ARL became renowned was the fatigue-testing work on defence platforms. Arthur Wills pioneered this research. He was originally from Western Australia, having been born at Boulder on the goldfields on 16 May 1906. He had been educated at the Perth Technical College and graduated from the University of Western Australia with a Masters Degree in Engineering. He worked in England for five years from 1931 on aircraft design and development and undertook research for the Fairey Aviation Company. He worked on the design of the Fairey Swordfish and later took charge of Fairey's Hamble Works. Wills returned to Australia and joined the Department of Civil Aviation in 1936 as an aeronautical engineer but, in 1939, took charge of research in structures and materials at the Division of Aeronautics of the CSIR, the infant ARL.

Wills recognised the implications of fatigue in aircraft and especially the effect of features that concentrated stress, such as boltholes and cutouts, on fatigue life. He initiated a research program in 1947 to develop a database on fatigue and, in 1949, presented a seminal paper entitled *The Life of Aircraft Structures* at the Second International Aeronautical Conference in New York. This explained, for the first time, the technique for determining aircraft fatigue lives from knowledge of applied loads and fatigue data.

Alf Payne and W.W. Johnston followed Wills' lead and, in 1950, led a pioneering research program into the fatigue behaviour of aircraft structures. Extending over a period of 12 years, 222 Mustang aircraft wings were tested under repeated loads and a complex series of loads that represented the load history of an aircraft in service. This led to Australia becoming the world leader in aircraft fatigue research during the 1960s. Indeed, this program was the most extensive series of fatigue tests of a full-scale structure ever undertaken anywhere and was 'used as an authoritative reference by the aeronautical industry.'[38]

The facilities at the ARL, particularly the wind tunnels were used for a variety of studies beyond those associated with aircraft design. For example, studies included an analysis of the lines of the Sydney Myer Music Bowl in Melbourne, and others associated with wind loadings on tall buildings. The Structures Division possessed a universal static testing machine that was used in a broad range of load and fatigue testing of materials, from welds in penstocks for the Snowy Mountains Hydro-Electric Authority to repair schemes for Melbourne's Kings Bridge after a span collapsed in July 1962.[39]



Mustang wing fatigue test, 1957.

Scientific advisers to the Services

The appointment of scientists to act as scientific advisers to the various Services was another initiative taken in the 1950s that had a lasting influence on the development of defence science in Australia.

The concept gained currency following the 1946 visit to Australia of Charles Wright, Director of Scientific Research at the Admiralty, when the idea of appointing a scientific adviser to the Navy was first raised. Indeed, a 1946 minute of the Defence Committee noted a recommendation of a sub-committee that 'each of the Services should be authorised to appoint a Service Scientific Adviser, these to maintain a liaison each with the other and with the Defence Scientific Adviser in respect of all matters of joint-Service interest and concern.'[40] Scientific Adviser Albert Percival Rowe later recommended that Wright be appointed to the position for three years.

All Service departments in the United Kingdom had scientific advisers 'with considerable staff'. In Australia, however, only the Department of Air employed a scientist who was a serving officer and was closely associated with the Chief of Staff of his department.[41]

Nothing came of the idea immediately, but it continued to receive attention, with the Army pursuing the idea. The Military Board suggested:

> *It is not considered that there need be any overlapping between the work of the proposed Army Adviser [to the Military Board] and that of other organisations concerned with defence. It is felt, on the contrary, that their functions would be complementary, and that the Army Adviser by identifying and presenting Army problems would enable the other parts of the Defence Science Organisation to work more effectively towards increasing our strength and efficiency in war.*[42]

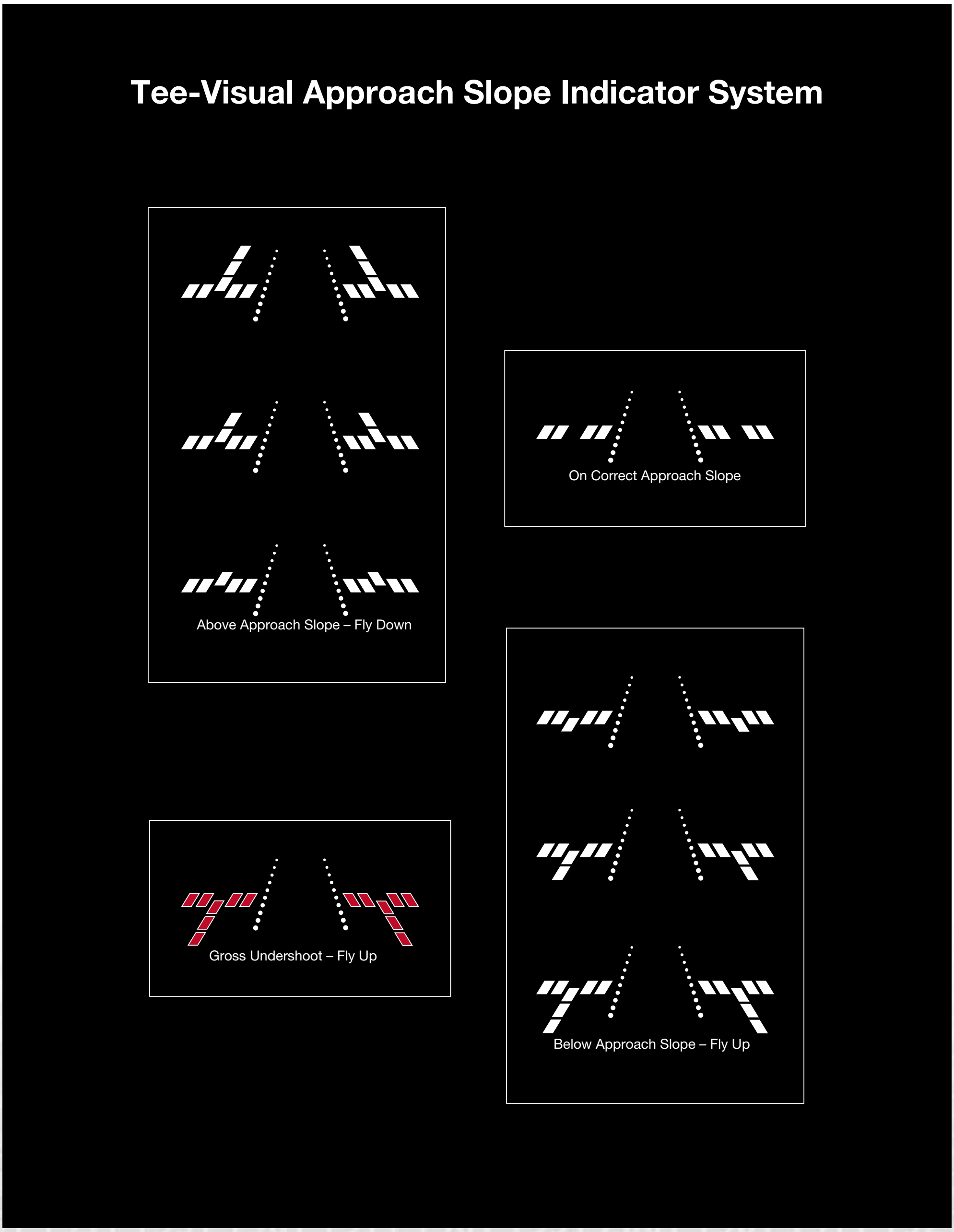
Rowe's successor, Leslie Martin, supported the idea after returning from a visit to the United Kingdom, when he suggested that increased attention should be given to operational research. The Defence Research and Development Policy Committee and the Defence Committee endorsed the idea, concluding that operational research techniques should be considered as a domestic responsibility of each of the departments concerned.[43]

Soon afterwards, in October 1952, William Ross Blunden was appointed the first scientific adviser to the Military Board. The appointment of a scientific adviser to the Naval Board followed two years later.[44]

The Service scientific officers played a key role in building bridges between the Services and those working in defence science, and in having Service personnel appreciate the contributions defence scientists were able to make. However, success in promoting the worth of science to Service interests depended on the individuals appointed to the positions and the openness of Service personnel to their advice.

The 1950s were optimistic years for defence scientists in Australia with the Joint Project, in particular, offering young scientists extraordinary opportunities to gain experience in leading edge research and to assist in transferring knowledge from Britain to Australia. Some scientists may have had concerns about the secrecy and security environments in which they worked.

However, they remained genuinely excited by the opportunity to engage in advanced science and had no need to dwell on the defence implications of their work. Moreover, as with the development of the 'black box', T-VASIS and the 'wet' process xerography, much of their work had benefits beyond solely military applications.



The award-winning visual landing system as seen by a pilot on final approach.

CHAPTER 5

A highly creative period: 1960–1968

The work of Australia's defence scientists during the 1960s—in what John Wisdom considered the latter half of the 'highly creative period' of the Australian Defence Scientific Service—largely proceeded with little regard for Australia's defence and foreign policies and with little interest from military leaders, except for the work at the Royal Australian Navy Experimental Laboratory.[1]

Much of the work was associated with highly technical projects and galvanised scientists working on them with rapid developments in computer technology opening new areas of research in modelling and simulation. The scientists revelled in the stimulating environment in which they worked, surrounded as they were by experts in every conceivable field, who were willing to collaborate and share their information. It was a highly self-indulgent period from a scientist's point of view.

Australia's defence policy continued to be based on the idea of 'forward defence', with Australian forces fighting on Asian battlefields in concert with strong allies such as the United States or Britain. Australia expected to be used to counter conventional forces supported overtly or covertly by Communist China and the Soviet Union. Dr Thomas Bruce Millar, Research Fellow in International Relations at the Australian National University, and a leading expert in Australia's defence policy, outlined the scenario pertaining in 1964:

> *Here, then, are the situations in which we may be called upon to commit our armed forces within the next five to ten years: (1) to defend eastern New Guinea from Indonesian invasion or Indonesian-inspired subversion; (2) to help defend, in conjunction with Malaysian, British and perhaps New Zealand forces, Sabah and Sarawak from Indonesian invasion or Indonesian-inspired subversion and to help in the naval defence of Malaysia; (3) to help defend, in conjunction with the United States and such other [South-East Asia Treaty Organisation] powers as will assist, Thailand from Communist invasion or externally-inspired Communist subversion; (4) to help defend, in conjunction with the United States and perhaps other [South-East Asia Treaty Organisation] powers, South Vietnam from externally backed Communist subversion, infiltration, terrorism and aggression; (5) to defend our own continent against Indonesian attacks, or Indonesian-based Chinese Communist attacks. Finally, there is the matter of Australia's role in the event of a major East-West war.*[2]

Millar went on to list ten 'miscellaneous needs' to be met to increase Australia's defence capabilities. They were to ensure Servicemen were ideologically armed; to increase the ability of soldiers to speak the language of the country in which they operated; to improve the professional status of Service people; to have more modern landing craft for men and equipment; to provide training against chemical, biological and radiological warfare; to have

‹ *Launch of an ELDO Europa satellite vehicle, Woomera.*

better internal communications within Australia; to establish a joint Services defence college; to have a planning horizon beyond the Mirage jet fighter, F-111 fighter-bomber and the Adams-class destroyers; to speed up the hydrographic survey of the Australian coast; and to have a continuity of Service ministers. He made no reference to defence science—except the need to hasten the hydrographic survey—or the manner in which it might enhance Australia's defence capability.

Weapons Research Establishment (WRE)

The WRE continued to expand until the mid-1960s with staff numbers peaking in 1964 at almost 6500. The period remained an optimistic one with scientists working on the frontiers of their disciplines, and collaborating with international peers who were similarly engaged. Salisbury, in particular, reflected the project-oriented culture of British scientists who had been involved in developing equipment that had helped the allies win World War II, and who lived by the philosophy that science could help win wars. This optimistic culture spilled over into an active social life and the real sense of fun that pervaded the site.


Machine shop, Weapons Research Establishment, Salisbury.

By this time the work of the establishment in association with foreign interests was carried out in accordance with four international agreements: the Joint United Kingdom-Australian Long Range Weapons Project, an Australia–United States Agreement relating to space tracking and communications, the European Launcher Development Organisation Convention, and agreements with the Advanced Research Projects Agency of the United States Department of Defense.

This international work itself was not directly associated with Australian defence science, but it provided an invaluable training ground for Australian scientists and engineers and became the means of transferring technologies from international partners to Australia. Moreover, the international work created immense favourable publicity for science in Australia.

Australia became associated with deep space research during the International Geophysical Year, 1957. The year previously, the Australian government had concluded an agreement with the United States Naval Research Laboratory for erection and operation of a 'Minitrack' electronic phase comparison satellite tracking system at Woomera, and with the Smithsonian Institution for erection of a Baker-Nunn satellite-tracking camera, also at Woomera. These stations were used in tracking the Vanguard satellites launched in 1957 and 1958, and the first Russian satellite launched in November 1957 that acted as a spur to American space research.

Later agreements were reached with the United States' National Aeronautics and Space Administration (NASA) that was established in 1958. For instance, an agreement in 1959 provided for construction of a Deep Space Instrumentation Facility at Island Lagoon near Woomera to assist with research into the behaviour of satellites and other space vehicles: it was to be one of three, the others being located in California and near Johannesburg, South Africa. Installation of the 26-metre diameter radio telescope commenced in May 1960.

Missile components in workshop, Weapons Research Establishment, Salisbury.

Radar dish at Island Lagoon, S.A., 1960s. The station closed in early 1974.

Lake Hart launch pad with ELDO Europa satellite vehicle in launch position.

Soon after a network of tracking stations was developed across Australia to support other NASA projects; these were at Muchea and Carnarvon in Western Australia, Cooby Creek in Queensland, and at Tidbinbilla, Orroral Valley and Honeysuckle Creek in the Australian Capital Territory. Equipment was supplied by the United States, but the stations were built, operated and maintained by Australian staff and became the responsibility of the WRE. Station directors and their assistants were WRE officers, while contractors generally provided operational staff.

The most spectacular feature of the international work during this period was associated with the rocket range at Woomera and the European Launcher Development Organisation program. The European Launcher Development Organisation included Great Britain, France, the Federal Republic of Germany, Italy, Belgium, Netherlands and Australia. The object of the organisation was to develop a satellite launch vehicle. Australia, through the WRE, was to provide the launching and support facilities. The rockets launched under the European Launcher Development Organisation program used the launching emplacement originally built for testing the Blue Streak rocket at Lake Hart after this program was aborted on 13 April 1960.

Launch of a sounding rocket from the Skylark launcher, Woomera.

The first planning mission visited facilities at Salisbury and Woomera in July 1962 with the first firing of the three-stage Europa 1 rocket occurring on 24 May 1966 witnessed by the largest press, radio, television and newsreel party ever to visit Woomera to that time and who, between them, represented virtually all major media in Australia and overseas.

The Europa 1 was indeed an international rocket and, at that time, the largest rocket launched outside the United States and Russia. Britain provided the first stage of the satellite launch vehicle, the Blue Streak (originally conceived as a medium range ballistic missile), the French developed the Coralie rocket as the second stage, and Germany provided the third stage. Italy provided the test satellite while Belgium developed the guidance equipment and Holland the telemetry equipment. Ten firing trials of Europa 1 were conducted at Woomera, the last on 12 June 1970, although orbital flight was not achieved, with the payload landing in the Caribbean. Thereafter, the European Launcher Development Organisation program transferred to French Guiana for the next phase of development.[3]

The nature of the contemporary world—the British Commonwealth and British politics in the 1960s—rendered virtually inevitable a reassessment of the benefits of the Joint Project to the partners. Britain, in particular, became eager to reduce its financial commitment to the project and signalled this in a new agreement negotiated between October 1967 and May 1968. While there were direct implications for the future of the rocket range at Woomera, with the British moving to pay for the use of the range rather than to contribute directly to its upkeep, there were also evident implications for the WRE at Salisbury with the reduction in trials staff.

The new arrangements prompted a separation of the functions of the testing range at Woomera and the research establishment at Salisbury, with the intention of the latter becoming increasingly concerned with research towards Australia's own defence needs.

Dr Don Woods, Director, Weapons Research Establishment, 1965–1976.

The scaling back of the Joint Project caused some alarm among scientists at Salisbury. Consequently, a team of senior personnel led by Mervyn Kirkpatrick, Superintendent of Planning in 1966 and 1967, sought a survival strategy to convince people there was a need for an Australian defence science capability. The strategy involved identifying and quantifying the skills of people working at the establishment. The initiative was undertaken largely against a background of indifference from senior Service personnel.

The opportunity to showcase the work of Salisbury scientists and defence science in Australia received a fillip on 29 November 1967 with the successful launch of the Weapons Research Establishment satellite (WRESAT) from Woomera.

The manner in which this came about was remarkable. Australia, with the United Kingdom and the United States, had been engaged in the Sparta program devised to study physical phenomena of bodies re-entering the earth's atmosphere. The project used multi-stage rockets with the Redstone booster as the first stage.

US Redstone rocket being prepared for launch of WRESAT, Australia's first satellite, Woomera, November 1967.

The success of the program and continued development of modelling and computer technology meant the project was completed with one Redstone rocket remaining. During an informal social gathering between senior scientists the Americans suggested that the Australians might be able to use the rocket, because they did not want to ship it home. The suggestion was made that Australia might use the rocket to launch a satellite. Don Woods, director of the WRE from 1965 to 1976, was keen and he virtually told his superiors what was planned. They ultimately agreed so long as the extra cost was marginal: the minister agreed, on condition that the project worked and there was no political fallout.[4]

The challenge was a mighty one with the need to have the project completed before the Americans removed all their equipment and returned home in 11 months. The satellite was conceived, designed and constructed at Salisbury with contributions from many parts of WRE and assistance from Adelaide University within the timeframe, and under Des Barnsley as Project Manager. The Americans remaining at Woomera provided assistance and NASA agreed to use its resources to track the satellite during its orbits of the earth.

The successful launch of WRESAT gave Australia the distinction of being the third nation after Russia and the United States to build and launch its own satellite. WRESAT also performed according to plan. It remained in orbit for 42 days, completing 642 orbits of the earth, transmitting data for five days and 73 of these orbits before burning up over the Atlantic Ocean on 10 January 1968.[5]

Arthur Wills later admitted that ‘we knew when we undertook this exercise that we were courting Lady Luck on the one hand and flying in the face of Providence on the other—and that the chances of success were pretty slender’.[6] Nevertheless the Australians succeeded.

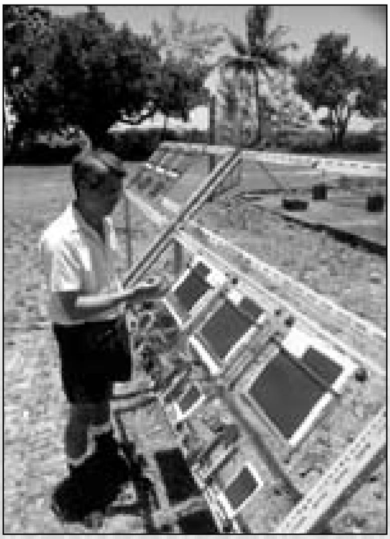
The launch of WRESAT represented the pinnacle of Australian achievements at Woomera. At that time, the WRE had a staff of 4497, with 1001 of these at Woomera. It comprised the largest research and development establishment in the country, and included 533 scientists and engineers and 1023 technical staff.[7]

Service establishments

Other Australian defence research establishments were founded during this period. Many of them were closely associated with particular arms of the Services.

The Joint Tropical Research Unit was established at Pin Gin Hill, 8 kilometres west of Innisfail and 87 kilometres south of Cairns, North Queensland, in late 1962, and was operated jointly with the British Ministry of Defence to provide facilities to study the deterioration of materials in the tropics.

The unit traced its origins back to 1944 when the British began tropical testing of materials in Nigeria in West Africa. At much the same time Australia used various tropical sites, such as Los Negros Island near New Guinea, for the same purpose.



Tropical exposure testing at the Joint Tropical Research Unit, Cowley Beach.

Britain's Tropical Testing Establishment in Nigeria closed in 1958. The British government approached its Australian counterpart with the idea of establishing a joint facility. Agreement was concluded with the United Kingdom-Australia Tropical Research Agreement; the Joint Tropical Research Unit was established at Pin Gin Hill. Another hot/dry site was acquired at Cloncurry, Queensland. Until 1976 general management and operational direction of the unit was exercised by the Chief Superintendent of the Materials Research Laboratories reporting to the Executive Controller of the Australian Defence Scientific Service and the head of the British Defence Research and Supply Staff.

Meanwhile developments continued at the other Service research establishments.

At the **Royal Australian Navy Experimental Laboratory** (RANEL) naval officers filled the post of laboratory superintendent until 1968. All were relatively short-term appointments, with ten serving in the position during the 12-year period. During this time, a senior civilian held the position of Principal Scientist: Ian Gatenby held the position from 1956 to 1958 before he was succeeded by Jack Lonergan, who transferred from the Department of Supply and served in the position until 1964.

RANEL had close links with kindred institutions in the United Kingdom and young scientists completed their training there, like their contemporaries in other defence research laboratories. Jack Lonergan recruited Mal Buckham in 1958, and after only a few days at RANEL, he was sent on exchange to the Admiralty Research Laboratories at Teddington in England where he worked on signal processing applied to passive sonars. Morry Frost graduated from the University of Sydney with a first-class honours degree in aeronautical engineering. He first joined the Aeronautical Research Laboratories in Melbourne in 1958, before transferring to RANEL as a scientific officer in 1960. He began work there in a team investigating the effectiveness of Ikara, an anti-submarine weapon being developed by the WRE.

Morry Frost.

Mal Buckham returned to RANEL in 1961 and with Morry Frost became involved in analysing maritime exercises such as Exercise Tuckerbox in 1961 with assistance from other RANEL staff. Small teams were used for the analysis. Those involved in the analysis of Tuckerbox II in November 1962 were Mal Buckham, Morry Frost, Jack Lonergan and H.R. Barber. Between 1964 and 1967 the group undertook two major 'order of battle' studies for the Navy that led to the extension of their assessment and analysis to encompass all aspects of naval warfare, not simply anti-submarine warfare. They were involved in Operation Seahorse in August 1965. Analyses of such exercises produced a valuable database of system performance that was not only useful in RANEL studies but attracted international interest. Other analyses focused on specific issues such as the effectiveness of Sonar 177/170 fitted to escort ships in anti-submarine warfare screens that the team studied in 1967. The Operations Research Section became formalised as a Group under Mal Buckham's leadership.

Group heads at RANEL. Back (L-R): Chris Charnas, Mike Turner, John Waller, Ian Jones, Charles James. Front (L-R): Bill Hunter, Charles Halton, Morry Frost.

RANEL boasted a professional (12) and technical (19) staff of 31 in October 1965. These were divided into one or other of three scientific groups: the Underwater Physics Group led by Bill Hunter, the Operations Research Group led by Mal Buckham, and the Fluid Mechanics and Underwater Weapons Group led by Mike Turner. The latter group's early work involved the development of the Royal Australian Navy Divers' Underwater Glider and research into mine identification systems before concentrating on research into mine countermeasures. The Engineering Services Group under Eric Kaye, and the Administration Group supported all groups.

The **Army Food Research Station** facilities were expanded from 1965. In 1971, they grew further with the addition of a large experimental processing wing to encompass all three Services. The name changed to the Armed Forces Food Science Establishment.[8]

At the **Tropical Trials Establishment** (as distinct from the Joint Tropical Research Unit) trials were carried out on an ad hoc basis until 1967, with special units being raised as necessary. In 1967 a permanent Army unit was established with a base at Cowley Beach. This unit comprised 112 Army personnel and 40 civilians until 1973.

Aeronautical Research Laboratories (ARL)

Lawrence Percival Coombes remained chief of the ARL until April 1964. He was succeeded briefly by J.B. (Jack) Dance in an acting capacity until Tom Lawrence returned to ARL. Lawrence assumed the position in May 1965 and remained until June 1967. The position proved something of a challenge for Lawrence. He wrote of this time:

I soon learned that there were several loose cannons on the deck. The Central filing system, for example, had been undermined; boffins at all sorts of levels, deemed themselves to be the Establishment's expert on a particular topic, not always of a technical nature, would write off to the outside world on Establishment letterhead, but in their own name, giving advice or undertaking commitments which were demonstrably false or impossible of achievement. Records of such correspondence existed only in private files.

I discovered, for instance, a recommendation that fatigue tests be undertaken on a certain aircraft as a matter of urgency, because calculation showed that all aircraft of that type had already exceeded their estimated fatigue life. But on examination no aircraft showed any evidence of fatigue damage ...

On another matter, an undertaking had been given to supply certain experimental fatigue data by a given date some years hence. When, during my incumbency, that date arrived, but not the data, the customer became rather terse. A simple, back-of-an-envelope calculation soon showed that had all the fatigue testing machines at ARL been devoted exclusively to that particular task, 24 hours per day, 365 days per year, the elapsed time necessary to do all the tests was about twice the elapsed time allowed.[9]

Lawrence did what he could to eliminate the problem, and ensure a measure of accountability, but the issues were typical of a scientific institution where scientists guarded their independence and status. This remained a feature of the ARL culture.

Irrespective of the culture, scientists at Fishermans Bend continued to undertake significant work. The work associated with the Joint Project declined, but relations with the armed Services grew closer and the focus of work shifted to resolutions of specific problems identified by the Services. The Air Force introduced two new aircraft into service during this period—the American designed and built F-111C swing-wing bomber and the French designed Mirage fighter that was built at the Government Aircraft Factory. Both aircraft prompted many research projects. The laboratories were also involved in testing aspects of the Australian designed and built Nomad aircraft. At the same time, scientists from ARL took a greater role in investigating military and civil aircraft crashes.[10]

Australian innovation

This was a time when those articulating Australia's defence needs believed these could be wholly satisfied by buying proven technologies from powerful allies. In these circumstances, the work undertaken by the various research establishments continued largely as before with the range and scope of projects undertaken generally being suggested by scientists themselves, though with endorsement of the Defence Research and Development Policy Committee that undertook regular reviews of programs. Butement recalled the attitude of one senior naval officer towards the concept of Ikara, a guided missile carrying a torpedo that was designed to be launched from a surface vessel and used against submarines. He quoted the naval officer as saying 'What bloody nonsense will they think of next?'[11] However, Butement managed to provide funds for the project and it gained approval in 1959.

Ikara had its origins in work carried out in the early 1950s on the Malkara wire-guided missile and was made possible by the use of a new generation of sonar equipment that extended the range at which submarines might be detected. The Ikara weapon was of two parts, the first being the remote controlled vehicle 3.4 metres long with delta-shaped wings spanning 1.5 metres and powered by a composite boost-sustainer solid motor. This carried an American Mk44 torpedo, 2.5 metres long, that had an active sonar guidance system to enable it to home in on a target. The government approved the program in November 1959 and design and construction of Ikara began the following year. It involved the collaboration of scientists from all defence science laboratories with those at Fishermans Bend led by Murray Evans becoming responsible for designing the remote controlled missile, and its testing, performance assessment, trials planning and evaluation, wind tunnel testing, and manufacture of many prototype parts. Scientists at Salisbury developed the solid propellant rocket motor and equipment for tracking and guiding the weapon during flight. The Royal Australian Navy undertook development of the magazine, handling and launching system while the Government Aircraft Factory, Melbourne, EMI (Australia) Ltd, Salisbury, and approximately 200 sub-contractors provided other assistance.

Trials on scale models were carried out in 1961 and 1962 at Woomera where missiles could be recovered and examined. The first full-size missiles were tested there in April 1963, with sea trials taking place aboard HMAS *Stuart* off shore from Sydney in August 1963. The first production version of Ikara entered service on HMAS *Derwent* in January 1966. Additional development, modification and trialling of the Ikara system followed and ultimately led to the system gaining international recognition. United States authorities closely followed the work and contributed approximately $5 million towards development under the program of Mutual Weapons Development Aid to allied nations. Delivery of modified Ikara systems to the Royal Australian Navy commenced in September 1968, to the Royal Navy in 1972 (with the UK taking delivery of the thousandth Ikara missile five years later) and to the Brazilian Navy in 1978 when it bought a version called Branik. The Royal New Zealand Navy introduced the Ikara aboard HMNZS *Southland*, formerly HMS *Dido* of the Royal Navy, in 1983.[12] Unfortunately, no sales were made to the United States, which meant that the system became relatively costly to produce.

Other work was undertaken at the behest of the Services. For example, during the 1960s the RAAF and the Department of Supply approached the DSL, Maribyrnong, to undertake development of a new thermocouple—a device used to measure and control temperature—that would be consistently stable in a desired temperature range. The DSL became particularly renowned for the high quality of research into alloys with defence applications. Dr Noel Burley and his team produced two new thermocouple alloys that were much more resistant to high-temperature oxidation than other alloys. The two new thermocouple materials, known as Nicrosil and Nisil, were nickel-based alloys containing chromium and silicon, and silicon and magnesium, respectively.

Burley was seconded under the 1968 United States-Australia Bilateral Agreement for Scientific and Technological Cooperation to act as Project Manager at the United States National Bureau of Standards and conduct a collaborative research program to establish the required standard thermal electromotive force data. After six months' research Burnley presented the characteristics of the new thermocouple system at the 1975 European Temperature Conference held in England. The technology used in making this alloy was accepted worldwide and international standards revised accordingly.[13]

Laser research became an important area of study for other scientists at the DSL. A Laser Group was established at Maribyrnong in 1963 with the aim of becoming better informed about the phenomenon of lasers and their potential. The so-called ruby laser was the first subject to be examined. The scientists at Maribyrnong developed new carbon dioxide gas lasers that were powerful, more compact and usable with commercially available gases at moderate voltages, along with new optical components to suit the new lasers. Then, in the 1970s, they designed, built and operated the first electron-beam-controlled carbon dioxide laser, the first continuous wave laser operating at atmospheric pressure and the first laser using plasma injection.[14]

The Technical Cooperation Program (TTCP)

Australian defence scientists benefited a great deal from their international networks that followed the various bi-lateral and multi-national agreements.

Australia remained an important partner in the Commonwealth Advisory Committee on Defence Science comprising British Commonwealth nations, though it gained little from its membership of this organisation. After returning from a visit to the United Kingdom in 1961 and discussing the future of the organisation, Defence Scientific Adviser Sir Leslie Martin suggested that Australia should withdraw. In the event, the Defence Committee agreed to remain a party of a revised format in the interests of Commonwealth relations.[15] Continuing tension and a lack of cooperation between India and Pakistan ultimately led to the committee being disbanded in 1993.

Far more productive was Australia's membership of The Technical Cooperation Program (TTCP). This program originated on 25 October 1957 following an agreement between the President of the United States and the Prime Minister of Great Britain to pursue defence

Jack Dowling (standing left), Des Barnsley, Alan Cooley and Tom Lawrence (standing right) being shown a Gemini capsule simulator at NASA, 23 July 1964.

initiatives in a collaborative fashion. Canada joined soon afterwards when the program was called The Tripartite Cooperation Program. Australia joined the Non-Atomic Military Research and Development sub-committee in 1965 following preparatory work by Des Barnsley, Australia's Defence Research and Development Attaché in Washington. Barnsley was the third to hold the position, his immediate predecessors being George Barlow (1957–60) and Peter Twiss (1960–62). During the course of his term he learned of the existence of TTCP and, after making discreet enquiries, received the suggestion that Australia would be a welcome partner. Negotiations followed involving Sir Leslie Martin and the Department of Defence and paved the way for Australia to join the three nations in the program.

The sub-committee of the Non-Atomic Military Research and Development (NAMRAD) included the heads of defence science and research organisation of the member countries; New Zealand became a member in 1969.

No longer was Australia a mendicant or mere buyer when it came to transfer of defence science and technology. Rather, it was an equal collaborator with partner nations. TTCP provided the means for the various nations to cooperate in the science and technology required for the development of new conventional weapons systems and concepts with the idea of reducing costs and minimising the risk and expense of unnecessary duplication. By 1971, this collaboration was fostered by means of 17 technology and systems groups covering 57 working panels and 43 working groups, members of which undertook collaborative projects. Participation in projects was voluntary, with scientists working according to a 'best efforts' arrangement under which nations had no obligation to make resources available. Each nation appointed an officer to be based in Washington to facilitate cooperation.

The fact that Australia's defence scientists were located in the Department of Supply, rather than the Department of Defence caused some initial confusion in Washington. W.R. (Bill) Watson was seconded from the Long Range Weapons Establishment at Salisbury to the Defence Department with the title of Defence Science Attaché to represent Australia's Department of Defence concerned with TTCP matters. However, Des Barnsley, an officer in the Department of Supply had been involved in early negotiations and was the officer known to the TTCP partners. Moreover, he remained in Washington after having his term as Defence Research and Development Attaché extended to facilitate the arrangement, and to deal with the implementation of the program as it related to scientists within the Department of Supply.

The first TTCP panel meeting convened in Australia was held in Melbourne on 4–6 April 1967. It comprised representatives of the United States, the United Kingdom, Canada and Australia. Australian delegates included representatives from Army, RAAF and Supply. A TTCP Sub-Group meeting interested in the field of military uses of infra-red radiation, followed in Melbourne on 10–14 April 1967 with Dr John Farrands (Acting Chief Superintendent, of the Defence Standards Laboratories) as chairman: business included work-in-progress presentations at WRE and DSL. At this time Australia was particularly interested in developments within the field of night-vision and lasers.[16]

Scientists from each of the major laboratories became involved in various working groups. For example, ARL scientists were involved in working panels and sub-groups concerned with guided missiles, aeronautics technology, ordnance, materials, behavioural sciences and conventional weapons technology.

Australia was also involved from time to time in other international joint arrangements. In 1968, for instance, the Clifford-Fairhall Memorandum of Understanding was signed with the United States, providing for the exchange of personnel under the Engineer and Scientist Exchange Program.

A small number of DSTO scientists enhanced the credibility of defence science with their participation on the battlefield in the Vietnam War. One group applied rudimentary science to intercept enemy communications more effectively than the Americans. Harry Newbigin received an award from the Americans for assisting in discovering Viet Cong tunnels. His work was predicated on the simple premise that the Viet Cong would not dig tunnels through hard rock; studies of the local geology would help locate the tunnels.

Relocation

A major change to the Department of Supply occurred in 1967 when it was scheduled to move its head office to Canberra in accordance with the wishes of the government. Robert Menzies, Australia's Prime Minister from 19 December 1949, had long been concerned at the lack of enthusiasm of parliamentarians for Canberra and the reluctance of public servants to transfer to the bush capital. In 1957 he insisted on centralising departments in Canberra to ensure its physical development. The relocation of defence personnel from Melbourne to Canberra began in 1959 and in January of that year as many as 400 positions were transferred north, along with their incumbents and families. The relocation of defence personnel continued until 1963, when attention turned to other departments. It became the turn of the Department of Supply in 1967.

This caused something of a crisis. Many senior officers comfortably settled in Melbourne preferred to retire rather than move to Canberra. As Tom Lawrence indicated:

> *Canberra, then as now, had a poor image among the uninformed: it was an ingrown public service town without intellectual challenge; there was nothing for the young to do; it had a climate that was harsh on the health of those brought up in the benign climate of Melbourne ...*
>
> *The Department was in some danger of being unable to staff, in Canberra, too many of its senior positions with officers having any prior experience of the Departmental workings.*[17]

George Barlow took the opportunity to transfer to Canberra. He had returned to Salisbury in 1960 after serving as the Defence Research and Development representative in Washington, but in 1965 was appointed Superintending Scientist and transferred to the Department of Supply headquarters in Melbourne. Here he became responsible for collaborating with the armed Services and coordinating research and development programs. He was appointed First Assistant Secretary Defence Science after transferring to Canberra in 1968 and had responsibility for international defence science activities.

Alan Butement was one of those who chose to retire, rather than make the move, though soon afterwards he secured the position of Director of Research for the Plessey group of companies in Australia. His retirement in July 1967 led to the abolition of the position of Chief Scientist within the department. Others, such as Tom Lawrence, who had grown up at nearby Yass and was familiar with the region, took advantage of the relocation to advance their careers and Lawrence volunteered to transfer to the position of Controller, Research and Development, in Head Office in Canberra in January 1968, with responsibility for Australia's defence science.

The relocation prompted a major reorganisation of the Department of Supply. The Production Division was split between Aircraft, Guided Weapons and Electronics Supply and Munitions Supply. Units of the other three divisions, Establishments and General Services; Finance and Contracts; and Planning and Management Systems, were grouped into two divisions, Finance and Management Services and Planning and Procurement. However, the Research and Development Division, now under Controller Tom Lawrence remained largely unaltered. Arthur Wills became Deputy Secretary (Research and Engineering), one of the three public servants in top-level management.[18]

Relocation of the head office of the Department of Supply to Canberra had no immediate or appreciable effect on activities within the defence research establishments spread across the country: they continued to operate as independent agencies. However, the relocation was a necessary first step to make head office control more effective, to promote closer relations with the armed Services, and to foster a more common sense of mission within the various establishments. Decades passed before these objectives were met, but the die was cast.

Russell Whitcher operating laser at Defence Standards Laboratories, Maribyrnong, 1970s.

Ikara guided missile being fired from a ship.

CHAPTER 6

Chief Defence Scientist: 1968–1975

The first tentative step towards consolidation and unification of Australian defence science within the Department of Supply and the appointment of the first Chief Defence Scientist occurred in 1968. This happened at the same time as the United Kingdom and Australian governments negotiated a new agreement that provided for greater separation between the Joint Project and the WRE 'and for a progressive re-allocation of the scientific capability to Australian defence needs'. This in turn led to the development of a defence science organisation within the Department of Defence under the leadership of a Chief Defence Scientist.[1]

These developments occurred against the background of the Vietnam War and the winding down of the Joint Project. Increasing public hostility to the Vietnam War had its repercussions within the scientific community, with a decline in the number of graduates seeking a future in defence science, though this was also a time when there were declining opportunities. Defence scientists continued to work on many projects, but increasingly they became involved in providing military advice to the defence force.

The formation of a new defence science organisation reflected the growing appreciation of the role of science and technology in the selection and acquisition of equipment for the Services. There remained the preference of the military chiefs to procure proven equipment from allies, increasingly the United States. However, this equipment did not always perform according to specifications in the Australian environment. Australia's defence scientists were called upon to address these issues.

Leslie Martin had remained Defence Scientific Adviser and Chairman of the Defence Research and Development Policy Committee from 1948 to 1968. He had also served as a member of the Australian Atomic Energy Commission from 1958 to 1968. For his services he had received the Order of the British Empire in 1954, and a knighthood in 1957.[2]

Martin's role as Defence Scientific Adviser had been part-time only. On his retirement, the Secretary of the Department of Defence Sir Henry Bland believed the time was right for a full-time appointment and creation of a separate Division of Defence Science. Howard Arthur Wills was appointed to the newly created position of Chief Defence Scientist and head of the new division within the Department of Defence in May 1968: Tom Lawrence succeeded him as Deputy Secretary of the Department of Supply. Wills now became the principal adviser on scientific and technical matters to the Defence Committee, the Chiefs of Staff Committee, the Defence Force Development Committee and the Defence Group of Departments.

Arthur Wills had briefly succeeded Alan Butement as Chief Scientist within the Department of Supply in 1967. He had become Assistant Controller, Research and Development, in the Department of Supply (1951–55); Chief Executive of the Atomic Weapons Tests (1955–57); Deputy Controller, Trials and Instrumentation (1958–63); Controller Weapons and Space Research (1963–64); and Controller Research and Development (1964–66).[3]

‹ Anchor recovered from HMB Endeavour, 1972.

The primary function of the Division of Defence Science, presided over by the newly appointed Chief Defence Scientist, was to assume responsibility for reviewing and coordinating research and development programs of the three Services and those carried out within the Department of Supply, and advising on Service equipment requirements. The initiative was meant to provide greater coordination and cooperation between various research and development agencies though this was complicated because agencies remained in different departments and reported to different departmental heads.[4] The major defence science establishments, for instance, remained within the Department of Supply, and Wills' only formal means of direction was via the Defence Research and Development Policy Committee that he chaired.

In 1971, the various research establishments were grouped within the Research and Development Division of the Department of Supply reporting to Alan Sharpe, Controller, Research and Development, who, in turn reported to Tom Lawrence, Deputy Secretary (Research and Engineering) and through him to the Secretary of the department, Alan S. Cooley.[5] Sharpe led a team of five first assistant controllers responsible for Aero-science, Joint Project and Space, Programs, Weapons Systems, and Requirements Assessment and an assistant controller responsible for American Projects.

Weapons Research Establishment (WRE)

Most of the major defence science laboratories continued, as previously, under the new arrangements though there were significant changes within the WRE at Salisbury following renegotiation of the Joint Project Agreement in 1968.

The new agreement between the Australian and British governments in 1968 prefigured greater Australianisation of the Joint Project, with Britain becoming more of a customer than a partner. Scientists previously wholly engaged in Joint Project work were redeployed to Australian defence projects as the Joint Project work was scaled down: the various disparate units were rationalised and incorporated into the Applied Physics Wing under Emlyn Jones and the Trials Wing under Mervyn Kirkpatrick, with the latter becoming totally responsible for all continuing Joint Project work. The laboratories at Salisbury that had been developed in an *ad hoc* manner to support the Joint Project and undertake Australian research were allocated between the newly created Applied Physics Wing and Weapons and Research Development Wing under F.G. (Sandy) Blight. With the Engineering (E.B. (Ted) Davis) and Administrative (A. Rodbourne) wings, they focused primarily on Australian defence research and development programs, and charged for any services provided to the Joint Project. All immovable property at Salisbury was transferred to Australia, and ownership of the Edinburgh Airfield was transferred from the Department of Supply to the Department of Air for use as a Royal Australian Air Force base later in 1968.

WRE relinquished responsibility for the space tracking stations to the central office of the Department of Supply on 20 January 1969. This was not directly identified with the new agreement but was in line with the developing policy on defence science.

Dr M.W. (Don) Woods, Director of the WRE from 1965 to 1976, had the challenge of managing the realignment of priorities.

By 1971 the key divisions and areas of research were:

Applied Physics Wing (Emlyn Jones)
Electronics (R.J. (Bob) Dippy)
Systems Analysis (J.W. (Jim) Crompton)
Optics and Surveillance (John E. Clegg)

Engineering Wing (E.B. (Ted) Davis)
Workshops and Mechanical Design (J. Gordon Brookman)
Communications and Electronics Engineering (John E. Lamprey)
Engineering Services (John D. Murray)

Trials Wing (Mervyn S. Kirkpatrick)
Area Administration—Woomera (Lt Col C. Duke)

Weapons Research and Development Wing (Frank G. (Sandy) Blight)
Aerospace (Peter M. Twiss)
Propulsion and Marine Physics (Dr Cyril L. Cook)
Weapon Systems (Elgar D. Treharne)

The heads of the various wings were classed as Deputy Directors: the leaders of the divisions were superintendents. This differed from the other research laboratories that were led by a Chief Superintendent, to whom the divisional heads, the superintendents, reported.[6]

The science continued despite the administrative changes. Black Arrow testing began at Woomera in 1969. Black Arrow was a small British satellite launcher vehicle that was first fired from Woomera on 28 June 1969. The British satellite Prospero was successfully launched from a Black Arrow at Woomera on 28 October 1971 into a near-polar elliptical orbit close to that planned. This was the first time a British satellite had been put into orbit from an all-British launcher vehicle.[7] Black Arrow testing continued until 1978.

WRE scientists continued to be involved in innovative work, not all of it focused exclusively on military applications. For example, they pioneered the application of laser research to terrestrial mapping following a commission from the Department of National Development, Division of Mapping, for a system to aid its topographical survey of land surface profiles in Australia. This followed from research led by Fred F. Thoneman into the use of laser technology soon after the discovery of lasers in 1960. The profiler that was fundamental to the system was designed by M.F. (Mike) Penny and developed in the period from 1968 to 1974. It comprised a rigid structure that was fitted to an aircraft, in which was mounted a laser transmitter, a receiving telescope and a

Black Arrow being prepared for launch, Woomera, 1970s.

strip camera to photograph the ground immediately below the aircraft. A receiving telescope collected a small fraction of light from the transmitter and the distance between aircraft and ground could be established after measuring time taken for transmitted light to be received by the aircraft. The strip camera recorded the precise track of the laser beam across the ground on 70-millimetre film.

An experimental model of the system was constructed and installed in a Dakota aircraft in the spring of 1969 during the initial design and development phase. Trials continued, most notably those carried out in February 1970 when the Dakota was flown to Lake Eyre, South Australia. Microwave terrain profilers had been in existence since the mid-1940s. However, the horizontal resolution and the measuring accuracy were poor when compared to a laser profile. The system named WREMAPS was mounted in an aircraft and, operating at 2000 metres above the ground, could record profiles of the terrain to an accuracy greater than half a metre.

The Department of National Development formally accepted the system on 12 July 1970 and continued to use it for 10 years.

Meanwhile, the WREMAPS technology was improved to produce an even more efficient system. WREMAPS-II was designed for the Department of the Army, in the early 1970s, and went into service with the Royal Australian Survey Corps. It was able to measure and record ground profiles from aircraft flying at altitudes of 5000 metres above ground level. Ultimately, Fairey Australasia Pty Ltd was appointed as the licensed manufacturer of the equipment.[8]

Aeronautical Research Laboratories (ARL)

Dr John Law Farrands succeeded Tom Lawrence as Chief Superintendent of the ARL at Fishermans Bend in October 1967, after Jack Dance had once again filled the role in an acting capacity. Farrands had been born in Melbourne on 11 March 1921. He had graduated from the University of Melbourne with an honours degree in Science in 1941 before serving in the Australian Army, rising to the rank of Captain in the Corps of Electrical and Mechanical Engineers. He joined the Department of Supply after the war as a physicist in the Munitions Supply Laboratories and, in 1951, gained a Commonwealth Public Service Scholarship that enabled him to undertake postgraduate studies in physics at the University of London. He returned to the DSL in 1953 with a PhD and a diploma from the Imperial College in Electrical Engineering. He worked as Scientific Adviser to the Military Board (1957–61) and as assistant controller in the central office of the Research and Development Division of the Department of Supply (1961–64), when he was appointed Superintending Scientist in charge of research programs at the DSL. When Farrands became Chief Superintendent of the ARL in 1967 the organisation was primarily concerned with research into aerodynamics, structural design of aircraft and missiles, propulsion and general engineering and materials.[9] Farrands succeeded Arthur Wills as Chief Defence Scientist on 8 November 1971 and his position as Chief Superintendent of the ARL was assumed by Frank G. (Sandy) Blight in February 1972.

At this time the various divisions and areas of research were: Aerodynamics (C.E. Kerr), Materials (Dr H. Laurie Wain), Mechanical Engineering (Tom S. Keeble), Structures (Jack Dance), Systems (J. Murray Evans) and Engineering (A.G. Jones).

Aerial view of Aeronautical Research Laboratories, Fishermans Bend.

The Ancient Aeronauts, 1993. Front L-R: David Humphries, Fred Hooke, Alan Edwards, Sandy Blight, John Farrands, Jack Dance, John Wisdom, Tom Keeble, Wynford Connick, Peter Bullen. Back L-R: Gordon Long, Murray Evans, Len Samuels, Laurie Wain, Derry Stewart, Francis Fox, Bob Ward, Dave Secomb.

Defence Standards Laboratories (DSL)

During this period, the DSL was engaged in a broad range of research and development activities in support of the Services.

In 1970, Alan R. Edwards succeeded Francis Fox, who had been Chief Superintendent of the laboratories since 1957. He also had responsibility for branches in New South Wales and South Australia and the Joint Tropical Research Unit in Innisfail, Queensland. Edwards had been born at Elsternwick, Victoria. Educated at Ivanhoe Grammar and Scotch College, he gained a degree in metallurgical engineering from the University of Melbourne. He joined the Supply Research laboratories in 1941 at a time when the Metallurgy section had three professional staff. He was seconded to the British Ministry of Aircraft Production (1944–46) to learn about metallurgical technology of jet engines. Upon his return Edwards joined ARL and began research into chromium and its alloys. He was promoted to Superintendent of the ARL Materials Division in 1960 and became national leader of the Materials Sub-group after Australia became a partner in TTCP. He was also active in the (British) Commonwealth Advisory Aeronautical Research Council: he set up the inaugural meeting of that organisation's Field of Materials in 1965.[10]

The various divisions and areas of research in 1971 were: Metallurgy (Dr Leonard E. Samuels), Organic chemistry (A.J.C. Hall), Physical Chemistry (Dr J.G. Minkoff), Physics (Jamie A. McDonald) and Research Programs (Dr P.W. (Bill) Bowe).

The laboratories were also responsible for the development and maintenance of standards in metrology, electricity, electronics and materials generally and provided specialist analytical and testing services and was involved in precision measurement, calibration, check-testing and advisory services.[11]

Not all the work of the laboratory scientists was concerned exclusively with military research. In 1969 and 1970 DSL scientists demonstrated the breadth of application of their expertise in metallurgical research when they undertook the conservation of the cannons that were lost from Captain Cook's barque HMB *Endeavour* during the course of his exploration of the Australian coast. Having completed his task of observing the transit of Venus in the South Pacific, Cook continued sailing to the west, extensively charting New Zealand before making landfall on the eastern side of the 'great southern continent', Australia, arriving near what is now known as Cape Everard on 19 April 1770. Cook explored and charted this, naming Botany Bay before proceeding north along the eastern coast of Australia. On 10 June 1770, the *Endeavour* grounded on a coral reef and, in order to free the ship, Cook and his crew jettisoned almost 50 tonnes of material, including six cannons. This material remained undisturbed on the Great Barrier Reef near Cooktown for the following 200 years until an American team from the Philadelphia Academy of Natural Sciences located four of the cannons and some ballast.

Metallurgists at DSL were asked to help restore the cannons and, in January 1969, following removal of coral up to 183 centimetres thick, the first of the material was recovered. This included six four-pounder cast iron cannons, each weighing approximately 610 kilograms, and nine tonnes of pig iron and stone ballast. The cannons were taken to Maribyrnong and, under the leadership of Dr Colin Pearson, the thick outer layer of coral was removed using a carefully controlled electrolysis process. This revealed the royal cipher with crown and monogram GRII, and the proof and gun founder's markings. In 1970, on completion of the restoration, Australian Prime Minister, John Gorton presented the cannon to representatives of the Commonwealth, Queensland, New South Wales, New Zealand, Britain and the United States.

Cannons from HMB Endeavour, before and after restoration, 1972.

The *Endeavour's* anchor was retrieved in 1972 and this, too, was taken to Maribyrnong and painstakingly restored using the same process as had been used on the cannon.[12]

In recognition of the nature of the work undertaken at the laboratories with greater emphasis on materials research, the name of the DSL was changed to the Materials Research Laboratories in 1974 at the time of another departmental re-organisation.

Defence studies

Meanwhile, there had been a departure from the traditional activities of the laboratories with the development of operational research studies. This had begun in the early 1950s following the demonstration of the effectiveness of operational research during World War II. The early work at the WRE and the ARL involved theoretical studies in which mathematical modelling was applied to issues previously studied in a qualitative way. The greater sophistication of weapons and the mounting costs of their development and testing encouraged the new direction of research that was facilitated by advances in computer technologies. This represented more sophisticated work than that undertaken by Ralph Cartwright.

A small group of ARL scientists was formed at the end of 1950 in the department's head office to study issues associated with anti-tank guided weapons. The pioneers had little literature to guide them, and no support from universities that had yet to recognise the emerging discipline. The computer modelling led to the development of board games and sand-table games, and the secondment of Service personnel to provide more relevant information upon which to base assumptions. Key personnel at this time were Neville Hurst, Bill Howitt, Brian Gilroy and Gus Schaefer.

The new WRE studies were associated with guided weapons and were based on mathematical descriptions of their behaviour based on the launch, flight path, operation of the fuse, and effect of the warhead on the target. Key personnel at Salisbury were Alex Biggs, Max Possingham, Brian Ford and David Strahle. Their work grew and gained greater credibility as the power of digital computers increased.

Operational studies had also been undertaken in other research establishments, most notably RANEL where Morry Frost and Mal Buckham were pioneers. In 1961, for instance, they began work on an assessment of anti-submarine warfare escort requirements for the Navy. In 1964, they produced a report on an anti-submarine battle model and, two years later, another on the cost and effectiveness of helicopter carriers in escort groups.

The basic tools for operational studies were common to the various laboratories and as early as 1960 scientists from the ARL and RANEL collaborated in an investigation of the defence of small convoys and the extent to which guided weapons might be used.

Plans were mooted in late 1967 to establish a Central Studies Establishment in Canberra to undertake operations research, namely 'the analysis of complex situations involving both men and machines, by techniques similar to those used in the physical sciences.'[13] It was envisaged as the nucleus of an activity that might become a research and development establishment in Canberra that was close to the headquarters of the Defence Department and that of Supply. The proposal was to build the unit based on the Operational Effectiveness Group at ARL and the group known as System Studies 3 at Salisbury. It was proposed that the military Services would avail themselves of the group.[14]

Limitations the government imposed on the numbers of personnel able to be moved to Canberra meant creation of the unit had to be postponed until March 1969 when the Central Studies Establishment was created. It was located at Lyneham in metropolitan Canberra, though did not begin its effective life until Bill Watson became Superintendent in December 1969 after his term as Defence Science Attaché in Washington. Inaugural staff were drawn from the ARL and the WRE. Within two years staff numbers grew to 36, of whom 19 were professional scientists. The establishment was divided into two study groups, one led by Neville Hurst, the other by Dr H.E. (Harry) Green with staff being allocated to teams, each tasked with particular issues.

Already there were staff with broad experience in operational research. Tony Taylor had worked on military operational research studies for the Royal Naval Scientific Service, NATO, the United Kingdom Ministry of Defence and the Plessey Company; Bill Davies had also spent time on military operational studies with NATO; and Clive Landau had spent 15 months on secondment to the United Kingdom's Defence Secretariat of the Ministry of Defence. Dick Body and Darryl Powell were recruited after completing studies at the Australian National University. Officers on secondment from the Services provided valuable information and officers attending Service exercises also collected data.[15]

Since much of the work of the Central Studies Establishment was to be undertaken for the defence forces, the various scientific advisers were to be important links to Service personnel and complementary operational studies groups established by the Services.

Ralph Cartwright fulfilled this role for a time after being appointed Air Force Scientific Adviser in 1967. He became involved in many ongoing studies, especially those concerned with structural issues concerning the F-111 that Australia had committed to buy. He was also involved in the area of structural fatigue with the Hercules aircraft, and an operational research study considering ways of rationalising the inventory of spares. H.V. Nesbitt was Scientific Adviser to the Military Board in 1971 with S. Howen the Tactical Trainer Project Director for the Department of the Navy.

Though they had no formal structure and only an informal relationship with the Chief Defence Scientist, the various scientific advisers were in a key position to promote the defence research establishments generally; they had the ability to suggest potential projects that were of interest to the Services; and they talked directly to the most senior personnel within the Services and those who made decisions about procurement.

Defence policy

The work of the defence scientists in the several research establishments had by now become more consistent with the prevailing national defence policy. This took on a new direction with significant implications for the defence science establishments, following the election of a Labor government on 2 December 1972 after a generation of successive conservative coalition governments. Almost immediately, on 19 December, the Minister for Defence Lance Barnard announced plans to reform defence management, primarily by abolishing the separate Service departments and the defence functions of the Department of Supply, and uniting these within the Department of Defence.

Sir Arthur Tange, who succeeded Bland as Secretary in 1970, was charged with implementing the reorganisation in the face of Service chiefs who feared a diminution of their power and heightened tension between Service and civilian personnel. Tange persisted and presented his *Australian Defence: Report on the reorganisation of the defence group of departments* to Minister Barnard in November 1973, outlining his restructuring plans. The restructuring that followed was a virtual revolution in defence management. Numerous boards and committees were abolished with statutory powers having to be reallocated to new committees. Finally, control of the new institution was divided between the Chief of Defence Force Staff and the Secretary of Defence. Both partners in the diarchy would share administrative responsibilities, but only the former would have command responsibilities.[16]

A major recommendation of the report was that of bringing into the Department of Defence specific areas of the Department of Supply, particularly those agencies concerned with research and development. These were to form a specialist ‘Defence Research, Development, Trials and Evaluation Organisation’.

Tange's report provided a snapshot of the major defence science agencies at the time:

	Staff Employed	
	Professional	Other
Weapons Research Establishment	520	3850
Defence Standards Laboratories	240	640
Aeronautical Research Laboratories	200	400
Central Studies Establishment	40	15

Additional staff at other smaller laboratories and trials units included about 1000, of whom about 200 were professional people.[17]

Tange observed of the major laboratories:

> *Although originally established in aid of defence factories, the Defence Standards Laboratories (DSL) has evolved in function in such a way that only about one fifth of its activities is now on factory support. Aeronautical Research Laboratories (ARL) has even less work in support of the factories. Although the Government factories and industry receive important assistance from the Defence Standards Laboratories and Aeronautical Research Laboratories, this small fraction of the resources of the laboratories does not demand the full breadth of the skills and knowledge of the laboratories. The interests of the Services determine the full range of skills and knowledge in the laboratories, and absorb the major part of their capacity.*
>
> *It is a logical conclusion that these laboratories should be re-grouped more closely to the Services, along with the Weapons Research Establishment and individual laboratories located in the Services.*[18]

In accordance with Tange's report, the separate Service departments were abolished on 30 November 1973 though the formal implementation of the amalgamation had to await passage through Parliament of the Defence Force Reorganisation Bill in September 1975. Meanwhile, the reorganisation of the various defence research establishments proceeded.

The government abolished the Department of Supply on 11 June 1974 and established the Department of Manufacturing Industry the following day, incorporating the former Department of Supply and the Department of Secondary Industry. In accordance with a government decision concerning defence restructuring made late in 1973, interim arrangements were made for operational control of research and development programs and units within the Department of Manufacturing Industry to be transferred to the Department of Defence on 1 July 1974, and to come under the direct jurisdiction of John Farrands, Chief Defence Scientist since November 1971. The establishments involved comprised the Australian Defence Scientific Service that included the WRE, Salisbury and Woomera; the DSL, Maribyrnong, Alexandria and Woodville North; the ARL, Fishermans Bend; the Central Studies Establishment, Canberra; and the Joint Tropical Research Unit, Innisfail. The arrangement involved about 5600 people.[19]

Under the new arrangements, the former Research and Development Division of the Department of Supply joined with the Division of Defence Science within the Department of Defence and became known as the Defence Science and Technology Organisation (DSTO), with plans of integrating the research and trial units of the armed Services. The change was essentially an administrative one and had no appreciable effect on activities of the several laboratories in the short term.

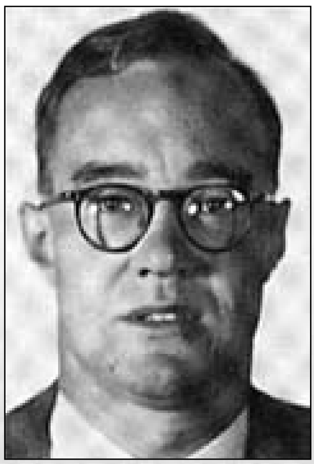
However, the reorganisation wrought a fundamental change in the role of the Chief Defence Scientist. While remaining responsible for providing advice to the government and the Chiefs of Staff, he increasingly became involved in managing the new organisation. John Farrands presided over the central office in Canberra in accordance with the new structure approved by the Public Service Board. He was supported by two Executive Controllers—George Barlow dealing with Program Planning and Policy, Military Studies and Operational Analysis, and Services Laboratories and Trials; and Jack Lonergan having responsibility for the various laboratory programs.

The several Service scientific advisers along with the Central Studies Establishment were to be grouped within a separate Military Studies and Operational Analysis Division.

Relocation of the various defence science establishments within the Department of Defence represented a major milestone in fostering closer relations between the nation's defence scientists and the armed Services. At the same time, the appointment of a Chief Defence Scientist with administrative as well as policy responsibility for defence science in Australia represented a major step in fostering greater financial accountability within the Australian Defence Scientific Service and enhancing head office control, with the concomitant weakening of the independence of establishments. The trend was to continue.

Jack Lonergan.

Dr John Farrands, Chief Superintendent, Aeronautical Research Laboratories, 1967–1971; Chief Defence Scientist, 1971–1977, and later Secretary of the Department of Science.



George Barlow.

CHAPTER 7

Defence Science and Technology Organisation: 1974–1985

The new DSTO was established at a time when Australia's defence policy was under critical review. The long-standing notion of forward defence was, by the early 1970s, no longer sustainable. The British government decided to withdraw its forces from areas east of Suez in January 1968. In 1969, the USA declared the Guam Doctrine of limited commitment in which it offered its allies protection from attacks from superpowers but left them to contend with regional issues. The USA withdrew from Vietnam in April 1975.

The Federal Labor government that came to power in December 1972 fostered a different policy, based on the notion of self-reliance and the priority of defending Australia's territory and approaches. The details and implications of this new policy took time to be clarified though there were immediate implications for Australia's premier defence research establishments when the government decided to restructure the Department of Defence. The Whitlam Labor government was sacked on 11 November 1975 and the Fraser coalition government triumphed at the polls on 13 December, but the new government retained the key features of the Tange reforms of the Department of Defence. Just as significantly, the Fraser government maintained the defence policy developed under Whitlam.

Creation of the new DSTO under the management and control of the Chief Defence Scientist and within the Department of Defence represented the most decisive initiative to date to unify Australia's defence science establishments and make them accountable to the nation's defence needs. It became the task of Chief Defence Scientist John Farrands to infuse the new organisation with an appropriate culture.

In early January 1975, the new organisation comprised four basic units, namely the laboratories of the WRE in Salisbury; the Materials Research Laboratories at Maribyrnong; the ARL at Fishermans Bend; and the Defence Science Administration in Canberra. The central office comprised a Programs and Administrative Division responsible for overall management of DSTO programs and resources and international cooperative arrangements; a Projects and Analytical Studies Division—that included the Central Studies Establishment—responsible for management of major projects, analytical studies and relations with other national science and technology agencies; and the offices of the three Service Scientific Advisers.[1]

The several laboratories remained independent establishments with separate administrations. Scientists from the separate laboratories collaborated closely on particular projects but the cultures of the laboratories remained distinct. The only common interests of the laboratories were a suspicion of and frustration with the bureaucratic demands from Canberra. New administrative arrangements did not lead to new collegiate activities beyond those required concerning collaboration on projects. Don Sinnott, who had joined WRE in 1967, recalled a comment of Director Don Woods, 'There are 700 miles between here and Canberra. That is one of the benefits': but then Woods was answerable to the Joint Project management rather than Australian authorities. In the same vein Sinnott recalled early advice from Bob Dippy, a divisional superintending scientist, 'See what you can do despite the system.'[2]

‹ Sea trials of the Kariwara slim-line buoyant fibre towed array.

A Services Laboratories and Trials Division

The final elements of the new DSTO were brought together on 28 January 1975 with the formation of the Services Laboratories and Trials Division under the management of a two-star Service officer, in the first instance, Air Vice Marshal Rodney Noble. The new division essentially included the various Service laboratories and trial agencies. It was formed following the amalgamation of the Army Design Establishment, the Armed Forces Food Science Establishment and the Tropical Trials Establishment, two naval establishments—the Royal Australian Navy Research Laboratory and the Royal Australian Navy Trials and Assessing Unit—and one non-Service establishment—the Joint Tropical Research Unit.[3] Other defence research establishments such as the RAAF's Aircraft Research and Development Unit based at Laverton, Victoria, and the joint RAAF/Army Air Movement Training and Development Unit based at Richmond, New South Wales, remained independent of DSTO, though often worked closely with it.

The new arrangement conformed with recommendations of the 1973 Tange Report that highlighted duplication in many research initiatives undertaken in the cause of national defence. The several establishments were brought together to reduce duplication, to create links with larger defence research units and to provide better access to the research of the Services. The new division included about 100 Service personnel from all three Services and about 570 civilians.

The Army Design Establishment had been renamed the Engineering Design Establishment on 1 December 1974 when it became responsible for design functions for all Services. The name changed to the Engineering Development Establishment in 1977.[4]

The Joint Tropical Research Unit transferred to DSTO's Service Laboratories and Trials Division on 1 July 1976. The following year, on 24 October 1977, it merged with the Tropical Trials Establishment situated at Cowley Beach in Queensland to form the Joint Tropical Trials and Research Establishment headquartered at Pin Gin Hill. The Director of the Materials Research Laboratories provided technical oversight.

Transfer of the Royal Australian Navy Research Laboratory (RANRL)—the name of the Royal Australian Navy Experimental Laboratory since 1969—from Navy administration to the Services Laboratories and Trials Division of DSTO meant no change of function for the research laboratory and the close relationship with Navy remained, though later that year, on 1 July 1975, staff transferred from employment under the Naval Defence Act to the Public Service Act. Otherwise, arrangements changed little. The Royal Australian Navy Research Laboratory remained a civilian organisation but Navy personnel continued to work there on secondment, mainly within the Operations Research Group in order to provide operational expertise. The RANRL comprised four scientific groups at this time, all of which had broadened their research fields. For instance, the research interests of the Underwater Physics Group had extended to include sonar systems and sonar signal processing that led to the development of a Sonar Cell within the Group in 1971. This was formalised in 1973 when John Waller, recruited on 1 September 1967, was appointed head of a separate Sonar Group.

The Operations Research Group in Sydney, led by Morry Frost, had become increasingly important. It had three main functions during the 1970s: (a) to develop analytical models of various military situations such as the performance of detection systems and weapons systems for use, as required, in specific studies; (b) to analyse military exercises and provide participants with authoritative information on what happened in the exercise and to provide the analysts with the most valid data possible to use in analytical models; and (c) to analyse situations as required by Naval staff using analytical models and a range of other techniques such as computer simulation. The group was divided into four small sections: War Studies, Submarine and Anti-warfare Studies, Above Surface Studies and Exercise Analysis.

The analysis of Exercise CORAL Sands had been a particularly large study. From 1969 to 1971 the group had been involved in a Destroyer Study that was the first major attempt to assess the operational tasks of a class of ship considered for acquisition by the Navy. This developed into several projects involved with new acquisitions such as guided missile frigates (the FFG class ships), the Orion P-3 aircraft upgrade and new submarines.

At other levels

The restructuring of DSTO was complete on 1 July 1975 when the research and development agencies of the Department of Manufacturing Industry came under full policy, administrative and technical control of the Department of Defence, though the legal transfer of these establishments had to await legislative amendment.

At the same time, the Defence Research and Development Policy Committee was replaced in July 1975 by a smaller body, the Defence Science and Technology Committee which was expected to be more appropriate to the department's broader objectives. It was chaired by the Chief Defence Scientist and comprised senior Service officers and senior civilians who had an advisory role on defence research activities and provided a forum for consideration of a wide spectrum of scientific and technological matters of continuing or particular defence interest.[5]

DSTO continued to have a Counsellor Defence Science in Washington and a Defence Scientific Technical Representative in London.

Other changes

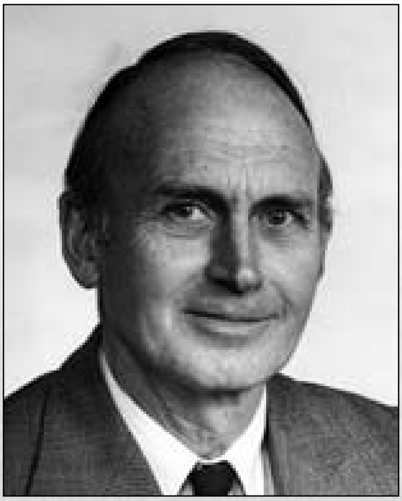
The 1968 Stonehouse agreement concerning the Joint Project, with extensions, continued until 30 June 1976 when it was superseded by a new four-year agreement, based on the wish of the United Kingdom to withdraw from the relationship following completion of current trials. Under the new arrangement, effective from 1 July 1976, management of the Woomera township was separated from the Salisbury organisation, the rocket range and its facilities at Woomera. The two units became known as the Woomera Support Area and the Trials Resources Area, both within the Trials Wing. British trials at Woomera finally ceased in 1978. The Woomera range was reduced to a care and maintenance condition consistent with continuing requirements of the Joint Project, and any Australian requirements. By this time there was a substantial American presence at Woomera associated with the Joint Defence Space Communications Station at Island Lagoon.

Other changes followed the last British trials under the Joint Project in 1978. On 3 April 1978, the WRE ceased to exist and became known as the Defence Research Centre Salisbury managed by Chief Superintendent James Woodhouse Crompton, formerly Superintendent of the Systems Analysis Division of the Applied Physics Wing. The separate wings were abolished and replaced by four laboratories—Weapons Systems Research Laboratory, Electronics Research Laboratory, Trials Research Laboratory and Advanced Engineering Laboratory—with the heads reporting to the Chief Defence Scientist. Administratively the Defence Research

Centre Salisbury was a loose federation of laboratories with the heads forming a committee to advise on management of the site as a whole, and the chairmanship being rotated among them. The reorganisation marked the total focus of these laboratories on Australian-only projects.[6] At this time staff comprised about 5400 civilians and 130 Service personnel. The Joint Project officially continued until 30 June 1980 though the work of the centre focused completely on research for Australia's defence needs.

There were changes, too, concerning the Materials Research Laboratories, where Alan Edwards had responsibility. The South Australian laboratory at Woodville North transferred to the CSIRO Division of Manufacturing Science and Technology in 1977. Meanwhile, the research activities of the Munitions Supply Laboratories at Alexandria in suburban Sydney had been transferred to Maribyrnong in 1974 and what was left was renamed the Materials Testing Laboratory in 1979. By this time the laboratory concentrated on providing scientific services to government and industry. In 1982 the Sydney annex had a staff of 39. Its relatively small size and separation from the main laboratories in Melbourne promoted inefficiencies. The Alexandria facilities were ultimately transferred to the Army in 1985.

Bloodhound anti-aircraft missile on its launcher, Woomera.

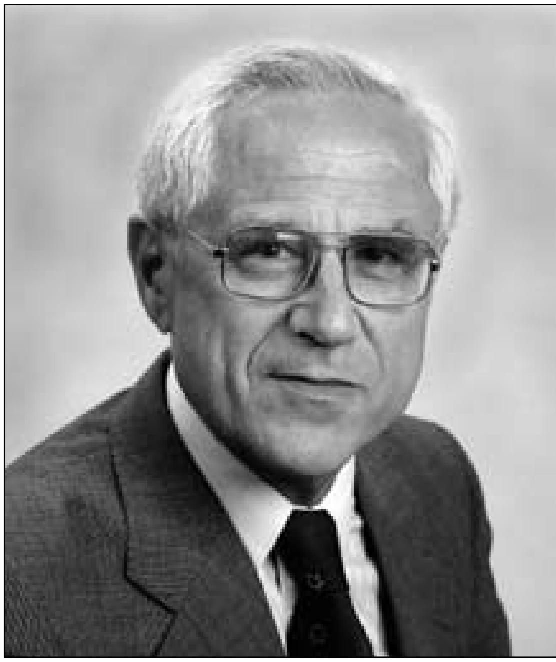


James Crompton, Chief Superintendent, Defence Research Centre Salisbury, 1978.

Two-stage Skylark sounding rocket, Woomera. The Skylark launcher was built from Bailey bridge panels and shipped to Woomera in sections.

Aerial view of the DSTO Salisbury site looking to the north, 1970s.

Under new management



Professor Tom Fink, Chief Defence Scientist, 1978–1986.

Professor Peter Thomas Fink became Chief Defence Scientist in 1978 after John Farrands was appointed Secretary of the Department of Science and the Environment.[7] Tom Fink's appointment was somewhat unusual in that he was an academic and had had no formal association with Australian defence science until being persuaded by Sir Arthur Tange, Secretary of the Department of Defence, to accept the position. Fink's main area of expertise was the physics of fluids. A New South Welshman, born on 12 October 1922, he had studied aeronautical engineering at the University of Sydney and, soon after graduating, travelled to the United Kingdom to work at the Imperial Defence College in London. Fink returned to the University of Sydney in 1959 as Professor of Mechanical Engineering and later became Dean of the Faculty of Engineering. In 1968, he moved to the University of New South Wales as Professor of Engineering and Dean of Engineering.

Fink soon had a detailed understanding of DSTO because one of his first tasks was to chair an internal review into objectives and procedures of the organisation following the Coombs Royal Commission on Australian Government Administration announced on 13 November 1979. The Fink review was conducted concurrently with an independent external review of DSTO chaired by Dr Albert Lloyd George Rees, former chief of the CSIRO Division of Chemical Physics. The two committees developed and maintained close liaisons and together the reviews represented the fifth in a series that focused on government-funded science agencies.

Fink was assisted in his review by retired Air Vice Marshal J.C. Jordan and Ray Finnegan. The review was primarily concerned with providing an assessment of the reorganisation of defence science carried out in 1974 and 1975 and making recommendations for the future. They concluded:

> *Our overall impression of DSTO is of an organisation which has adapted well to its integration into the Defence Department, has absorbed satisfactorily the rundown of the Joint Project and has adjusted sensibly to the economies required of it in accordance with the Government's policies.*[8]

However, the authors observed elsewhere:

> *If there was a common Defence view of DSTO it was that the Organisation provided a satisfactory service, but sometimes failed to understand Service needs and policies and to align its activities sufficiently closely with the needs of the Services. Conversely DSTO felt itself insufficiently understood by the Services, particularly in relation to its longer-term capabilities, and felt they tended to look to DSTO too much for remedies rather than initiatives.*[9]

The review highlighted one of the long-term conundrums concerning DSTO: that of the frustrations of scientists within the organisation because of their wish to undertake research they believed important with minimal external constraints, as opposed to the government's need for research that would directly enhance the nation's defence capabilities, and the Public Service need for accountability.

The scientists urged that DSTO be made a separate statutory authority similar to the CSIRO and free of Public Service constraints in order to maximise its effectiveness as a scientific research agency. The reviewers rejected this idea completely, arguing that DSTO should remain an integral part of the Department of Defence and efforts be made to minimise any inefficiencies.[10] Those arguing for the status of a statutory authority failed to appreciate the internal politics of the Department of the Defence, the fierce competition for funds and the relatively small size of DSTO, and not least, the clear advantages of having defence scientists integral to the department.

The review also noted continuing inefficiencies deriving from the largely independent historical development of the main laboratories but made no major recommendations concerning them, though it did dismiss the idea propounded in the Tange Report that they be reorganised into separate laboratories concerned with maritime, land and air warfare issues.

However, the review did recommend the disbandment of the Services Laboratories and Trials Division. The several establishments had little in common and their notional grouping in 1975 had not promoted cooperation. Moreover, the idea of having a Serviceman as Controller meant there was regular and frequent turnover of personnel. Rodney Noble who remained in the position until 1979 was the longest serving Controller. He was followed briefly by Air Vice Marshal Lyndon Spencer Compton in 1979, and by Rear Admiral Darryl Frederick Lynam from 1979 to 1980, then by Colonel William J. Slocombe.

The internal review recommended that the Royal Australian Navy Research Laboratory, whose research staff required the same academic standards as those in the major laboratories, be given the status of an independent laboratory. The Armed Forces Food Science Establishment was also considered a distinct agency that should become an outpost of DSTO's central office, while the Materials Testing Laboratory in Sydney, though no longer undertaking research, should be associated with the Materials Research Laboratories. The committee recommended that the Engineering Development Establishment be returned to the Army, though with some of the engineering tasks associated with explosives and ammunition being retained within DSTO. The several test and evaluation establishments—Trials Research Laboratory, Royal Australian Navy Trials and Assessing Unit and the Joint Tropical Trials and Research Establishment—were grouped in a new Test and Evaluation unit within DSTO Central.

Dr George Rees had assistance from Professor Alan Reginald Billings of the University of Western Australia and Dr Keith Thomas Farrer, Chief Scientist at Kraft Foods, in conducting the independent external review of DSTO. The three brought to bear long experience in the areas of science and technology from the viewpoints of academia, industry and government. Their aim was to 'examine the quality and research content of DSTO's work, its effectiveness in meeting program objectives and its relationship with industry and other science in Australia.'[11]

The committee identified 'a number of deficiencies relating to the quality and balance of DSTO's scientific work, to the effective use of its resources and to its relationship with industry and other non-defence activities.'[12] The major recommendation to address these was to have DSTO become a statutory authority. Ralph Cartwright, acting as secretary to the Rees committee, could not rid himself of the impression that it was unnecessarily critical of DSTO as if following an agreed agenda.

The major recommendations of the external review flew in the face of organisational decisions taken to that time and the major recommendation of those undertaking the internal review. It was not implemented. Recommendations concerning the restructuring of the Services Laboratories and Trials Division generally reflected those made by the Fink committee, although Rees and his colleagues recommended that the Armed Forces Food Science Establishment be transferred to CSIRO.

The government accepted many of the 110 recommendations of the two reviews in whole or part, though not the most substantial of those made by the Rees Review. Still, several organisational changes were made to DSTO in February 1982. These changes generally referred to the establishments forming part of the Services Laboratories and Trials Division.

- Responsibility for the Engineering Development Establishment was transferred to the Army
- Responsibility for the Royal Australian Navy Trials and Assessing Unit was transferred to the Navy
- Responsibility for the Armed Forces Food Science Establishment, the Joint Tropical Trials and Research Establishment and the Materials Testing Laboratory was transferred to the Chief Superintendent, Materials Research Laboratories
- Responsibility for the Royal Australian Navy Research Laboratory was transferred to the Deputy Chief Defence Scientist
- The Trials Resources Laboratory ceased to exist as a separate establishment and was absorbed within the Advanced Engineering Laboratory at Salisbury.[13]

There remained two laboratories in Melbourne, the Materials Research Laboratories at Maribyrnong and the Aeronautical Research Laboratories at Fishermans Bend. Wynford Connick succeeded Dr Len Samuels as Director of the Materials Research Laboratories in 1983. Connick was another to embody the traditional close association with British defence research agencies. He had been born in Swansea, United Kingdom, and graduated from the University of Wales with a BSc in chemistry in 1954 and an MSc in 1955 when he joined the United Kingdom Atomic Weapons Research Establishment. He was invited to transfer to the Defence Standards Laboratories in 1963 to establish a research program in explosives. He remained at the Materials Research Laboratories until 1978 when he served a term as Counsellor Defence Science at the Australian Embassy in Washington before returning to the Materials Research Laboratories.

Following the 1982 reorganisation, DSTO comprised 10 operating establishments, five of them being the major research laboratories under the Chief Defence Scientist and the Royal Australian Navy Research Laboratory reporting to the Deputy Chief Defence Scientist, along with the Central Studies Establishment at central office and the three smaller establishments that had become branches of the Materials Research Laboratories. DSTO comprised approximately 4850 people, about 1000 of them being scientists and engineers. The laboratories forming the

Defence Research Centre at Salisbury, South Australia, comprised the largest concentration of personnel.

Fink sought to unify the various establishments by instituting regular meetings between himself and the several heads.

A new organisation

More changes were in the wind. On 7 May 1981, Prime Minister Malcolm Fraser, and the Minister for Defence James Killen announced the formation of the Defence Review Committee in association with the establishment of a Committee of Review of Commonwealth Functions also known as the 'Lynch Committee' and colloquially as the 'Razor Gang'.

The Defence Review Committee was chaired by industrialist John Utz and included General Sir Arthur MacDonald, former chief of the General Staff, Sir Frederick Wheeler, former Permanent Head of the Treasury, and businessman and chief executive officer of Boral, Eric Neal. The committee's terms of reference were 'to review the organisation of the higher Defence machinery in the light of experience since the Defence reorganisation of 9 February 1976.'

Thirteen recommendations of the internal and external reviews concerning the form of organisation of DSTO and its relationships to higher defence committees were referred to the Defence Review Committee.

On 4 May 1982 the committee presented an 'Interim Report' to the Prime Minister and the Minister for Defence, recommending that a Department of Defence Support be created, harking back to the earlier Department of Supply. This new department would assume responsibility for several defence support activities then spread between the Departments of Defence, Industry and Commerce, and Administrative Services. They included defence production, naval dockyard support, defence research and development, defence purchasing, and defence industry development.

The government accepted the main recommendations of the Interim Report and created the Department of Defence Support on 7 May 1982, with Charles Halton as Secretary. This new department assumed responsibility for the research laboratories, including the Royal Australian Navy Research Laboratory, which now had the same status as the major research laboratories.

Chief Defence Scientist Tom Fink had strenuously argued against relocation of the laboratories claiming the separation of responsibility for science policy and day-to-day administration would reduce the effectiveness of the Chief Defence Scientist's role. The committee was not receptive, claiming that the Chief Defence Scientist could maintain effective control through his role as Deputy Chair of the Research and Development Board of Management and by his appointment as Chief Scientific Adviser to the Secretary, Department of Defence Support.[14]

The committee presented its Final Report on 28 October 1982.[15] Fink's forebodings proved correct and he spent much of his energy reconciling or contending with differences between the powerful secretaries of Defence and Defence Support. That distracted him from DSTO issues. There was also a great deal of duplication of effort with senior DSTO personnel having to report to both Tom Fink and Charles Halton.

Fortunately, for DSTO's future, this arrangement did not last long. In March 1983 there was a change of Federal government that returned Labor to power after which, on 11 March 1983, the research laboratories reverted to the control of the Chief Defence Scientist and to DSTO within the Department of Defence.

Program management

The laboratories and their chiefs continued to guard their independence jealously and pay minimal heed to central office in Canberra. However, there was increasing pressure from the Department of Defence and the Public Service generally—particularly from the Department of Finance—for greater central coordination of programs and a more transparent method of determining organisational, establishment, program and task budget priorities.

Hitherto planning had not been a feature of Australian defence science. The various laboratories had remained virtually autonomous, with little reference to the Service chiefs. Project work was endorsed by the Defence Research and Development Policy Committee, but was not planned in a formal sense. However, Tange had highlighted the need for a new Programme and Planning Division to ensure the research and development units of the department focused more closely on meeting the department and Service requirements.[16]

A harbinger of the new approach was the 1975 appointment of Ralph Cartwright to the Policy and Program Planning Division of central office in place of Jack Lonergan who transferred to the Department of Science. Cartwright's duties were to:

> *Formulate and define the principal objectives and policies of the overall Defence Science and Technology Organisation; advise on the most effective deployment of Science and Technology resources in relation to Defence needs, and prepare long term plans for the effective use of DSTO resources for Australian initiated research.*[17]

At John Farrands' insistence Cartwright sought a suitable management tool in a 'Planning Guidance and Planning Base' system used by the United States Army. The model, as adapted to DSTO needs, addressed 29 elements and provided for projects involved with equipment and operations to be married with the available scientific skills base and engaged the armed Services directly in the deployment of scientific effort and replaced the ad hoc arrangements previously employed. Neither DSTO scientists nor the Services were keen on the new planning initiative because of the apparent constraints it imposed upon them. Yet a more formal process was required because of the nature of the competitive bidding that allocated resources to the Defence Department first of all, then to divisions within the department, and finally establishments and divisions within DSTO. There were always competing priorities with the fully justified programs having the greatest chances of success. Moreover, under pressure from government for greater economic accountability, the Defence Science and Technology Committee sought greater detail about and justification for particular programs and tasks.

At this stage the impact of the Planning Guidance was limited because DSTO was only a small part of the large Department of Defence and the management tool did not readily relate to the manner in which departmental priorities were determined or the manner in which resources were allocated within DSTO. Still, the government insisted on greater economic accountability across all sectors of the Public Service, and the Department of Defence recognised the need for program budgeting with the 1981 implementation of Statements of Objectives and Activities that sought to provide a quantitative formula for setting priorities and resource programming. This became the basis for implementation of DSTO's program planning, management and review process.[18]

The laboratories resisted the increasingly bureaucratic demands of head office where they could, but their traditional independence was increasingly curtailed as they were forced to justify programs in order to attract funds, and later to review and justify performance.

The increased formality was evident in Departmental Science Instruction No.1/85, dated 31 December 1985, which detailed 'the procedures to be followed in initiating, defining, approving, executing and reviewing Research and Development (R&D) activities in the DSTO Program.' The program was planned as part of the Five Year Defence Program and became the basis for DSTO funding. The instruction indicated that the program comprised a number of sub-programs, with each division being typically responsible for two to five sub-programs for which funding would be sought in May–June each year. The instruction then indicated that the sub-programs were divided into separate 'tasks', each task being the basic unit for DSTO approval and recording systems. These tasks could be sponsored by the Services, central office, other agencies or DSTO itself. The instruction went on to indicate the need to establish task priorities for funding and recording purposes and the need for the annual review of tasks and sub-programs.

There was evidently a need for a measure of control with DSTO undertaking as many as 200 new or redefined large tasks each year—defined as those requiring 'up to five professional man-years per year plus appropriate support'—and as many as 1500 smaller tasks, that required less than one man-year.[19]

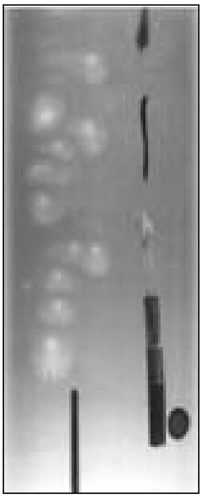
The new program planning regime sought to accommodate both 'top-down' initiatives by centralising decisions on sub-programs, and 'bottom-up' initiatives by giving laboratory managers the flexibility to explore ideas generated by their scientists. However, the process was far more formal than that existing only a decade before, and it was to become more so, largely because of the new political reality. It meant that projects were far more closely scrutinised than previously with less chance of groundbreaking projects receiving funding than in the past.

Innovations

While the conduct of new projects came under closer scrutiny, work continued on many projects that had already had a long gestation and those that had demonstrable utility. DSTO scientists engaged in these projects remained largely cocooned from management changes—if indeed, they were at all interested. Some of the work was associated with addressing issues raised by the Services, but most of it remained largely focused on projects that continued to showcase the inventiveness of DSTO scientists.

Development of the Barra passive array sonobuoy was one of the most successful defence joint development projects. Considerable time had elapsed between conception and testing, as occurred with many projects. Dr Alan Butement had conceived the idea of sonobuoy, along with Henry d'Assumpcao, and the two took out the original patent. The Weapons Systems Research Laboratory of the WRE began work on the project in 1964. Known initially as Project Nangana, the task was to develop a sonobuoy system that could be deployed from aircraft to detect, locate and classify submarines and surface ships.

Though Butement and d'Assumpcao had conceived the idea, its realisation depended on an enormous amount of work by innumerable engineers. This was very inventive, a feature being the use of an underwater test facility established in a natural sinkhole in South Australia's south-east. Here the behaviour of the sonobuoy entering the water could be studied by means of remote-controlled cameras placed at varying depths. These trials led to the development of an improved sonobuoy that could be launched from aircraft and deployed under water. The ability to provide accurate bearings on targets was an innovative feature of the technology. Sea trials involving close collaboration with the Royal Australian Navy and the Royal Australian Air Force followed in South Australia in July and August 1967 and later off the New South Wales coast near Jervis Bay. Fully operational sonobuoys were developed after 1971 and it was during production that the sonobuoy received the name 'Barra'.



Submerged Barra sonobuoy.

The Barra sonobuoy consists of two parts: a surface float and a container that separate on impact with the water after deployment from an aircraft. The container sinks beneath the surface and releases a horizontal array of hydrophones. These hydrophones collect data that is sent via the surface float to a sonics processor in an aircraft flying in the vicinity. The use of two or more sonobuoys permits detection and location of multiple noise sources.

Night time testing of Barra sonobuoy in a sinkhole near Mount Gambier.

Australian scientists designed and manufactured the passive sonobuoy while those of the United Kingdom designed, developed and manufactured the airborne processor in accordance with an agreement made on 9 August 1975. AWA Limited won the initial contract to produce Barra sonobuoys in 1977, with the first being presented to the United Kingdom's High Commissioner for Australia on 25 February 1980.[20] Improvements continued to be made in mass production; by 1985 as many as 20,000 sonobuoys had been made, and production continued for many years afterwards.

Kariwara was another major defence system developed for the Navy. Henry d'Assumpcao had suggested the idea of towed arrays as early as 1961 only to have Navy personnel dismiss the idea, suggesting that they would never tow anything of that nature behind a ship, and that the Americans would have developed the idea if they had considered it worthwhile. D'Assumpcao persisted and learned that the Americans had indeed considered the idea and were actively developing the array with the Hughes Aircraft Corporation, but had kept it secret, even from close allies. But, after learning that Australia had begun research into towed arrays, the Americans provided invaluable information and made available, at peppercorn cost, an array named 'Towflex' that was acquired from the Chesapeake Instrument Company in 1971 and installed on HMAS *Diamantina* for sea trials. This precipitated a joint Australian-United States project named 'Boolee', that extended over five years. Sea trials conducted between 1975 and 1979 in several regions in the Indian and Pacific oceans led to the decision to focus on research and development of a thin-line submarine towed array.

Development of a thin-line acoustic array streamer followed. In this instance, hydrophones and electronics were located within a polypropylene rope core strengthened with Kevlar and filled with gel that was not prone to leak. This system was particularly attractive because it could be fitted to ships and small conventional submarines and could be winched in and stored aboard these vessels. The feasibility study was successfully concluded in early 1985 and, later that year, DSTO scientists began a Project Definition Study in partnership with industry to develop and test the technology. The following year the system was deemed to be required equipment for Australia's Collins class submarines.

Meanwhile, work continued on the commercial development of the array to Royal Australian Navy specifications in collaboration with defence companies such as Philips, GEC Marconi Systems and Thales Underwater Systems. The first three arrays were delivered in 1997. The system later found a civilian use in seismic survey work.[21]

Australia's defence scientists also developed an advanced medium-range active sonar system named Mulloka. This grew from a study begun in 1971 by scientists at the Advanced Engineering Laboratory and the Royal Australian Naval Research Laboratory, Sydney. The study sought to determine whether the British-designed 177M sonar designed to operate in North Atlantic waters and fitted to the Navy's 'River' class destroyers, could be re-engineered to be more suitable for Australian waters. It quickly became obvious that a system suitable for Australian conditions required a radical departure from the technology used in the British system.

The decision to proceed with Mulloka was taken in early 1972 and work began on constructing a prototype to fit to one of the 'River' class destroyer escorts. This was accomplished near the end of 1974 and sea trials began in March 1975. The trials were only partially successful. The Mulloka system demonstrated superior performance to existing medium-range sonars, but water seeped into the system and corroded components.

Modifications and trials continued until the Navy finally accepted the system on 17 August 1979 when it was fitted to HMAS *Yarra*. EMI Electronics (Australia) won the contract for the manufacture of the system, with Honeywell Marine Systems Division of Seattle, United States, winning the contract for design and development of the transducer array. Ultimately, the Mulloka system was fitted to the 'River' class and the two Australian-built guided missile frigates.[22]

Another innovation developed by Australia's defence scientists was the Laser Airborne Depth Sounder (LADS) that has had a wide application beyond strictly defence needs. This is a self-contained, transportable bathymetric survey system that uses a pulsed laser mounted in a fixed-wing aircraft. It is the fastest and most cost-effective tool for surveying in coastal waters to a depth of 70 metres and in areas too shallow or otherwise hazardous for navigation.

LADS was conceived and developed by scientists at the Electronic Research Laboratory and Advanced Engineering Laboratory in response to a request from the Royal Australian Navy's Hydrographic Service. The Navy had estimated that it would take 80 years to complete hydrographic surveys of Australia's continental shelf using shipborne acoustic depth sounders and sought another means of conducting the surveys.

Initial investigations began in 1972, though the first phase of the Weapons Research Establishment Laser Airborne Depth Sounder (WRELADS) program, as it was known originally, commenced in 1975 with the development of hardware that established basic system design and processing algorithms. Under the leadership of Mike Penny, a prototype was constructed—WRELADS I—and installed in a 'Beechcraft' Queenair aircraft. Test flights were conducted over South Australian and Queensland littoral waters between November 1976 and June 1977 to test basic design concepts. WRELADS II followed. This upgraded model, installed in a 'Dakota' aircraft, underwent 550 hours of flight trials over north Queensland, West Australian and South Australian waters between August 1979 and May 1984.

Tenders were called in 1987 for the construction and trial of an operational version, with BHP Engineering and its partner Vision Systems Ltd being awarded the contract in May 1989. Finally, on 28 January 1992, Minister for Defence Science and Personnel Gordon Bilney launched the LADS optimisation trials and acceptance tests program at Adelaide airport. The Navy accepted LADS on 8 October 1993.

The LADS technology ultimately proved a commercial success. Vision Systems acquired BHP's share of the LADS business in 1994 and established its subsidiary, LADS Corporation, to operate and maintain LADS under contract to the Australian Defence Force and to hold the licence to exploit LADS technology commercially on the international market. An improved LADS laser platform was developed for United States Navy use in a P-3 Orion aircraft in 1996. In 1998, the new-generation LADS MkII, built by Vision Systems in a $24 million research and development program, commenced commercial operations mounted in a de Havilland Dash 8-202 aircraft. Tenix Defence Systems Pty Ltd acquired Vision Systems' defence business, including LADS Corporation in June 2000, and the company was renamed Tenix LADS Corporation Ltd. By early 2001, LADS MkII had been deployed on contracts in Australian waters for the Australian Defence Force and in support of international oil exploration and seismic survey companies. By 2002, the system had been used to survey more than 75,000 square kilometres of seabed and had been used in places as diverse as Alaska, Florida, Ireland, Norway and Qatar. In 2003, Tenix LADS Inc., the United States subsidiary of Tenix LADS Corporation, signed a US$12 million contract with the United States' National Oceanographic & Atmospheric Administration to survey territorial waters around Alaska, using LADS.[23]

Illustration of Laser Airborne Depth Sounder (LADS) in operation and (inset) DSTO team on presentation of Institute of Engineers (S.A.Division) Award for LADS invention, 1985, L-R: Chris Lightowler, Gavin Perry, Dallas Lane, Alan Hicks, Mike Penny (holding award), Ralph Abbot, Henry d'Assumpcao, John Pyle, John Brooks, Bernie Rush.

A project on a very different scale, but indicative of the breadth of DSTO research interests, was the development of the Pilot's Force Measurement Glove, invented by Dr Garth Morgan, William Menadue and Robert Clarke. This invention, aimed at gaining a quantitative measurement of 'stick' force, revolutionised contemporary in-flight testing procedures and was a world first for Australian engineers. The glove was developed at the Advanced Engineering Laboratory, Salisbury, at the request of the RAAF's Aircraft Research and Development Unit in the early 1980s. An Australian patent for the invention was granted on 8 June 1983 and, in June 1985, the glove was displayed at the Paris Air Show, attracting wide interest. The technology was successfully transferred to industry in about 1989 after additional testing, and Normalair-Garrett Australia undertook to develop and manufacture the glove. Meanwhile, the glove went into service with the Aircraft Research and Development Unit.

Industry collaboration

Production of the weapons and products mentioned above was undertaken in partnership with Australian industry. The need to collaborate with and support Australian industry remained a fundamental objective of DSTO as a means of maintaining capabilities that might be built upon in times of war. However, industry was involved in work only after initial feasibility studies had been completed. DSTO carried out far more research and development in-house than did other countries that were partners in the Technical Cooperation Program, largely because of a perceived limitation of contractor expertise and capability in the face of rapid changes in military technology and the few opportunities in the small Australian market for local industries to be involved in military research and development.[24]

Nevertheless, DSTO prided itself in promoting technology transfer. In the first instance it did so by means of contracts for scientific and technical services, such as the operation and maintenance of the sonobuoy test range or support to the space tracking stations. DSTO also made itself available for consultation in the production of overseas designed equipment and provided assistance where required in addressing production issues. As well, DSTO sometimes sought assistance with the design and production of items like sensors, communication equipment and platforms while developing locally designed equipment such as Malkara, Ikara, Barra and LADS. On the other hand, it often sought assistance with the development of particular equipment for concept demonstration purposes such as the major Jindalee and Kariwarra programs, or small developments at the behest of the Services. In all instances Australian industry was considered as a supplier of services and components, rather than a partner in defence research and development.

The contemporary attitude of DSTO towards potential industry partners was reflected in the comment of Chief Defence Scientist Tom Fink:

> *[T]he relatively small amount of indigenous project development in Australia particularly in the defence field, creates some barriers to the building up of a dynamic [research and development] capability in Australian industry ...*
>
> *There is hence a discontinuity in the [research, development, training and education] spectrum between the point at which the DSTO would wish to relinquish its prime role and that at which Australian industry ought to assume prime responsibility. At present this occurs somewhat late in the exploratory development segment of major project activity. Perhaps a measure of the industrial maturity of a country is precisely where that point is situated. Accordingly Australia might be judged to be less advanced in its industrial than in its scientific maturity.*[25]

DSTO also became the incubator of new high-technology companies. This has occurred in many instances. For instance, a scientist involved in the development of a movement sensor ultimately left DSTO and, with others, obtained the licence to develop the system, and established Vision Systems that was formed in 1982 and grew to become an international company.

The Technical Cooperation Program (TTCP)

Transfer of the defence science establishments to the Department of Defence resolved a continuing anomaly as far as Australia's TTCP partners were concerned. No longer was there a need for two senior representatives in Washington, a Research and Development Representative from the Department of Supply and the Defence Science Attaché from the Department of Defence. Thereafter there was the need for only one official representative under the new title, Counsellor, Defence Science. Laurie Wain, Superintending Scientist from the ARL, assumed the position in 1976.

DSTO scientists continued to value collaboration with colleagues in TTCP. The 1980 reviews of DSTO both examined its association with TTCP. At the time Australian defence scientists participated in all 10 Sub-Groups, 35 of 37 Technical Panels and 16 of 17 Action Groups.[26] Benefits of TTCP membership were considered 'easy to identify but hard to quantify',[27] but both the internal and external review conducted at this time considered Australia's involvement to be the most important means of access to international defence science and technology. Membership continued to give DSTO credibility with military personnel and rewarding opportunities for individual scientists. Moreover, it provided scientists with the opportunity for peer review that was not available to them through publication of their work in scientific journals.

TTCP awards were instituted in 1983 to commemorate 25 years of successful collaboration. A succession of DSTO scientists have been honoured since then.

Dr Laurie Wain, Chief Superintendent, Materials Research Laboratories, 1978–1981.

The conduct of defence science in Australia took on a new focus and closer identification with the Australian Defence Force with the formation of DSTO in the early 1970s and major reviews of its functions in the early 1980s. There was little change immediately apparent in the actual work of the scientists or in the cultures of the various laboratories. They continued to act largely independently of one another and of head office in Canberra. However, the momentum for change was irreversible. The succession of governments, starting with the new Labor government in 1972, insisted on integrated defence policies and greater levels of financial accountability that required an even closer focus by DSTO on the needs of the Services and the push for a more uniform culture within the organisation.

CHAPTER 8

New directions: 1985–1993

Attention returned to consideration of Australia's defence policy in the mid-1980s, after the return of a Federal Labor government on 5 March 1983. A succession of reviews of Australia's defence policy and force structure followed. These reviews had an impact on DSTO and ushered in another period of major change, more significant than any since those of the mid-1970s.

Implementation of the changes in the government's defence policy outlined in the 1976 White Paper had been stymied by internecine bickering within the Department of Defence about the best means of having the Australian defence force defend the Australian land mass and approaches out to about 1000 kilometres.[1] Consequently, the government in 1985 commissioned a report by defence academic Paul Dibb to establish a blueprint for the future. Dibb had joined the Joint Intelligence Organisation in 1970, rising to Deputy Director (Civilian) in 1978, spent 12 months as Senior Assistant Secretary, Strategic Guidance and Policy Branch in the Department of Defence before joining the Strategic and Defence Studies Centre at the Australian National University in 1981 as Senior Research Fellow in International Relations, and becoming Deputy Head of the Centre. The Dibb review enabled the government to put an end to the bickering that had bedevilled the Department of Defence. The government's conclusions on defence policy were later set out in the 1987 Defence White Paper.

Perhaps more significantly, as far as its direct impact on DSTO was concerned, was the move to corporatise a broad range of activities previously undertaken within the Department of Defence. This involved the dismantling of what was then the Office of Defence Production with corporatisation of the government aircraft factories and the arms and munitions factories and the sale of the Williamstown Naval Dockyard. The government aircraft factories were incorporated as Aerospace Technologies of Australia Pty Ltd in November 1986 and became operational in March 1987. Tenders were sought for the Williamstown Naval Dockyard in April 1987 and in 1988 it passed to Transfield Defence Systems, later renamed Tenix Defence Systems. The several munitions, explosives and clothing factories formed Australian Defence Industries (ADI) Limited that was incorporated on 21 July 1988, and became operational when it took control of the defence factories and Garden Island Dockyard on 3 May 1989.[2] These three initiatives reduced civilian employment in the Department of Defence by 15,000.[3]

The initiative aimed to create an armament industry that was far more competitive than previously. Consequently, unions at the Williamstown shipyards were reduced from 23 to three, with a consequent increase in efficiency. ADI made major efficiency gains in closing munitions factories at St Marys near Sydney and Maribyrnong in Melbourne, and building a new factory at Benalla in country Victoria.[4] Virtually new facilities built on the northern area of the former explosives factory at Salisbury close to the DSTO laboratories were relinquished.

Coming on the heels of these significant changes was another series of reviews of DSTO, culminating in one by the Australian Science and Technology Council. This review began in May 1985 and concluded with the report tabled in November 1986. The Council study, chaired by

❮ *Original Jindalee radar network, Alice Springs, N.T.*

Professor Roger Tanner, was part of a broad review of government investment in research and development and was commissioned to ensure limited funds were invested wisely. The review highlighted the 'small proportion of expenditure on research and the large numbers of technical and industrial staff ... [indicating] the tactical, applied and technical support nature of much of DSTO's work.'[5] It also suggested that much of the organisation's engineering was undertaken to unnecessarily high standards with little consideration to cost and time constraints. The report suggested changes in the purpose of the organisation with greater emphasis upon applied research, rather than development, with industry now considered an important partner being asked to take greater responsibility for development and commercialisation of DSTO initiatives. The report was more valuable for the observations it made on DSTO than for any changes implemented. A major recommendation that DSTO be granted greater autonomy within the Department of Defence and its own budget line was not accepted.

Nevertheless, changes in the manner in which DSTO managed its affairs were necessary because of the continuing evolution of Australian defence policy, changes within the scientific community and industry, increasing emphasis by governments on financial accountability and a more corporate approach to administration. It was no longer accepted that defence benefits would necessarily flow from research that scientists themselves considered important. DSTO scientists were expected to become increasingly involved in applied research, in advising on the most appropriate equipment to be acquired, and in helping to extend the life of equipment already acquired. Moreover, during the latter years of the 20th century there was rapid growth in the capability and willingness of Australian universities to undertake research with defence applications and the capability of industry to support defence science. Governments were keen to capitalise on this trend and promote an economic rationalist approach to government.

Then, while its agencies sought to adapt to the government's new defence policies, the Soviet Union collapsed, and with it the spectre of Soviet military power was removed. The revolution in *realpolitik* had no immediate impact on the fundamentals of Australia's defence policy, but certainly underscored the need for continued flexibility in defence planning.

This passage by political commentator Paul Kelly in the introduction to the political and economic history of the 1980s, *The End of Certainty*, could easily be applied to the evolving history of Australia's DSTO and the defence industry generally:

> *The story of the 1980s is the attempt to remake the Australian political tradition. This decade saw the collapse of the ideas which Australia had embraced nearly a century before and which had shaped the condition of its people. The 1980s was a time of both exhilaration and pessimism, but the central message shining through its convulsions was the obsolescence of the old order and the promotion of new political ideas as the basis for a new Australia.*[6]

Perhaps Tom Fink recognised the auguries because he retired as Chief Defence Scientist in late 1986. Tom Fink, already an Officer of the Order of the British Empire (OBE) and a Companion of the Order of the Bath (CB), was appointed an Officer of the Order of Australia (AO) in 1988. While a very successful academic, he had had a tough time in charge of DSTO. He entered the job with little appreciation of the nature of the grinding mill of the Public Service environment, particularly in the biggest department, and the complications flowing from creation of the Department of Defence Support. He worked hard, but underestimated the importance of politics, believing that intelligence and lucid arguments would prevail. He continued to be perceived as an academic. Living at University House and walking to work each morning with his satchel on his back was unusual for a senior public servant. Still, during his tenure, the stature of the Chief Defence Scientist was enhanced. He had also made a recruiting coup by persuading Dr Garry Brown to become Director of the Aeronautical Research Laboratories at Fishermans Bend.

Brown had been born and educated in Adelaide where he graduated from university with a first class honours degree in Engineering and a Rhodes scholarship. After gaining a DPhil from Oxford University he took a position in aeronautics at the California Institute of Technology. After stints there and at Adelaide University he returned to Caltech in 1997 as Professor of Aeronautics. From here he was recruited to Fishermans Bend. Brown was known as a bright scholar and remembered for rejuvenating ARL and unifying its focus with the introduction of task plans. He did so in the face of sustained resistance from those who considered this interference in their work. He was also a key figure in promoting the through-life testing of aircraft that became the hallmark of the ARL.

Henry dAssumpcao, Superintendent, Electronic Research Laboratory, DRCS/DSTO, 1981–1987; Chief Defence Scientist, 1987–1990.

George Barlow, one of the bright young scientists recruited in the late 1940s, and Deputy Chief Defence Scientist since 1980, retired in 1987, further emphasising the notion of a changing of the guard.

Henry d'Assumpcao was the one to inaugurate changes that brought an 'end to certainty' within DSTO after succeeding Tom Fink as Chief Defence Scientist on 1 January 1987. He had been persuaded to apply for the position of Chief Defence Scientist by colleague Mal Buckham to ensure that someone familiar with the organisation was appointed to the position and could fulfil its potential. Senior members of the organisation were generally reluctant to seek the position of Chief Defence Scientist because it removed them from research, even though they became less identified with cutting-edge research as they assumed scientific management roles. Moreover, most were reluctant to move to Canberra. Head office there had traditionally been treated as a necessary evil more likely to constrain than assist the work of the laboratories which continued to guard their independence. Moving to Canberra on a term appointment also involved considerable dislocation of personal and family arrangements. Henry agreed to assume the position for a limited time in order to implement changes that he believed were important if the organisation was to survive.

Henrique Antonio d'Assumpcao had been born into a tight-knit Portuguese community in Macau on 9 August 1934, and was one of several from that community to receive his education in Australia. In Henry's case this was at Sacred Heart College and Brighton, South Australia, before taking a first class honours and later a Master of Engineering degree from the University of Adelaide. He joined the WRE at Salisbury in 1956, at a time when the facility was expanding rapidly. He worked at the Royal Radar Establishment in the United Kingdom for a year (1958-59) and after returning to Australia continued to rise through what became DSTO, gaining experience in radar, underwater acoustics, signal processing, sonar systems and electronic warfare: he was co-inventor of the Barra passive array sonobuoy. He was Superintendent of the Electronic Research Laboratory's Electronic Warfare Division (1978–81) when he became Director of the Laboratory. Henry, like his predecessor as Chief Defence Scientist, considered himself to be a scientist rather than a manager, but he had the advantage of having been promoted to the position from within the organisation and having an intimate knowledge of and regard for it.

Dr Garry Brown, Director, Aeronautical Research Laboratories, 1981–1990.

Henry d'Assumpcao had firm ideas about the manner in which he wanted to shape the organisation to ensure it reflected the current state of technological development and he presided over the most radical restructuring since the 1970s. He aimed to have the organisation reflect current realities and to break down the separateness of the various establishments that had derived from their separate histories and geographical dispersion, to integrate them more closely into a single organisation, and to promote a closer partnership with industry. Even on the single Salisbury site where the new Chief Defence Scientist had spent most of his time, the laboratories had remained fiercely independent,[7] to the extent that some lobbied to have the separate laboratories fenced off from one another.[8] There was difficulty in overcoming the geographical constraints, but the restructuring aimed to remove organisational constraints. In this regard d'Assumpcao was fortunate that the Labor government abolished the Public Service Board in September 1987 that allowed him to delegate powers to laboratories to permit local managers to make acquisitions to established cost levels without reference to Canberra. This eliminated occurrences of the silly situation where previously a request for a handheld calculator had required two Canberra administrators to visit Melbourne to establish justification for the calculator.

Wynford Connick, Director, Materials Research Laboratories, 1984–1992; Director, Aeronautical Research Laboratories, 1992-1994; Director, Aeronautical & Maritime Research Laboratory, 1994–1995.

The main components of the change involved the creation of a new laboratory structure, a shift in the DSTO staff profile to include a proportional increase in scientific, engineering and skilled staff, and implementation of arrangements to increase industry involvement by outsourcing services previously provided from within the organisation, and encouraging the more rapid transfer of projects to industry for commercial development. The new structure was introduced on 1 December 1987 with other changes planned for 1 July 1988, and staff reductions to be completed within five years. The new arrangement was designed to place greater emphasis on new research and exploration, and less on proving-up and engineering development.

There continued to be five major laboratories after the reorganisation, all of them now had the word 'Research' in the title to emphasise the proposed new direction of the organisation.

There was little change to the ARL under Director Garry Brown, except for the addition of elements of the Advanced Engineering Laboratory from Salisbury: the main focus of work remained on aircraft and aircraft systems. The Materials Research Laboratories under Wynford Connick were reorganised in accordance with outcomes rather than disciplines but remained primarily concerned with defence materials, underwater weapons systems, sea and land vehicles and life sciences. The work of its scientists changed little with the reorganisation, though the laboratory gained the Mine Warfare Group from the Maritime Systems Division of the Weapons Systems Research Laboratory in Salisbury. There was also little change to the Weapons Systems Research Laboratory. Under the stewardship of Dr W. Godfrey Robertson, it continued to focus on guided and unguided weapon systems, sonar systems and tactical combat systems, though it added a component from the Advanced Engineering Laboratory and lost an element to Materials Research Laboratories.

L-R: Colin Evans, Henry d'Assumpcao, General Peter Gration, Bob Ramsay, Scot Allison.

However, the new Electronics Research Laboratory at Salisbury under Director Scot Allison differed greatly from the old. It comprised most of the Electronic Warfare Division from the Electronics Research Laboratory, parts of the Communications and Electronics Engineering Division of the Advanced Engineering Laboratory, a new Information Technology Division that included computer research and support, and high level command and control work from Combat Systems Division. Its work involved command, control, information technology, communications and electronic warfare.

Moreover, a new Surveillance Research Laboratory concerned with electromagnetic surveillance was formed at Salisbury. It became the responsibility of Bob Ramsay and comprised the Optoelectronics Division of the former Electronics Research Laboratory and the Physics Division of the Materials Research Laboratories together with the Mechanical Engineering Branch from the Mechanical Engineering Division of the Advanced Engineering Laboratory and two new divisions, High Frequency Radar and Microwave Radar formed from the Radar Division. Bob Ramsay began working at Salisbury in 1965 after graduating with an electrical engineering degree from the University of Adelaide. He became involved in the design and development of many communications and defence projects and had been appointed Director of the Advanced Engineering Laboratory in 1984.

Existing smaller laboratories at Scottsdale and Innisfail were to continue to be part of the Materials Research Laboratories but were to be renamed MRL DSTO Tasmania, and MRL DSTO Queensland. The Royal Australian Navy Research Laboratory, transferred from Rushcutters Bay on Sydney Harbour to the former Royal Edward Victualling Yard at Pyrmont on 3 November 1984, was to continue to be part of the Weapons Systems Research Laboratory, though the Mine Warfare Group was to be controlled by the Materials Research Laboratories in Melbourne: moreover, the establishment was to be renamed DSTO Sydney. There had been

REVY 3 building, home to DSTO Sydney at Pyrmont, 1985. (RANEL Assn)

a concerted effort to integrate the Royal Australian Navy Research Laboratory into the wider DSTO organisation. However, there may have also been an element of bringing into line those at Pyrmont who had been slow in accepting the integration of their establishment into DSTO and in considering themselves as part of the broader organisation.

There were to be four smaller establishments reporting directly to central office in Canberra, namely, Defence Information Services Branch charged with providing information and library services to Defence; Trials Directorate concerned with trials planning, conduct and analysis; Trials Branch concerned with trials instrumentation; and Defence Support Centre, Woomera, that provided administrative support to the Joint Defence Space Communications Station and the Woomera testing range, though there were plans to transfer particular functions and facilities at Woomera to the South Australian government.[9]

The change in staffing profile was to be managed by a reduction of 800 staff, primarily at lower levels in the organisation, and recruitment of approximately 400 people for scientific, engineering and technical positions within the five years of the plan. Perhaps the greatest impact of this restructuring and refocusing occurred at Salisbury with the closing of the Advanced Engineering Laboratory which encompassed Communications and Electronic Engineering, Mechanical Engineering and Workshops and Trials and Technology Support: 650 staff departed Salisbury in the four years after the restructuring. This certainly caused the most angst among affected staff, though immediate hardships were eased by separation packages: others recognised the growing anachronism at a time of rapid advances in computer technologies and associated software.

Each of the new laboratories at Salisbury was to have its own workshop and, as elsewhere, engineering staff were to be integrated into the laboratories. There was a commitment to maintain specialist workshop skills not available in industry. However, in accordance with the wish to transfer work to industry, there was no longer a need for the large workshops and the great numbers of apprentices. Consequently, the Apprentice Training School was scaled down and ultimately closed.[10] By this time, too, DSTO could no longer afford to offer jobs annually to as many as 50 apprentices who completed their training, as had been the tradition. This tradition of employing apprentices after their training, over the period of more than 30 years, had resulted in a huge imbalance of blue-collar workers when compared to the numbers of scientists and engineers. The closing of the apprentice school and the reduction of workshop positions had a major impact upon staffing levels and profiles. Total DSTO staff had numbered 4364 on 31 December 1985 with those of the Advanced Engineering Laboratory accounting for almost 1200 of these.[11]

Henceforth DSTO was to be exclusively a research and experimental organisation relying on outsourcing for the provision of equipment that had previously been built on site. At the same time, projects once considered feasible were to be transferred to industry for proving and commercialisation rather than be undertaken in-house.

Henry d'Assumpcao's appointment as Chief Defence Scientist coincided with a division of responsibilities within the Defence portfolio, with Ros Kelly being appointed the Minister for Defence Science and Personnel. She sought to foster the organisation and, to encourage it in the new direction, announced a change to the DSTO charter in December 1987. This provided for the establishment of a trust account to enable earnings from the commercialisation of projects to be reinvested in ongoing and new research, rather than being lost to general revenue.

Another initiative was an industry seminar held at the Hilton Hotel in Melbourne on 24 June 1988 to inform as many as 250 industry leaders who attended, of the new directions of DSTO research.

A 1988 Department of Defence Minute Paper that included the DSTO Corporate Statement concerning proposed restructuring provided a snapshot of the organisation and the scope of its work at the time. Staff in the various establishments continued to undertake research across a broad range of categories. These included Airframes, Aeropropulsion, Aircraft and Aircraft Systems, Optoelectronic Surveillance, Radar, Electronic Warfare, Explosive Munitions and Fuzes, Materials and Materials Processing, Nuclear, Biological, Chemical Defence, Weapon Propulsion and Ballistics, Combat Systems, Undersea Sensors and Maritime Systems, Operations and Exercise Analysis, Mine Counter Measures, Weapon Guidance and Performance, and Advanced Mechanical and Electronic Engineering.[12]

Soon afterwards a new Information Technology Division was established within the Electronics Research Laboratory at Salisbury with Ian Chessell as its chief.

A measure of the new philosophy of re-invigorating the laboratories was reflected in the appointment of David Humphries to succeed Garry Brown at Fishermans Bend in 1990 and David Evans to succeed Godfrey Robertson in charge of the Weapons Systems Research Laboratory at Salisbury. Both were recruited from the British Ministry of Defence on term appointments. Neither remained for long periods. David Humphries became director of the Materials Research Laboratories in 1992 before returning to Britain in 1995.

Henry d'Assumpcao believed his radical restructuring of DSTO to have been his most singular achievement as Chief Defence Scientist. His biggest regret was the breaking up of the Central Studies Establishment in Canberra in late 1987. The Central Studies Establishment had provided the opportunity for close cooperation and interaction with the Services and with the central policy areas of Defence, and the chance to demonstrate the utility of DSTO to the

Australian Defence Force in general. The potential was never realised. DSTO failed to give it a sufficiently high priority and the establishment was never considered a desirable place in which to work, with DSTO doing little to encourage good people to join it. Moreover, the unit engaged in a broad range of studies, with mixed success. Its members gradually became involved in Service politics, failed to give objective advice and became hostile to its principal client, the policy area within Defence. A succession of secretaries had become concerned with the quality of the advice offered by the establishment. The last straw concerned the poor advice given in the case of a destroyer study undertaken for the Navy. Secretary Alan Woods believed there was no alternative but to dismember the unit, to transfer a slimmed-down analytical core to the Force Development and Analysis Division, and to distribute the rest to other parts of DSTO. Henry d'Assumpcao would have preferred reforming the Branch had he not been involved in restructuring the whole organisation at the time.[13]

Having overseen the significant restructuring of the organisation, appointed new directors to two laboratories and completed the four years in Canberra to which he had committed himself, Henry d'Assumpcao retired at the end of 1990 to take a position with the embryonic University of South Australia. He found the Canberra bureaucracy to be wearing, but he gave DSTO scientific credibility and achieved a great deal in his four years, particularly with his reorganisation of DSTO that established the direction for his successors to follow. Awards d'Assumpcao garnered were a measure of the regard in which he was held: he had already been elected a Fellow of the Academy of Technological Sciences and Engineering in 1981; he was made an Officer of the Order of Australia in 1992; elected a Fellow of the Institution of Engineers Australia the following year; and was awarded the Institution of Engineers' M.A. Sargent Medal in 2003.

Scot Allison filled the role of Acting Chief Defence Scientist. He had joined WRE in 1963 after graduating from the University of Queensland, and spent five years with the Joint Project in the field of guided weaponry. He became an exchange scientist first at the Royal Aircraft Establishment in the United Kingdom and later the United States' Naval Research Laboratory in Washington, DC. He gradually rose through the organisation, becoming Director of the Electronics Research Laboratory in 1987. Scot Allison's interim appointment was part of a strategy by Departmental Secretary Tony Ayers to expose key people in the organisation to Canberra in an endeavour to break down the continuing barriers between laboratories in the states and central office. The strategy was not wholly a success. Scot Allison, like most of his colleagues, was unable to take a permanent position in Canberra because of family reasons and returned to Adelaide and the position of Director of the Electronics Research Laboratory.

Dr Robert George Ward succeeded Henry d'Assumpcao in January 1991. Bob Ward's appointment was unusual in so far as he came from industry and outside the organisation. The appointment highlighted the reluctance of DSTO personnel to entertain the top position, but it also provided the opportunity for senior officers of the department to continue to foster change within DSTO because the new Chief Defence Scientist was unencumbered by personal relationships and loyalties concerning the organisation. Still, none could gainsay Ward's experience and qualifications. He had been born in England and specialised in metallurgy in his university training. He was Professor of Metallurgy at McMaster University in Canada before joining BHP as head of research in 1966. He became general manager of Planning and Research in 1970 and general manager of Research and New Technology in 1974.[14] He had been Deputy Chairman of the Australian Atomic Energy Commission, and a member of the National Energy Research and Development Council and the Advisory Council of the CSIRO. Ward's appointment also reflected the government's eagerness to have industry more closely involved with DSTO.

Following a direction by the Minister for Defence Senator Robert Ray, on 30 May 1991, to make defence support more efficient and to direct savings into capital acquisitions, and at the behest of Secretary Tony Ayers, Bob Ward presided over another radical restructuring of DSTO. The restructuring was in accordance with the direction established by the 1987 Defence White Paper and was reinforced by the Force Structure Review tabled in May 1991: it followed the philosophy that had promoted corporatisation of the government's factories and shipyards. The manner of its implementation within DSTO was planned and largely implemented by Scot Allison while acting Chief Defence Scientist with support and advice from Peter Lush, Manager of Corporate Services since 1989, after being Branch Head, Civil Personnel, within the Defence Department and before that an officer with the Public Service Board.

Research areas within DSTO were to be enhanced, meaning the major impact of the forced staff reductions fell in the areas of administration, facilities, stores and engineering services, with the idea of devolving more engineering work to industry. A major objective was a staff reduction of 700 across DSTO with 550 to be lost from Salisbury over five years, including 170 administrative staff.[15] Salisbury was a particular target because of the numbers of staff on the site and the inefficiencies that had arisen.

A great deal of time and effort at each laboratory went into managing the changes. Once more, the significant reduction in staff numbers caused considerable angst, though, in this instance, general staff were not the only ones to bear the brunt of the restructuring. Successive reports had highlighted the managerial inertia within the organisation and a general unwillingness of those in senior positions to even acknowledge new government policies and head office directives, let alone move to implement them. Secretary Tony Ayers believed swift and drastic action was required to address the issue and to ensure the best people were placed in senior management positions rather than those who were next in line because of seniority. Moreover, he was keen to promote movement between laboratories at senior levels in order to break down the relative isolation of each and the cosy relationships and 'in-breeding' that this promoted.

Ayers' opportunity for decisive action arose following the constant lobbying of DSTO chiefs of divisions to be granted a classification similar to that of senior scientists within CSIRO. Successive campaigns had been stymied by the Public Service because of a perceived difference between the work of DSTO's 'applied' scientists and that of the 'pure' scientists of CSIRO. But persistence had prevailed and the reclassification had finally been accepted. The price for the enhanced pay and conditions was that all DSTO director and divisional chief positions were declared vacant with previous incumbents and aspirants having to apply for the positions.

The ultimate outcome of the process may well have been positive. It certainly sent a powerful message to all within the organisation that new attitudes and a sense of accountability were required of senior management. Still the process was poorly handled and caused considerable angst. The spill of senior positions took many by surprise and rather than being undertaken quickly the process of refilling positions dragged on for several months before being quickly concluded immediately prior to Christmas 1992. Several division chiefs did not regain their positions; it seems that some of them failed to appreciate the seriousness of the initiative and took their reappointment for granted—to their cost. Roger Lough was the only one of four division chiefs of the Weapons Systems Research Laboratory in Salisbury to be reappointed at that level. However, his appointment was to that of chief of the Aircraft Systems Division in Melbourne, and its timing close to Christmas complicated his relocation. The angst was compounded because the Chief Defence Scientist kept his distance from the process, leaving Scot Allison to inform senior personnel of their success or otherwise, and Peter Lush to advise unsuccessful candidates of opportunities and avenues available to them. Some of those who failed to be reappointed to their former positions elected to remain in the organisation though they felt aggrieved at the manner in which they had been treated.

The new structure was inaugurated on 4 November 1991. From that date DSTO comprised a central office in Canberra with a Policy Division that continued to grow in significance and 16 research divisions within four research laboratories. The Weapons Systems Research Laboratory at Salisbury was abolished and its staff and activities were transferred to other laboratories. For instance, Combat Systems merged with the new Information Technology Division and, with the Guided Weapons Division, became part of the Electronics Research Laboratory; Maritime Systems was renamed Sonar Systems and became part of the Surveillance Research Laboratory; Ordnance Systems was merged with the Explosives Division of the Materials Research Laboratories; the Aircraft Structures Division and the Aircraft Materials Division of the Aeronautical Research Laboratories were merged to form the Aircraft Structures and Materials Division.

There were two establishments headquartered in Melbourne—the ARL and the Materials Research Laboratories; and two in Salisbury—the Electronics Research Laboratory and the Surveillance Research Laboratory. However, there were also elements elsewhere. The Materials Research Laboratories retained responsibility for the maritime research facility in Sydney, the tropical research facility at Innisfail, the Food Science Branch at Scottsdale, and the Explosives Ordnance Division at Salisbury. The United Kingdom-Australia Tropical Research Agreement terminated in 1992, but DSTO retained the Innisfail facility. The Electronics Research Laboratory had a crypto-mathematics group in Melbourne—later relocated to Canberra—and a command Support Systems group at Fern Hill Technology Park in Canberra, established in 1989. The ARL had elements of aerodynamics and avionics based at Salisbury.

The need to break down the insularity of the different laboratories remained. The reality of this was driven home to Roger Lough in 1992, soon after he took up his position as chief of the Aircraft Systems Division at the ARL in Melbourne. It occurred at the time when he was charged with chairing the Merit Promotion Panel in Melbourne, along with a Senior Principal Research Scientist from each of the Aeronautical Research Laboratories and Materials Research Laboratories. He decided that the panel should meet at Maribyrnong. He and his colleague from ARL drove over to Maribyrnong on the appointed day, only to be refused entry because they did not have an appropriate pass and had to be signed in by their Materials Research Laboratories' colleague. It transpired that the Senior Principal Research Scientist from ARL, who had been at ARL for upwards of 25 years, had never been to the Materials Research Laboratories at Maribyrnong nor had he considered the implications of visiting there.

Innovative science

Australia's new defence policy, with its emphasis on the defence of the sea and air approaches to Australia, was a vindication of the work already invested in the development of the Jindalee over-the-horizon radar.

The Jindalee technology had its genesis in early research into high frequency radar and the ionosphere conducted at the WRE during the 1950s. A small research team led by John Strath sought to apply the research to provide surveillance over the horizon. Little real progress was made until Strath presented a paper on the concept to a program meeting of the expanded

TTCP in 1968, the year after Australia had joined the program. He subsequently learned that the Americans had also researched this area and were willing to collaborate with Strath. Access to American data galvanised the Australians, and the notion of an over-the-horizon radar to provide surveillance across Australia's northern sea and air approaches became a core research project from 1970. Strath's concept was based on the idea of having a high frequency radar signal beamed skywards from a transmitter and refracted from the ionosphere to illuminate a target on the earth's surface. The echo from the target returned by a similar path to a separate receiver site. Received data was processed into real-time tracking information.

Dr John Strath.

Developing Jindalee from 'concept demonstrator' phase to proven operational capability continued from 1971 to 1987 after John Strath succeeded in gaining funding of a scaled-up prototype. The first experimental radar, designed and built by defence scientists, was constructed at Alice Springs in central Australia in the mid-1970s. Jindalee 'A' was modestly powered and had a narrow detection field. However, a demonstration witnessed by Sir Arthur Tange, Secretary of the Department of Defence, Chief of Air Staff Air Marshal James Rowland, and Chief Defence Scientist John Farrands, succeeded in detecting aircraft and ships in the Indian Ocean and, with the staunch support of John Farrands, guaranteed support from key people within the department, though Service chiefs generally remained sceptical of the value of the concept.[16]

The ongoing support ensured funding for Jindalee 'B', costing some $30 million. It was more high-powered than its predecessor, covered at least 60 degrees in azimuth, had radar track-while-scan capability, and an advanced automatic frequency allocation system. It also had a multiport computer processor that was designed in-house and was central to signal processing. It achieved operational capability during the 1980s and its success, and its appropriateness for Australia's current defence policy, prompted Minister for Defence, Kim Beazley, to announce approval in October 1986 for the design and development of an over-the-horizon radar network. A reference to the system in the 1987 Defence White Paper and the decision to proceed with the development of a network of up to three installations to cover the approaches to northern Australia vindicated the decades of research. That same year, the final stage—the operational radar Jindalee 'C'—was handed over to the Royal Australian Air Force (RAAF). This was achieved at an additional cost of $70 million with the earlier stage re-engineered by BAE Systems (formerly AWA) for the rugged demands of operational life. BAE Systems had been the support contractor for Jindalee since the Stage 'B' days.

Finally, in 1990, Cabinet approved construction of the Jindalee Operational Radar Network (JORN), and the $1 billion contract was awarded to Telstra Australia. The contract encompassed a network of two operational radars, one near Longreach in Queensland, the other near Laverton in Western Australia, and required Australian production of more than 70 per cent of the contract value.[17] Thirteen years later, on 2 April 2003, Defence Minister Senator Robert Hill was to preside over the operational release of JORN Phases 3 and 4 to the RAAF at its airforce base in Edinburgh. This event symbolised JORN entering operational status prior to final acceptable from the Tenix/Lockheed Martin consortium which ultimately became its manufacturers.

Australian Minesweeping and Support System.

Mike Turner's early work led to the development of the Australian Minesweeping and Support System. He won the inaugural Minister's Award for Achievement in defence science.

The several laboratories continued to undertake innovative projects; many, like Jindalee, extending over many years. The Australian Minesweeping and Support System (AMASS) was another project successfully commercialised after having been developed by scientists in Sydney. It was based on the early work of Mike Turner and for which he became the inaugural winner in 1988 of the Defence Minister's Award for Achievement in defence science. The work had been a long time in gestation with research into the use of towed permanent magnets for mine sweeping purposes having begun in 1973.

AMASS was the world's first operational emulation sweep. Its development followed the Navy's call for expressions of interest for the provision of mine sweeping capability in 1983; AMASS was developed for them in accordance with its Craft of Opportunity program to provide a reasonably inexpensive mine hunting and sweeping capability that would permit a range of small craft, such as tugs and fishing boats, to be converted rapidly into mine sweepers or mine surveillance vessels.

The key to the system was the development of dyads, or buoyant permanent magnetic cylinders, combined with water-driven acoustic generators that, when towed behind a vessel in various configurations, could emulate the magnetic and acoustic signatures of a range of vessel classes, and sweep sensitive influence mines to a depth of 90 metres. It was necessary to vary configurations to ensure the magnetic and acoustic signatures fell within the range of the targeted class of vessels. AMASS had several attractions and advantages over other systems: it was relatively inexpensive, required no electrical power, could withstand many mine explosions, and had no real competitor.

DSTO and the Australian company ADI Limited signed a licence agreement to develop the system technology further in 1992. ADI Limited launched the system in mid-1993 with a view to selling it to foreign navies. AMASS entered service with the Royal Australian Navy in 1993, with the United States Navy acquiring the system in mid-1995 and beginning trials under the United States Foreign Comparative Test Program. The Royal Danish Navy bought the system in early 1996, thereby becoming the first of several European and Asian countries to do so.[18] AMASS became a significant commercial success. Till 2006, it had generated more than $60 million in export sales.

Development of the Nulka Active Missile Decoy for the protection of ships from missiles proved another major success and went into service with navies of several nations. Nulka revolutionised ship protection with its unique hovering rocket. Once launched from a ship, Nulka could fly a pre-programmed flight path to attract sea-skimming missiles away from the vessel.

The system derived from a concept based on work undertaken in the 1970s and known as Project Winnin. Nulka was devised as a means of protecting shipping from missiles comparable to the French built Exocet that had been acquired by several countries. DSTO scientists developed Nulka's hovering variable-thrust, solid propellant rocket-motor technology in consultation with the Explosives Factory Maribyrnong, the Ordnance Factory Maribyrnong and the Government Aircraft Factory at Fishermans Bend. Successful trials were concluded in 1981. The loss of the British destroyer HMS *Sheffield* on 4 May 1982 during the Falklands War increased the sense of urgency. Four years later, in August 1986, Australia and the United States signed a Memorandum of Understanding to undertake full-scale collaborative engineering development of the system. Then, in 1988, AWA Defence Industries—later BAE Systems—was awarded a contract for the engineering development of the Nulka system and hovering rocket vehicle, with ADI being sub-contracted to develop and manufacture the rocket motor at its Mulwala facility in New South Wales. A separate contract went to the American company, Sippican Inc., to develop the electronic payload for the decoy. Meanwhile, between 1988 and 1992, Nulka was tested in the Fishermans Bend wind tunnel where the decoy's aerodynamic configuration was developed.

In January 1994, the Department of Defence and AWA Defence Industries signed a licence agreement for the development of Nulka. Two years later Australia signed a Memorandum of Understanding on the joint production of Nulka decoys for the Royal Australian Navy (for use on its FFG and ANZAC class ships) and for the United States Navy. In 1999, DSTO and BAE Systems signed a technology licence agreement for Anti-Ship Missile Simulation Software. This software was incorporated into a Nulka Tactics Generation Model, used as a generic anti-ship missile defence modelling facility as well as for Nulka marketing and development. By May 1999, Nulka was in full production for the Royal Australian Navy, United States Navy and Canadian Armed Forces and was later used in active service in the second Gulf War in April 2003.[19]

DSTO became the pioneer and world leader in extending the effective life of weapons platforms, particularly with the use of composite bonded repair technology to prolong the life of fighter aircraft. The technology was developed by Dr Alan Baker and his team in the Airframes and Engines Division of ARL and involved adhesively bonding patches of advanced fibre composite materials to repair damaged aircraft structures and arrest stress corrosion cracking. The repairs were structurally efficient, could be applied rapidly and were cost effective.

The technology had many advantages over traditional mechanical repair methods, such as bolting or riveting. The composites were lightweight, offered uniform load transfer, sealed interfaces to reduce corrosion and leakage, created minimal damage to the parent structure and facilitated non-destructive inspection. Continuing evolution of the technology permitted specialised repairs to be applied across the Australian Defence Force fleet and has also been used on civilian aircraft.

DSTO licensed Australian-owned private company, Helitech Industries Pty Ltd, to market and develop the composite bonded repair technology in 1990, with the Minister for Defence receiving DSTO's first royalty payment in April 1994. Helitech, in collaboration with DSTO, developed a composite bonded repair for the United States Air Force C-141 Starlifter heavy transport aircraft in 1995 and Helitech's wholly owned American subsidiary, Composite Technologies Inc., won a contract for repair of the United States Air Force Starlifter fleet wings. Helitech has also used the licensed technology to develop rotor blade repairs, and has conducted major repairs on the US Army's AH-64 Apache attack helicopter fleet.

This DSTO technology has been used in commercial airliners as well as other military aircraft belonging to the RAAF, United States and Belgian Air Forces to maintain and extend the life of their aircraft fleets. The ongoing development and use of composite bonded repair technology has resulted in significant maintenance savings and life extension to the RAAF fleet.[20]

The successful commercialisation of any project reflected great success indeed. Australian industry was reluctant to invest in new projects unless their commercial success was assured, despite the government's wish to involve Australian industry more closely. Australian projects had to be exceptional because of the small local market, the reluctance of American forces to acquire weapons and technologies that were not developed locally, and the dominance of the American arms market.

Early trials of Nulka system (Hoveroc) being tested at Port Wakefield, S.A.

Nulka Active Missile Decoy being deployed at sea.

Dr Alan Baker won the Minister's Achievement Award in 1990 for developing composite bonded repair technology.

The team responsible for developing Nulka prior to the tests at Port Wakefield.

Composite bonded repair patch being applied to a Macchi aircraft.

Industry cooperation

Bob Ward's appointment as Chief Defence Scientist was partly to strengthen DSTO's partnerships with industry and external research agencies. DSTO and its predecessors already had long associations with Australian industry. However, the traditional role of industry had been to provide components for weapons and other systems under development and fill major Defence procurement contracts for weapons and other products wholly developed by DSTO scientists. This was the case with the major innovations illustrated above. Australian industry had not been involved with the concept development of key weapons and products, except for the provision of components.

However, Bob Ward sought to enhance industry involvement in DSTO's support of the Australian Defence Force. His plan for doing so was outlined in a report *The Future Role of DSTO in Enhancing Australian Industry Capability*, that was tabled in Parliament in November 1992. The report highlighted the prevailing attitudes that prevented close collaboration between DSTO and Australian industry:

> *The advanced technology required by the Australian Defence Force and supported by DSTO provides limited commercial opportunities for industry due to characteristics including high specialisation, small market niche, limited domestic application, intense international competition and high risk. In addition, Australian industry lacks experience in overseas market penetration with advanced technology, and has a low investment*

> *in research and development compared to [Organisation for Economic Cooperation and Development] countries. Economically, the recession in Australia and international downturn has increased fiscal restraint on DSTO and Defence, and reduced the availability of capital for new investment by Australian Industry.*[21]

From DSTO's point of view, there was also the need to ensure that the pursuit of commercial activities did not compromise support for the Services, and that they took into account national security considerations and agreements governing international defence data exchange. The United Kingdom experience was not encouraging. There the government had established a firm, Defence Technology Enterprises, in 1984 to commercialise products of the defence research establishments, only to have it cease operations in 1990.[22]

Nevertheless, there was the opportunity to increase partnerships with industry particularly by differentiating between core defence projects related to combat situations and governed by security issues, and non-core activities in which industry might be engaged, and positively courted to participate.

In the first instance, and with agreement of Cabinet's Expenditure Review Committee, DSTO established an Industry Support Office located at the Aeronautical Research Laboratories in Melbourne. The idea was that this office would encourage the transfer of aerospace-related research with broad commercial applications to Australian industry.

The report also raised the option of DSTO establishing strategic alliances with industry 'to jointly research and develop technology of mutual interest.'[23] It did not elaborate on the implications of this latter initiative and indicated simply that 'industry support for this initiative would be crucial for its success, [and] DSTO will need to explore this concept further in conjunction with industry.'[24]

Still, the report set the direction for closer relations between DSTO and Australian industry. Many DSTO scientists would have believed the need to consider commercial aspects of their work to be another restraint on their endeavours. However, the new direction represented the wish of the government; those with a broader vision and an eye to the political climate would have appreciated that DSTO's future depended on the organisation embracing the new initiative. The latter may also have seen the benefits of engaging with industry at an earlier stage than previously.

Cooperative Research Centres

As well as seeking to forge new links with Australian industry, Bob Ward sought to extend the government's objective to establish closer links between publicly funded research organisations and industry. The nature of defence science work, particularly the security implications, meant many DSTO scientists were reluctant to engage with other research agencies. Mutual suspicions were deepened during the course of Australia's involvement in the Vietnam War but had begun to dissipate during the 1980s. Indeed, DSTO and CSIRO had signed an agreement in 1989 to engage in collaborative research. The new policy was articulated when, in May 1990, the government announced a program to create Cooperative Research Centres that were designed to facilitate links between scientists and industry.

Though primarily focused on research for defence applications, DSTO became involved in several collaborative research projects with universities and industry. In 1992, for instance, it participated in seven Cooperative Research Centres. A key centre was the Cooperative Centre for Aerospace Structures that brought together Hawker de Havilland, Aerospace Technologies of Australia, the Universities of Sydney, New South Wales and Monash, the Royal Melbourne Institute of Technology and DSTO's ARL. The headquarters of this Cooperative Research Centre was located at ARL's site at Fushermans Bend.

The Centre for Distributed Systems Technology involved the University of Queensland, the Queensland University of Technology, the DEC computer company and DSTO, pursuing a heterogeneous database system for the Department of Defence. Other Centres included those for Intelligent Decision Systems, Robust and Adaptive Systems, Polymer Blends and the Australian Maritime Engineering Research Centre.[25]

The Cooperative Research Centre for Sensor Signal and Information Processing was established in 1992, but officially opened at Technology Park in South Australia in August 1993. The centre represented DSTO, five universities, and industry partners Telecom and Digital Equipment Corporation Australia under Professor Henry d'Assumpcao, former Chief Defence Scientist.[26]

International collaboration

TTCP remained the most important vehicle for international collaboration for DSTO scientists with those of other nations. DSTO scientists were involved in major Navy and Air Force trials in underwater studies with their United States, British and Canadian counterparts in the Indian Ocean, Atlantic Ocean and off Hawaii. Australia's participation in the program gave DSTO credibility in the eyes of military chiefs, since the United States would transfer technologies to Australia only through its defence research arm, DSTO.

In addition, the Australian government entered into bilateral agreements with other nations from time to time. For instance, it negotiated a cooperative agreement with the New Zealand government in 1982; an agreement on gun and mortar propulsion research with Germany in 1989; it signed a Memorandum of Understanding of cooperative defence research and development with the Canadian government in 1990; it signed a collaboration agreement with France in 1990, and another with Singapore in 1993. Australia also had a Memorandum of Understanding on Cooperation on Defence Equipment Research, Development, Production, Procurement and Wider Industrial Cooperation with Sweden.

Australian defence science had been originally based on close cooperation with that of the United Kingdom. This cooperation was enhanced with the Joint Anglo-Australian Project. There was mutual eagerness to maintain this close relationship as the Joint Project wound down. A Memorandum of Understanding to pursue close cooperation in defence research had been concluded in 1978. A new and more detailed Anglo-Australian Memorandum of Understanding on Research (AAMOUR) took effect from 7 July 1986 to continue with cooperative research. The Memorandum of Understanding was Australia's largest bilateral research program providing for the exchange of information, collaborative research and exchange of personnel: in 1993 there were three active topics and three DSTO scientists were attached to the United Kingdom's Defence Science and Technology Laboratory.

Members of the TTCP Maritime Technical Panel (Mine Warfare and High Frequency Acoustics) gathered at Pyrmont in November 1998 for the 25th meeting.L-R: Ron Kuwahara (Canada), John Wickenden (UK), Gary Speechley (DSTO), Brenton Smyth (DSTO), Alan Theobald (DSTO), Reinhard Holtkamp (NZ), Lynda Mackenzie (DSTO), John Wade (UK), Douglas Todroff (USA), Ed Linsenmeyer (USA), Brendon Anderson (DSTO), Robert Dow (DSTO).

Close collaboration also continued with the United States in accordance with the Clifford-Fairhall Memorandum of Understanding and the Mutual Weapons Development Data Exchange Agreement. Three DSTO staff worked in the United States in 1993. The Research, Development and Engineering Agreement with the United States Department of Defense—the Deutsch-Ayers Agreement—negotiated in 1994 enabled DSTO scientists to work in such institutions as the United States Office of Naval Research and the United States Air Force Office of Scientific Research.

The later 1980s and early 1990s represented something of a watershed in the history of defence science in Australia. Political reality dictated that it be held accountable to the needs of the Australian Defence Force—and the Treasury.

At the same time the political reality had changed. This brought a new focus on implementing the policy of self-reliance in defence matters in an era of financial restraint and economic rationalism. This meant DSTO was expected to remake itself by abandoning old ideas, and to capitalise on its intellectual property and engage more closely with industry in order to maximise the economic return on its activities. Its continuing relevance depended on the extent to which it was prepared to change its culture.

The new realities brought DSTO and the Services closer together. There had long been a battle by DSTO to have the work of its scientists appreciated by key Service personnel. The Navy had generally been supportive because of the close collaboration from the early days of RANEL. This acceptance grew as DSTO scientists became more closely involved with actual wartime scenarios. Rear Admiral Robert Walls, maritime commander during the first Gulf War, certainly welcomed the assistance of DSTO scientists who helped prepare the Navy's vessels for the conflict in which Australian Service personnel were involved from August 1990 to September 1991. DSTO scientists went aboard the first two frigates to be deployed to the Gulf, as they steamed between Sydney and Fremantle to ensure protective systems were in place.

Senior Air Force personnel also appreciated the value of the ARL's work in enhancing the life of aircraft. However, the regard was not always shared by those in less senior positions who considered DSTO scientists to be boffins—bright people engaged in research with little regard for practical realities.


DSTO
AUSTRALIA

CHAPTER 9

Consolidation: 1993–2000

Australia's defence policy continued to evolve, with a concomitant impact on DSTO. Continuing defence reviews and reports placed ever-increasing importance on the role of the organisation and regard for its expertise. This became significant at a time when Australia gradually lost its technological edge within the region as neighbours gained access to modern weaponry. In these circumstances, it became necessary for Australia to maintain its 'knowledge edge'. DSTO was fundamental to this.

The change in emphasis was reflected in successive Defence White Papers. As Paul Dibb indicated, the 1994 Defence White Paper, *Defending Australia*, which Federal minister Robert Ray tabled in November 1994, stressed the need for the Australian Defence Force 'to become more selective about identifying those areas in which it needed to maintain a decisive lead and give priority to them.' 'Selective capabilities' rather than 'technological edge' became the new conceptual framework for Australia's defence policy. Dibb continued:

> *Among the key areas where excellence needed to be developed, and which were needed to give Australia a 'decisive edge where it counts most', were:*
>
> - *intelligence, evaluation and distribution;*
> - *surveillance and reconnaissance;*
> - *command and control;*
> - *key weapons and sensors; and*
> - *electronic warfare.*
>
> *In particular, command, control and communications were seen as areas in which Australia needed to maintain a high degree of excellence.*[1]

These were the areas in which DSTO excelled and in which much of its current research was being undertaken.

However, a coalition government led by John Howard returned to government on 2 March 1996 with Ian McLachlan as Defence Minister. While agreeing that the defence of Australia remained the Defence Force's primary responsibility, the policy of the new government outlined in a new Defence Strategic Review tabled in 1997 also advocated what might be termed 'forward cooperation'.[2] Defence policy continued in the general direction established a decade earlier of enhancing capabilities for regional operations, though now with a higher priority being given to strike and amphibious operations and air power. 'Hence, combat aircraft, submarines and surface combatants (in that order) supported by well-developed intelligence, surveillance and command and control systems, are seen as Australia's first line of defence and its highest priority.'[3]

‹ DSTO support for submarine operations.

While the new government advocated a slightly enlarged role for the Australian Defence Force, McLachlan's term was characterised by the push to make savings in the order of $800 million chiefly by the loss of thousands of Defence jobs in search of efficiency gains, but at a high cost to Defence personnel and their families, particularly in terms of morale. By this time DSTO had already undergone radical surgery.[4]

Culture change

Dr Richard George Brabin-Smith was appointed Chief Defence Scientist in February 1993 and became responsible for overseeing the continuing evolution of DSTO, particularly with the greater emphasis on defence science directly supporting Defence Force needs. 'Brab', originally a Londoner, had an honours physics degree from the University of Nottingham and a doctorate for work on low temperature magnetic resonance. He joined DSTO's Central Studies Establishment in 1973 and moved to the Force Development and Analysis Division in 1980. He spent a year at the Pentagon as an analyst in program analysis and evaluation and after returning to Australia assisted with the conduct of the Paul Dibb Review into Australia's defence capabilities. He rejoined the Department of Defence in 1986, as head of the Force Development and Analysis Division and became head of the Strategic Policy and Development Division in June 1990, which in November 1990 merged with the International Policy Division.

Senior DSTO personnel who had earlier attended a conference at which he had spoken and highlighted apparent deficiencies within the organisation, viewed Brab's appointment with cautious suspicion. However, Brab was a political realist as far as Canberra was concerned and was appointed for this reason. He had effectively ceased to 'do' science in the late 1970s, and since then had been involved in defence policy development. He believed that the future of DSTO could be guaranteed only if there was a firm policy framework to guide the science, rather than undertaking science that might have defence applicability. He wrote:

> *DSTO's basic raison d'etre is to give advice to the other parts of the Defence Organisation; advice that is professional, impartial and informed on the application of science and technology that is best suited to Australia's defence and security needs. Everything else is secondary; the tail must not wag the dog.*[5]

His constant endeavour was to seek to identify and define the issues facing the Australian Defence Force that DSTO could solve and have the laboratories address these.

None had ever doubted the high quality of the science DSTO scientists undertook, but it was important that it be directly relevant to the needs of the Defence Force if it was to be supported by defence personnel. Brab, with the full support—even insistence—of Secretary Tony Ayers and Chief of the Defence Force, General John Baker, sought to hasten DSTO in the direction in which it was already heading towards greater customer focus and greater financial accountability in accordance with evolving Defence policy.

The policy was not without its casualties. Dr Mark Readhead of the Maritime Operations Division had the distinction of gaining the first Royal Australian Navy Scholarship on 11 September 1995 to conduct research into 'acoustic lenses'. The scholarship enabled him to spend 12 months at the Marine Physical Laboratory of the Scripps Institution of Oceanography at the University of California. He sought to develop a new capability for detecting and classifying underwater objects and vessels by using 'acoustic daylight' based on the scattering of ambient sound from the object. The idea of an acoustic lens was to focus the noise scattered by an object onto a suitable detector. The research may have led to significant scientific discoveries, but it was expensive and with a long timeframe that senior managers believed could not be justified in the new economic environment. The research ceased in accordance with the need to focus on higher priorities.


Dr Bill Schofield, Director, Aeronautical & Maritime Research Laboratory, 1995–2001.

The emphasis on defence needs first, with science ranked second, continued to bother some scientists who yearned for the earlier days when research projects were largely determined by themselves with a greater or lesser association with defence needs and with little regard for departmental bureaucracy in general or the views of central office in Canberra. But close attention to client needs was necessary when the increasing costs of defence placed greater emphasis on accountability within an organisation that was only a small part of the Department of Defence and in which the Services guarded and sought to increase their proportion of budget funds.

Organisational changes followed the appointment of the new Chief Defence Scientist and a review that followed the tabling of the 1994 Defence White Paper. The most evident effect of continued restructuring was the reduction of the four DSTO research laboratories to two in April 1994—the Aeronautical and Maritime Research Laboratory (AMRL), headquartered at Fishermans Bend in Melbourne under Director Wynford Connick and the Electronics and Surveillance Research Laboratory (ESRL) with headquarters in Salisbury, South Australia, under Director Scot Allison. It was Brabin-Smith's wish to have 'only one bull in each paddock.' Connick had been appointed Director of ARL in 1992 and became the first director of the new Aeronautical and Maritime Research Laboratory in 1994. He remained in the position until retiring in mid-1995, when he was succeeded by Dr Bill Schofield.

AMRL included five divisions: Air Operations; Airframes and Engines; Ship Structures and Materials; Weapons Systems; and Maritime Operations. There were six divisions comprising ESRL: these were Communications; Electronic Warfare; High Frequency Radar; Information Technology; Land, Space and Optoelectronics; and Microwave Radar.

The establishments in other centres beyond Canberra formed part of one or other of these two laboratories. For instance, AMRL included the Maritime Operations laboratories at Pyrmont, the Food Science laboratories in Scottsdale and the tropical exposure testing facilities at Innisfail.

Brab also persisted with a major change begun earlier, namely the manner in which laboratories were administered. He insisted that directors concentrate on science and allow administration to be managed from Canberra. He demanded that the loyalty of administration officers be to the Science Corporate Management Branch rather than individual divisions and that their first concern was delivery of good service. In earlier days the chief administration officers on the various sites held very powerful positions because of their tight control over budgets. This irked scientists and, for a time, they succeeded in having administration devolve to the level of individual laboratories, even to the extent of each having its own pay cell.

This made for great inefficiencies, unnecessary duplication and poor cooperation between laboratories. It was indefensible during a period of tight and reducing budgets. Brab sought to rationalise this, returning to the idea of having one administrative arm at each site but with overall management exercised from Canberra. Peter Lush, Assistant Secretary Science Corporate Management, played a major role in overseeing changes and implementing a more corporate approach to administration. Peter Sharp, his successor, consolidated the changes and took them further by implementing staff cuts at one level and improving skills at another. In one message to administration staff he insisted, '... each of us has to reassess the nature of our future. We can no longer afford an attitude of a "job for life"', and added:

> *That does not mean that suddenly at short notice we are to be retrenched. What it does mean is that each of us can usefully examine whether we have employment options outside the one we are in, and whether, given what we know about the direction of DSTO and the Public Service, it would be better to develop new options for employment.*[6]

Murray Domney continued the initiatives to coordinate and unify procedures.[7]

The greater focus on staff development was another important and complementary initiative. Leadership programs were implemented for staff at all levels within the organisation with a particular thrust to make better leaders of scientists. Peter Sharp articulated the philosophy of senior management:

> *Supervisors in the 90s will operate in a period of discontinuous change. If they are to achieve their goals they will need to lead more and supervise less; to team more and preside less; to plan more and check less; to develop staff more and confine them less; to initiate efficiencies more and hang on to territory less; to influence more and control less. The supervisors of the 90s will be less comfortable than in the 80s, but their achievements will be greater.*[8]

A key element of the restructuring was to continue to change the culture and doctrine of the organisation to meet challenges inherent in rapid developments in information and communications technologies that highlighted the growing importance of 'knowledge-based warfare'. This was epitomised in the American concept of 'Revolution in Military Affairs'. This 'system of systems' was 'an extremely high technology, expensive and comprehensive approach to modern warfare' that the Australian Defence Force could not hope to emulate except in accordance with its 'affordable priorities' in systems integration and integrated logistical support appropriate to the region.[9] Supporting this concept became the challenge for DSTO.

The continued commercial thrust was evident when Dr Bill Schofield was persuaded to move to Canberra to succeed Ian Hagan as First Assistant Secretary, Science Policy. He had been born in Perth in 1940, but gained his Honours Degree in Mechanical Engineering from the University of Melbourne in 1961 and a Masters Degree in 1964. He joined the Aeronautical Research Laboratories in 1965 and spent most of his career at Fishermans Bend. He became Leader of the Combustion Group in 1981 and chief of the Flight Mechanics and Propulsion Division in 1988.

This initiative was complemented by Brab convincing Secretary Tony Ayers of the need for a new senior position at assistant secretary level to foster stronger links with industry. He argued that failure to do so would make DSTO vulnerable to its detractors. His wish was granted and Ann Thorpe was appointed as Assistant Secretary Science Industry Interaction: She was followed by Karen Nagle.

The team of Brabin-Smith, Schofield, Allison and Connick, with senior staff in Canberra, then focused on reshaping DSTO's culture and fostering the push towards a goal-oriented organisation responsive to the wishes of its key clients. An important aspect of this customer orientation was the appointment of 'Customer Account Managers'—in effect the directors—with responsibility for each key customer group; though funding remained tied to laboratories and divisions rather than the customer account managers. At the same time, even greater emphasis was placed on applied research throughout the broader organisation, with the outsourcing of engineering and engineered products to private industry. The rapid developments in telecommunications, in particular, largely driven by industry, meant that in many areas defence science no longer set the pace. The issue now was in taking key civil innovations and developing appropriate defence uses.

Innovation

While most recent changes to DSTO had been concerned with consolidating and rationalising establishments, DSTO established a new outpost at HMAS *Stirling*, south of Perth, Western Australia in November 1995: the new facility was officially opened by Defence Minister Kim Beazley in February 1996 immediately prior to the change of government. DSTO Sydney, in particular, had long been involved with Australia's submarine fleet. However, this relationship changed with the decommissioning of the Oberon class submarines that had been based in Sydney. The Collins class submarines were based in Perth.

The new facility and staff were to provide operational and exercise analysis, combat system decision and training aids and frontline support to submarine and surface-to-ship sonar systems. Dr Chris Davis, formerly of DSTO Sydney, took charge of the new facility and 18 staff, projected to grow to 25 within three years. Chris Davis had joined DSTO Sydney and the Undersea Warfare Studies Group in 1987 and had remained until assuming his new post in Perth. Colin Harling, who had contributed a great deal to exercise analysis at Sydney, was one of the key personnel at the new site. He established computer-based exercise analysis at Stirling that led to the development of a commercial product known as MEXANS—a maritime exercise analysis system.

Many DSTO scientists had been associated with the development and construction of the Collins class diesel-electric submarines built by the Australian Submarine Corporation at Osborne in suburban Adelaide, where the 'keel' of the first of the submarines, HMAS *Collins,* was laid on 14 February 1990.

DSTO made a fundamental contribution to the project with Dr John Ritter leading a team that developed a new high-strength steel for the submarine together with appropriate welding technology that saved Australian industry in the region of $17 million. Ritter's collaboration with the Navy's Submarine Project Office, the Swedish designer Kockums AB; the builder Australian Submarine Corporation; and the steel producers BHP and Bisalloy Steels, resulted in the acceptance of a fracture control methodology that ensured that optimum resistance to shock loading was built into the new submarines. It also meant Australian industry was able to perform all steelwork maintenance and repair work for the Collins class submarine.[10]

Another significant DSTO contribution to the project was the development of acoustic tiles for the hull that were designed to reduce the vessels' acoustic signatures. None of Australia's allies would share the technology, so it was imperative to develop this independently. DSTO's Dr David Oldfield and his team succeeded in doing so in association with Mackay Consolidated Industries that specialised in rubber products, and thus developed tiles appropriate to the environment in which the submarines were to operate.[11]

DSTO scientists made other contributions, with Dr Chris Norwood leading a team that succeeded in significantly reducing the noise generated by the submarines during operations at depth and while snorting. Dr Todd Mansell assisted the Royal Australian Navy and the Defence Materiel Organisation in acquiring a replacement combat system. Other DSTO scientists assisted with reducing the fire risk aboard the submarines, investigating new methods of air independent propulsion and with the shock trials conducted in Australia as part of the commissioning process.[12]

Dr John Ritter won the 1993 Minister's Achievement Award for developing high-performance steel and welds used in the construction of the Collins class submarine.

Dr Chris Norwood took out the 2000 Minister's Achievement Award for his work on the management of noise and vibration in the Collins class submarine.

Dr Todd Mansell was recognised with the 2004 Minister's Achievement Award for his pivotal role in the acquisition and replacement of the combat system for the Collins class submarine.

Dr David Oldfield's research into anechoic materials for the Collins class submarine won him the 1991 Minister's Achievement Award.

Then, once difficulties with the intended combat system became apparent, DSTO established a Submarine Combat Research Division at Salisbury led by Dr Roger Creaser. This provided the opportunity for all stakeholders to come together to address the issue.

The Collins class submarines carried Ping Intercept Passive Ranging System (PIPRS) equipment for locating potential enemy vessels. This was a concept developed at DSTO Sydney to determine the range of active acoustic transmissions of the kind used in anti-submarine warfare to locate possible targets. Tony Collins invented the system: he was working on a project dealing with sonars associated with the Oberon class submarines when he conceived a new means of using the existing technology that would enhance it considerably.

Traditionally, passive sonar arrays were used to determine the presence, location and direction of travel of other vessels by means of their acoustic signatures. Active sonar pings from such vessels tended to confuse the hydrophones. In researching the means to overcome this issue, Collins and his colleagues concluded that there was an advantage in intercepting the active sonar ping from hunting vessels rather than their acoustic signature. The idea was to use hydrophones on a submarine to intercept the sonar ping propagated from the hunting vessel in a curved wave front and use this data to determine the location of this vessel before it drew within range to receive the reflected signal from the hunted vessel. Having the ability to determine the origin of the initial transmission before the signal returned to its source gave the hunted vessel the opportunity to take action first, thereby giving it greater advantage. The team was able to develop a system for achieving this advantage by using standard hydrophone arrays and commercial microcomputers, and developing appropriate algorithms.

Having developed the prototype, DSTO licensed SonarTech Pty Ltd to commercialise the system, and it subsequently supplied PIPRS equipment to the Royal Australian Navy's fleet of Oberon class submarines and those of other navies around the world, including the United States. An enhanced system, the Submarine Acoustic Transistory Event Processing System, was deployed in the Collins class submarines. The PIPRS principle was also used to develop a torpedo defence system that was successfully trialled by United States submarines.[13]

Valuable research was active on other fronts as well. For instance, in 1997, DSTO developed a Long Range Ultraviolet Stimulator for electronic warfare testing and training by the Australian Defence Force. The technology was based on DSTO's Flight Line Test Set that performed pre-flight testing of an aircraft's missile approach warning system by simulating the ultraviolet signature of an approaching missile. The new application took this technology and extended the range to more than three kilometres, allowing it to be useful for electronic warfare ranges for equipment testing, training and tactics development. DSTO licensed the new technology to the United Kingdom electronic warfare specialist, Elettronica Systems Ltd, that was already licensed to market the Flight Line Test Set, and also the Australian company, Vision Abell, that later formed part of Tenix Defence Systems Pty Ltd. These companies later built upon the DSTO technology and developed the long range Mallina Ultraviolet Stimulator to operate over ranges up to 6 kilometres. Long Range Ultraviolet Stimulators were sold to several nations including Germany, the Netherlands, South Africa, the United Kingdom and the United States.[14]

The Australian Synthetic Aperture Radar (AuSAR) was another significant project conceived by DSTO scientists and again developed in the face of scepticism of Service personnel. This was an advanced technology that allowed a radar system with a conventional antenna 1 metre to 2 metres in length to collect photo-like imagery at more than 500 times the resolution of normal radars, day or night and in all weather conditions. Originally a solution without a question, it was later judged to be invaluable for defence mapping and surveying.

The original C-47 AuSAR test bed. Nick Stacy operating the first Ingara real-time processor aboard the King Air 350 test bed, c. 1998. AuSAR images of Uluru and Saddleworth, Victoria.

Project AuSAR, the brainchild of Dennis Longstaff, began in 1989 within DSTO's Microwave Radar Division under the initial leadership of David Heilbronn and with expectations of building the system within three years. BHP Aerospace and Electronics, and the CSIRO's Department of Radio Physics joined DSTO in the project for a time but by 1991 both organisations had withdrawn. However, with the urging of Don Sinnott, chief of the Microwave Radar Division, the team pressed ahead with further development concentrating on the total system rather than the radar only. By 1992 AuSAR was in an advanced state of design, enabling the first AuSAR image of the South Australian town of Balaclava to be captured on 4 March 1993 on the system's inaugural flight aboard a Dakota C47 (DC3) operated by the Aircraft Research and Development Unit.

In 1994 the project name of AuSAR was changed to 'Ingara', an Aboriginal word for 'long way', and an air-to-ground data link and a data exploitation ground station were developed. The data link in itself was a significant design achievement being the first air-to-ground data link in Australia to have such a high data-imagery rate. The system was used for the first time in a military exercise in 1994. The following year the first integration of the data link and ground station was made during Exercise Kangaroo 95 when, for the first time, an Ingara team of 20 was able to see in nearly real time what was happening 250 kilometres away from their base in Darwin. A systematic development and testing phase followed.

The focus of Ingara changed in early 1997 with the formation of Joint Project 129 that sought to conduct surveillance for land and selected maritime operations, from the air, at a high operational tempo, with a high degree of certainty of identifying targets and with a low probability of false responses. Ingara was now integrated into a smaller Beach 350 King Air aircraft to test and validate broad area airborne surveillance concepts. Lessons from the Ingara multi-mode radar project and the development of its maritime and littoral surveillance capabilities for Joint Project 129 and for Project Air 5276—the P-3C Orion upgrade—were critical in convincing the Americans to collaborate with Australia in the Global Hawk project.

Global Hawk was the world's largest military remote controlled aircraft. It was jet-powered and equivalent in wing size to a Boeing 737 commercial airliner. It had a range of around 14,000 nautical miles and could fly at altitudes of 65,000 feet for more than 36 hours. The Ingara work played an integral role in adding maritime surveillance and dynamic control capability to the Global Hawk system and systematically tested the deployed system against various scenarios. The system was successfully proven in the Gulf War where tactical intelligence was collected at night and through thick oil smoke.[15]

Research continued in many fields. Another useful project, concerned with stress measurement by thermoelasticity, described the study of stresses generated by different loads at different temperatures. DSTO's Dr Jim Sparrow initiated research into this area in 1985 following the acquisition of a highly sensitive infrared temperature detector known as SPATE (Stress Pattern Analysis by the measurement of Thermal Emission). However, Dr Albert Wong discovered there was an anomaly in Lord Kelvin's Law that cast doubt upon the accuracy of measurements obtained with SPATE, which could resolve cyclic temperatures to 0.001 degrees Celsius. Wong, with team members Sparrow and Dr Shane Dunn, used the anomaly to develop algorithms that made possible the measurement of total stress. This offered a potential for measuring residual stresses, which had important ramifications in structural analysis.

Initial use of the SPATE equipment was limited to measuring the sum of the principal stresses at any point, but Dr Tom Ryall overcame this limitation by developing methods to separate the measured stress into its components. As the method applied to two dimensional stress fields only it was therefore only applicable to thin structures. However, Ryall and Wong rendered SPATE redundant in 1992 when they developed a system known as FAST (Focal-plane Array for Synchronous Thermography). This was an infrared camera system designed for analysing stresses in metal and composite structures. It produced, in minimal time, higher resolution maps of stress in structures than was previously possible and at the time represented a major advance in technology. FAST stress maps could identify critical regions of high stress that might lead to fatigue or overload failure in structures, and was used to help identify the point of structural failure that resulted in the loss of a RAAF P-3C Orion aircraft.

Department Secretary Tony Ayers with Dr Tom Ryall and Dr Albert Wong, joint winners of the Minister's Award for Achievement in defence science, 1995.

This pioneering work played a key role in advancing full-field measurement of cyclic stresses via thermoelastic stress analysis, and earned Dr Thomas Ryall and Dr Albert Wong the 1995 Minister's Award for Achievement in defence science.[16]

DSTO scientists continued their research into practical uses for laser technology. In the 1990s, the Co-planar Pumped Folded Slab laser, based on laser-diode pumped solid-state laser technology, was invented, patented and developed by DSTO's Dr Jim Richards and Alasdair McInnes. The laser was licensed for use in the improved LADS that has since been marketed worldwide.

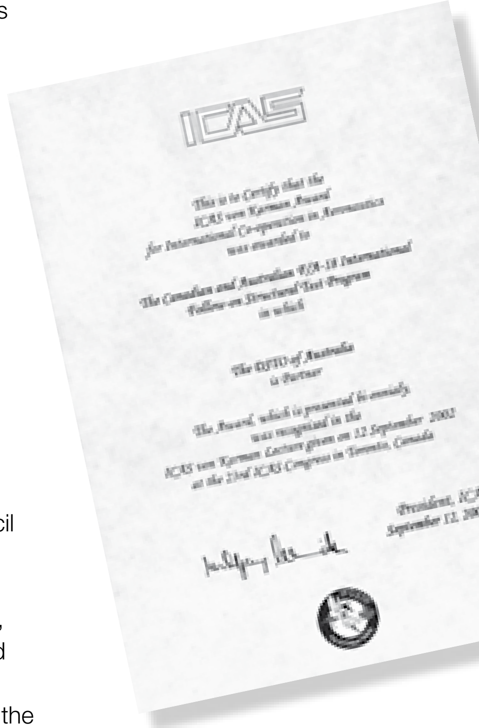
The Co-planar Pumped Folded Slab laser had many and varied applications in defence, industry and medicine. One of its key features was its versatility, in that it could be programmed to emit continuously, or in short pulses (a few billionths of a second), in the infrared, visible or 'eyesafe' regions of the spectrum, all with state-of-the-art performance with only minor changes to the configuration.[17]

DSTO scientists at the Aeronautical & Maritime Research Laboratory in Fishermans Bend continued to enhance DSTO's reputation through their work in extending the life of aircraft. Fundamental to this was the development of tests for the aircraft structure. The full-scale structural test of the F/A-18 Hornet aircraft was recognised as an outstanding example of international cooperation in the field of aeronautics. The International Follow-On Structural Test Project—a joint venture between Canada and Australia—followed a decision taken by the RAAF in 1988 that a full-scale structural test on the empennage of the F/A-18 Hornet was required to establish its economic safe life. This decision had arisen out of earlier preliminary discussions between DSTO's Chris Rider and Dave Simpson of the National Research Council, Canada, at a panel meeting of TTCP. Under the agreement the Canadians tested the centre fuselage and wing and agreed to provide much of the flight test data for the Australian aft fuselage and

Fatigue testing of F/A-18 Hornet for International Follow-on Structural Test Project and (inset) David Graham who won the Minister's Achievement Award in 1997 for his leadership of the project.

empennage test. The Australians, in return, provided most of the flight test data for the empennage and rear fuselage section. The Australians acquired a new empennage and rear fuselage section while the Canadian Forces retired an aircraft from service for their program.

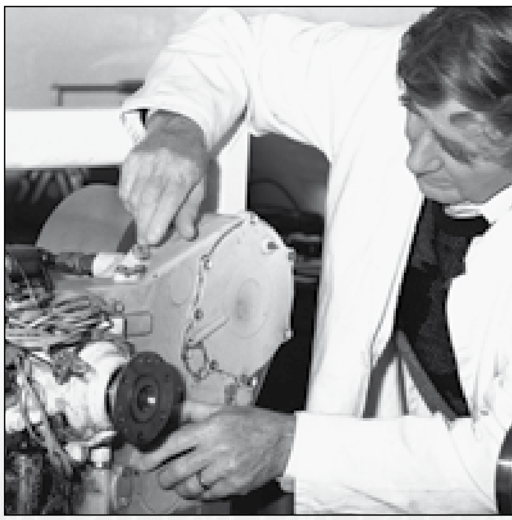
David Graham became the project manager for what was DSTO's biggest fatigue project. Full-scale testing of major components commenced in 1995 at Fishermans Bend and over subsequent years involved 24,000 hours of test 'flying' in a specially designed rig that duplicated the stresses and loads that an F/A-18 Hornet would experience in real flight. Along the way, many new test techniques were pioneered and an invaluable set of operational data was collected to support the aircraft for RAAF service.



Von Karman Award.

In recognition of this achievement the International Council of the Aeronautical Sciences awarded its prestigious Von Karman Award in 2001 jointly to DSTO, the RAAF and the Institute for Aerospace Research, National Research Council, Canada. Previous recipients of the award included the United States, Italy and Japan for their collaboration on the Boeing 767, and France and Germany for their cooperative work on the Airbus.[18]

DSTO's pioneering spirit and award winning innovation was evident too in research that facilitated the monitoring of gearbox failure in helicopters. Peter McFadden began a major research program following investigation into a gearbox failure in a Wessex helicopter. McFadden left DSTO in the mid-1980s to take up a position at Oxford University, but David Forrester continued the work and subsequently won renown for applying time frequency analysis to machine fault diagnosis. In 1988, Forrester, who held an Australian patent and a United States provisional patent on an algorithm for detecting faults in epicyclic gears, developed a system for detecting transmission faults and successfully demonstrated this on the Sea King helicopter. An updated version of this system for onboard monitoring was developed and used by the Royal Australian Navy in its entire fleet of Seahawk and Sea King helicopters with new hardware and software being designed by David Blunt and Scott Dutton.



Brian Rebbechi working on the F/A-18 gear box.

In 1996–97, following in the same tradition, Brian Rebbechi undertook work into gearbox condition analysis on the Aircraft Mounted Auxiliary Drive gearbox of the F/A-18 Hornet and developed a vibration-based diagnostic method of assessing the condition of gearboxes already installed. The work led to a redesign of the gearbox and savings of millions of dollars in operational costs to the RAAF and United States Navy.

The helicopter gearbox monitoring technology won international recognition in 1999 when the American company Chadwick-Helmuth, the world's largest producer of aviation vibration analysis equipment, acquired the licence that enabled it to commercialise the DSTO technology and market it worldwide.[19]

Defence Efficiency Review, 1997

Meanwhile, the Department of Defence and DSTO continued to undergo review. A 1990 report commissioned by the Minister for Defence and undertaken by Alan K. Wrigley, *The Defence Force and the Community: A Partnership in Australia's Defence*, followed the 1987 Defence White Paper and reiterated the advantages of having private industry undertake defence support activities. This series of reports and reviews led to the implementation of the Commercial Support Program that sought to commercialise non-core defence activities and open areas of defence support activities to private sector competition. Secretary Tony Ayers considered this program as 'one of the most important initiatives to be introduced in Defence.' There followed the Defence Efficiency Review and the subsequent implementation of the Defence Reform Program aimed at creating a more efficient Defence Force focused on its core activities.[20]

The extent to which the successive restructurings of DSTO had been successful was evident from the report of the Defence Efficiency Review, which was tabled by Defence Minister Ian McLachlan on 11 April 1997. The review was chaired by Dr Malcolm McIntosh, chief executive officer of the CSIRO, and included Dr Richard Brabin-Smith; Vice Admiral Robert Walls, Vice Chief of the Australian Defence Force; Ian Burgess, AMP Chairman; John Stone, former Treasury Secretary; and Andrew Michelmore, General Manager for Western Mining Corporation.

The review reiterated the need for the organisation and complimented DSTO on the work being done, suggesting it was already pursuing initiatives raised by the review. Indeed, at this stage when the DSTO budget allocation stood at $210 million the organisation had increased its scientific output in the face of decreasing funding in the government's budget over a 10-year period.[21] The only major recommendation of the review was the need to become more involved in advanced modelling and simulation.[22]

One of the other more important initiatives to flow from the Defence Efficiency Review was the implementation in 1997 of the Capability and Technology Demonstrator program that had been initiated within DSTO. The aim of the program was to identify developments in advanced technology within industry and Defence that matched priority areas of defence capability and which should receive financial support to fast track their development. It encouraged industry to become actively involved in defence research by offering funding on an annual basis for projects showing a defence capability. Much of the innovative work came from small and medium enterprises; most of it was based on electronics and information technologies.[23] In the initial years DSTO managed the program in association with the Defence Materiel Organisation.

There continued to be a measure of organisational review to identify scope for improvement. Scot Allison, who retired from the position of Director of the Electronics and Surveillance Research Laboratory in mid-1996 after 33 years with DSTO and its predecessors, was asked to review the operations of the Ships Structures and Materials Division at Maribyrnong. He found a microcosm of the DSTO of previous years with several separate fiefdoms largely intent on protecting their own interests. The laboratory maintained its academic culture and continued to undertake good work, but little effort was made to publicise this. In 1997 a reorganisation of

Aerial view of the new 'Knowledge Systems Building', DSTO Salisbury in 1997.

Defence Minister Ian McLachlan with Dr Richard Brabin-Smith and Dr Ian Chessell during the formal opening of the redeveloped DSTO Salisbury site in September 1997.

Scot Allison.

the Ships Structures and Materials Division resulted in the creation of the Maritime Platforms Division and the Combatant Protection and Nutrition Branch, with the Maribyrnong components of these identified for eventual relocation to Fishermans Bend.[24]

The Melbourne elements of the Maritime Operations Division were transferred to Sydney. There was also no future for explosives research at Maribyrnong because of encroaching residential development. So the explosives ordnance function was transferred to Salisbury. Dr Ian Chessell, as chief of division, integrated this function with the Guided Weapons Division at Salisbury to form the new Weapons Systems Division.

Other initiatives included a greater focus on operations research, and the decision to create a Land Operations Division under chief Roger Lough in 1997 to address issues faced by Army. DSTO also obtained government agreement to embark on research aimed at defence against biological weapons. This proved timely in view of the approaching 2000 Olympic Games in Sydney.

A snapshot of the DSTO organisation after another divisional restructure on 1 July 1997 saw Dr Bill Schofield take over as Director of the Aeronaurical & Maritime Research Laboratory while Dr Ian Chessell became Director of the Electronics & Surveillance Research Laboratory. The divisions and their chiefs responsible to Bill Schofield based at Fishermans Bend included Airframes and Engines (Peter Preston), Air Operations (Chris Guy), Maritime Platforms (Tony McLachlan), Maritime Operations (Roger Creaser in Salisbury), Weapons Systems (Nanda Nandagopal in Salisbury), along with Theatre Operations Group (Ken Anderson) and Combatant Protection and Nutrition Branch (Brent Paul). Those reporting to Ian Chessell at Salisbury were Land Operations (Roger Lough), Wide Area Surveillance (Bruce Ward), Tactical Surveillance Systems (David Gambling), Information Technology (Neil Bryans), Electronic Warfare (Max Lees) and Communications (Tony Bedford). Murray Domney, head of Science Corporate Management, and and Don Sinnott, First Assistant Secertary Science Policy, reported to Chief Defence Scientist, Brabin-Smith.

Physical rationalisation

The ongoing restructuring of DSTO ultimately had an impact on the physical rationalisation of DSTO sites in Salisbury, Fishermans Bend and Sydney, and the proposed closure of Maribyrnong.

Rationalisation of the sites was certainly a consequence of new technologies but was also driven by the push from government to dispose of excess defence land. The *Rationalisation of Inner Melbourne Accommodation* gained currency from ministerial announcements in 1992 concerning the future use of RAAF Williamstown. At that time Defence owned or leased 11 different sites in and around Melbourne.

Salisbury

Already plans were in place to rationalise DSTO activities in Salisbury: a property review completed in January 1984 recommended consolidation of DSTO activities into a smaller area. The site at that time differed little from that taken over for the Joint Project in 1947. Buildings had been refurbished internally to accommodate new uses, but there had been little by way of new building work with research continuing to be undertaken in as many as 650 buildings spread through the 1000 hectare complex.

Headquarters of the new DSTO Salisbury site.

During the early 1990s, plans were made to consolidate DSTO activities into a 280 hectare site focused on the previous Laboratories Area. The centrepiece of the new development was the building of a new office and laboratory complex at an estimated cost close to $51 million. The proposal was tabled in Parliament on 5 December 1994 and approved two days later. Construction commenced the following year and the Minister for Defence Ian McLachlan officially opened the new complex on 5 September 1997.

Consolidation of DSTO activities enabled the disposal of up to 700 hectares of land. This ultimately passed to the South Australian Land Management Corporation for redevelopment as an industrial park, much of it designed to support the General Motors Holden plant beyond the railway on the site's eastern boundary.

Meanwhile, the Chief Defence Scientist's Advisory Committee in early 1996 noted the need for a formal plan to guide development of the Salisbury site for the following five to seven years. At the same time it noted a similar need in Melbourne 'in light of the prospect for accelerated DSTO departure from Maribyrnong.'[25]

Melbourne

The prospect of closing the Maribyrnong site had been considered a distinct possibility following the 1994 amalgamation of the Aeronautical Research Laboratories at Fishermans Bend and the Materials Research Laboratories at Maribyrnong.

By this time various organisational restructures at Maribyrnong meant that staff numbers had declined from 600 to 230, and only about one-third of the 10 hectare site was being used. Some redevelopment had taken place. In 1983, for instance, construction began on a new Physics Division building to replace three others that were run down and inadequate: one had been built during World War II as a temporary canteen. Governor General Bill Hayden had opened a new laboratory in November 1990 named in honour of Tom Fink.

On the other hand, considerable redevelopment had taken place on the 13 hectare Fishermans Bend site. The Commonwealth government had originally leased the site from the Victorian government and it had been augmented by closure of the Fishermans Bend airfield in 1968 following inauguration of the Westgate Bridge project. The Commonwealth government had acquired the whole site in July 1988 for $13.5 million and adopted a new master plan for its development. The site had undergone redevelopment since that time; works to the value of $11.95 million extended from 1987 to 1990, followed by redevelopment begun in 1990 at a cost of $17.5 million. Then in 1994, work began on upgrading the transonic wind tunnel at a cost of $12.7 million.

Planning the rationalisation and consolidation of DSTO sites in Melbourne commenced in 1998 with the preferred option being relocation of Maribyrnong activities to the Fishermans Bend site. The proposal involved construction of a new three-storey building to accommodate the Maritime Platforms Division and the Combat Protection and Nutrition Branch, including the Nuclear, Biological and Chemical component; and a new single-storey library building. Total cost of the project was estimated at more than $56 million. The Standing Committee on Public Works approved the project and it was passed by Parliament on 8 December 1999.[26]

The relocation came as a challenge to those at Maribyrnong who lamented the closing of a facility that was DSTO's oldest establishment with links back to 1922, and with its own culture and traditions. A Relocation Consultative Committee ensured any dislocation was minimised and that staff were kept informed of progress.

Defence White Paper, 2000

The Defence White Paper tabled on 6 December 2000 laid out a 20 year plan for the future. The defence policy reaffirmed the emphasis on the security of Australia's immediate neighbourhood with high priority being given to military operations to Australia's immediate north, especially littoral operations, and an emphasis on contributing to the stability of South-East Asia and the Asia–Pacific region.

The extent to which demands made on DSTO had changed by the turn of the century were highlighted in the White Paper where it noted that:

> *The most important development changing the conduct of warfare is the ability to increase vastly the speed and capacity to collect, organise, store, process, tailor and distribute information. This development is driven primarily by information technologies to meet civil and commercial needs.*
>
> *... the challenge for military communities will be to identify the potential and then commit the time and resources to adapt them into military tools and capabilities ...*
>
> *The ability to identify effectively and incorporate those technologies that sustain the capability of the [Australian Defence Force] will be guided by simulation and modelling, through both qualitative and quantitative war games.*

> *To succeed in this dynamic environment Defence, and particularly DSTO, must remain attuned to trends and be agile in responding to them. This means that DSTO must be a highly focussed and expert science and technology organisation that can interpret military needs. It must be able to assess overseas trends, develop new technologies where appropriate, and build strong linkages with industry to ensure that, where appropriate, new technologies are exploited to advantage.*[27]

The organisation remained concerned with evaluating and enhancing platforms and equipment and devising improved means of accomplishing tasks, but now information technologies loomed large. Indeed, in 1999 the Australian Defence Simulation Office was established with Defence Headquarters in Canberra headed by former Air Force Scientific Adviser Cliff White. This new office was to connect with DSTO's own simulation research facilities, the Synthetic Environment Research Facility at Salisbury and the Air Operations Simulation Centre in Melbourne.[28]

Collaboration

Successive reviews had commented upon the DSTO scientists' continuing isolationist attitude. This attitude was the product of the academic upbringing of many, but also reflected the culture of secrecy that is integral to sensitive matters of national security. DSTO scientists could collaborate with others outside the organisation in general matters only. The independence of other institutions was another factor; universities, for instance, were reluctant to be directed by other organisations.

Gradually, however, means were found to collaborate with other organisations. In the mid-1990s, for instance, DSTO and CSIRO agreed to collaborate across a broad range of research that was guided by the CSIRO-DSTO Research Liaison Coordination Committee. The association was facilitated by the close relationship between Brabin-Smith and Malcolm McIntosh who knew each other from their days working on defence policy. Collaborative research included that by DSTO's Guided Weapons Division and CSIRO's Division of Radio Physics working together on automatic target recognition: DSTO's Electronic Warfare Division worked with the CSIRO to develop microwave monolithic integrated circuits. The CSIRO's Epping facility was the only one in the country capable of producing the circuits that were used in radar and electronic warfare systems. Other joint projects were concerned with research in 'underwater vision, marine antifouling, fire retardants, polymers and composites, remote sensing, narrow band semiconductor materials and narrow band optical fibres.'[29] Yet, while there was commitment to make the collaboration work, and there was a close relationship between the heads of both organisations, little of great consequence occurred. The official goodwill between the organisations was not well reflected at the laboratory level.

Still, DSTO scientists continued to be involved in various Cooperative Research Centres, from six in 1994–96 to nine in 1999–2000. Moreover, the idea of engaging with industry in accordance with strategic alliances had gained favour, though it largely depended on individual networks rather than any formal process. Industry alliances increased from seven in 1994 to 20 in 1999. This was separate from licences granted; licences had grown from 48 in 1994 to 68 in 2000; and research agreements grew from two in 1996 to 17 in 2000.[30] By 2002–03 as much as $26.8 million, or 9.3 per cent of DSTO's budget was being spent outside the organisation on research partners, and technical support and service contracts.[31] This meant that DSTO had become a vehicle for encouraging and underpinning broad defence research.

DSTO research was the life-blood of many emerging defence companies, with an average of two companies per year being built on DSTO-licensed technology by 2000.[32] As mentioned above, DSTO licensed SonarTech Pty Ltd to commercialise the PIPRS system. SonarTech Pty Ltd was typical of many new companies formed to collaborate with DSTO: in this instance the very people responsible for developing the system formed the company.

Australia's membership of TTCP continued to benefit Australia through collaboration with defence scientists from the member nations. Enthusiasm for the program at the topmost level waxed and waned depending upon the interests of incumbents, particularly in the United States, the dominant partner that contributed funds equivalent to the sum of those provided by the other partners. However, there was little likelihood of the program ceasing because it was too important politically to all partners.

Moreover, the program always worked well at the laboratory level particularly by means of Australian postings to overseas laboratories that gave Australian scientists the chance to establish networks and benefit by exchanges. Participation in the program also gave DSTO scientists clout when dealing with Service personnel, by bringing them up-to-date knowledge. DSTO is involved in no less than 350 exchange or cooperative TTCP activities at any given time, contributing to about 60 specialist areas of technology.

Virtually all of DSTO's senior scientists served at one time on technical panels appropriate to their interests and experience: many served as national leaders of these panels. Participation in the program was a powerful means of making DSTO credible. In addition, Australian scientists

Tensile testing in the Cooperative Research Centre for Aerospace Composite Structures.

were able to make particular contributions because of the uniqueness of many regional conditions, and the worth of ideas. DSTO scientists feature regularly in the annual TTCP awards which recognise outstanding cooperative research activities among the member countries.

Besides the TTCP arrangement, DSTO continued to maintain separate bilateral research activities with the USA, UK, France, Netherlands, Sweden and Singapore. Its program of defence science cooperation with the UK has grown and matured over the years. The 1995 Anglo-Australian Memorandum of Understanding on Research (AAMOUR), which had served both Australia and UK so well for 10 years, was upgraded in 2005 with the Anglo-Australian Memorandum of Understanding on Science and Technology (AAMOST). As DSTO's largest bilateral program on science and technology, AAMOST is designed to identify areas where further research collaboration may add significant value, especially in network centric warfare, counter-terrorism, battlespace automation and simulation and modelling.

DSTO scientists also played several roles in international arms control. Indeed, they began advising the Australian government on chemical disarmament and protection in the late 1970s. A DSTO scientist formed part of United Nations' missions visiting Iran and Iraq to investigate allegations that chemical weapons had been used in recent conflicts.

Dr Peter Dunn, chief of Protective Chemical Division at Maribyrnong, led the 25-person United Nations' Special Commission for Chemical Weapons inspection team that visited the Persian Gulf in June 1991 to investigate Iraqi chemical weapons facilities. His early work, after joining the Defence Standards Laboratories, had focused on scientific aspects of the atomic tests at Maralinga; this led to research into chemical defence activities and providing advice to the Australian Defence Force on safe handling, use and disposal of chemicals. The 1991 visit was Dunn's fourth to the region after having visited Iran in 1984, 1986 and 1987 and Iraq in 1987. These earlier visits and his participation in various TTCP programs had won him an international reputation concerning chemical weapons and numerous awards including being made a Member of the Order of Australia in 1985.[33] DSTO continued to support the United Nations Special Commission on Iraq with its scientists collaborating with other countries on the development of field detection equipment and laboratory techniques to determine the presence of trace levels of residues of chemical warfare agents.

Dr Peter Dunn.

One DSTO scientist active in research into chemical warfare agents was Robert (Bob) Mathews. In the late 1970s he had undertaken research in the detection of toxic vapours in the atmosphere. Mathews served as Scientific Adviser to the Australian delegation to the Conference on Disarmament from 1984 to 1992 and was awarded an Order of Australia Medal in 1994 for his contribution to disarmament. In 2004, he was appointed to the Scientific Advisory Board of the Hague-based Organisation for the Prohibition of Chemical Weapons, having provided scientific support since 1993 to the Australian delegation to this organisation. As head of DSTO's NBC arms control, Mathew continues to work assiduously in support of Security Council Resolution 1540 which seeks to counter the threat of terrorists acquiring weapons of mass destruction.

Several DSTO Sydney personnel also served with the United Nations' Comprehensive Nuclear Test Ban Treaty Organisation in Vienna. Martin Lawrence, who joined the Royal Australian Navy Research Laboratory on 26 June 1978, assumed his Vienna appointment in 1997. Mike Bell followed in May 1999 and Neil Tavener in November 1999. All were involved essentially in monitoring and managing various measuring devices, though Mike Bell's role included installing and testing tremor monitoring devices in many parts of the world.

In 2001, Bill Jolley, a research scientist from DSTO's Weapons Systems Division, was seconded to the United Nations Monitoring, Verification & Inspection Commission (UNMOVIC). He led the planning and operations activities of the missile section. Approximately 20 Australians (including others from DSTO) were part of the international weapons inspection team roster. DSTO scientists were also involved in supporting the Australian Defence Force during later Iraqi operations.[34]

Closer to home, DSTO scientists formed part of the Australian-led International Force for East Timor (INTERFET) that was deployed in East Timor on 20 September 1999. They were involved in several roles coordinated by Ian Heron of the Land Operations Division, perhaps the most significant being deployment of the Theatre Broadcast System by Andrew Coutts.

Work began on this communication system in 1996 after DSTO scientists learned of the American global broadcasting system. They realised that the American system would not meet Australian Defence Force requirements, but believed the technology could be adapted and modified for military purposes. They succeeded and, in 1999, Federal cabinet approved funding for a three-year trials capability phase and provided seed money for DSTO to field a capability of several receiver suites. The Australian system was originally developed as a Concept Technology Demonstrator to test its ability to deliver a range of information services to troops in the field over a satellite link, including secure video, audio, imagery and other data, such as selected Australian television news and entertainment. It was further developed as a mature technology by the Defence Materiel Organisation, which assumed responsibility for production of the receiver units at the end of 2000.

Theatre Broadcast System.

The Theatre Broadcast System was first used operationally in East Timor by Australian forces in Dili, Ocussi, Balibo and Suai during the early days of Australia's peacekeeping mission where, for the first time, battalion headquarters had a wideband communications system in the field. The system could be carried into the field in two small trunks, and a small antenna dish was the only visible sign of a communications post once the system was operating.

Other DSTO staff—Grant Burford, Brad Noakes, Phil Davies and Mike Brennan—saw service in East Timor following deployment of the Australian Defence Force there: Jamie Watson of the Maritime Operations Division was charged with observing the amphibious operations. DSTO staff in Australia offered support with Land Operations Division personnel involved in operations analysis concerning communications, intelligence, surveillance and reconnaissance.[35] The active involvement of DSTO personnel did a great deal to demonstrate the organisation's utility to the Australian Defence Force.

Richard Brabin-Smith left DSTO on 30 June 2000 to become Deputy Secretary, Strategic Policy in the Department of Defence. He had been a reluctant Chief Defence Scientist but took to the challenge enthusiastically and remained in the position longer than all but one of his predecessors. He had proved a fierce champion of the organisation after having been initially viewed as a threat. Unlike his predecessors, he came to the position as a 'scientific bureaucrat' with an understanding of Canberra and departmental politics and was adept at 'managing upwards'. Because of this, he succeeded in greatly enhancing the standing of DSTO in the eyes of its chief customers. He had a major impact on reshaping the culture of the organisation, for which he was made an Officer of the Order of Australia in the Queen's Birthday Honours List in 2000. Brabin-Smith consolidated and greatly extended the changes initiated by his predecessors and thereby ensured that DSTO continued to enhance its value to the Australian Defence Force.

Senior Leadership Team, 1993. Standing (L-R): Dr Don Sinnott, Dr David Gambling, Dr Peter Preston, Dr Roger Creaser, Neil Bryans, Dr Roger Lough, Morry Frost, Dr Malcolm Golley, Dr Tony McLachlan, Neil Orme, Ian Hagan, Dr Tony Bedford. Seated (L-R): Dr Norman Chorn and John Ghattorna (consultants), Dr Max Lees, Scot Allison, Dr Richard Brabin-Smith, Wynford Connick, David Humphries, Peter Sharp, Dr Bill Schofield, Bob Ramsay.

CHAPTER 10

Defence science in a new world order: 2000–2005

The western world's attitude towards warfare and security changed after the terrorist attacks in the United States on 11 September 2001, and with them the demands made upon DSTO. In addition to their work in continuing programs, DSTO scientists were called upon to provide immediate support for Australian military operations in Afghanistan and Iraq, while at the same time playing a larger role in supporting an Australian Defence Force that was involved in counterterrorism operations, peace-keeping, homeland defence and border protection. The requirement to support homeland defence meant DSTO needed to interact with state and Federal agencies, such as the Australian Federal Police and various security agencies beyond the Defence Force, and increase collaborative efforts with other research agencies, such as CSIRO, that were also addressing security issues.

Dr Ian Chessell, Chief Defence Scientist, 2000–2003.

Dr Charles Ian Chessell, Chief Defence Scientist since October 2000, became responsible for overseeing the accommodation with the new strategic demands placed on the organisation. He had been born in Melbourne in 1942 and studied at Melbourne University where he gained a PhD in physics in 1970 with a thesis studying radiowave propagation in the lower ionosphere. He joined DSTO working in the area of his specialty. He spent 12 months as a visiting research fellow at the National Oceanographic and Atmospheric Administration in Boulder, Colorado, during1979–80. In 1988 he was appointed the inaugural chief of DSTO's Information Technology Division. For 18 months in 1994 and 1995 he was attached to the Acquisition and Logistics Organisation of the Department of Defence where he worked on computer acquisition policies and procedures for the department. Dr Chessell returned to DSTO in 1995 as inaugural chief of the Weapons Systems Division before becoming Director of the Electronics & Surveillance Research Laboratory following the retirement of Scot Allison in 1996.

Immediately after his appointment as Chief Defence Scientist, Ian Chessell became involved in work associated with aspects of the 2000 Defence White Paper. This White Paper was seminal to the extent that it elaborated a long-range plan for defence procurement with major implications for DSTO, such as advising on major procurements like the proposed Joint Strike Fighter. Much was expected of DSTO and much of the organisation's ongoing work was driven by this plan; its budget had to be increased on this account.

This need for greater financial and performance accountability led to the ongoing refinement of management tools such as the matrix management system linking the 12 divisions and six customers, Army, Navy, Air Force, Headquarters, Intelligence and Operations. Each director

‹ Shapes Vector system for monitoring large-scale computer networks.

was allocated management of a customer to enhance customer focus. The annual process was to discuss the research and development requirement in accordance with a three-year rolling plan. Funding was now allocated accordingly, with provision for long-range research that could be funded with a measure of discretion. This flexibility was required following the 11 September 2001 terrorist attacks in America.

The several scientific advisers to the Services continued to fulfil a valuable role, though their value remained dependent on the advisers themselves and the willingness of the Services to heed their advice. Nevertheless, the role of the scientific adviser was considered important and an additional adviser was appointed to liaise with the Defence Materiel Organisation in 2000, in recognition of DSTO's enhanced role in advising on new equipment purchases and in providing continuing support. Bruce Brown became the one to establish the new role.[1]

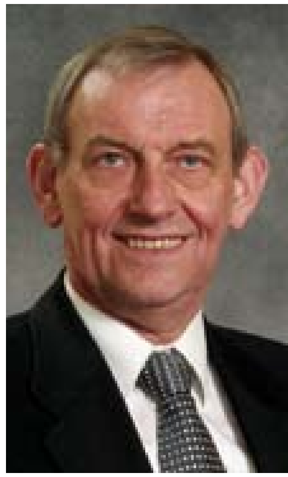
Safe handling of toxic materials in preparation for laboratory analysis.

The September 11 terrorist attacks in the USA in 2001 had an immediate impact on DSTO programs. The deployment of Australian forces to Afghanistan meant DSTO was called on to design, test and supervise the manufacture of camouflage uniforms appropriate to the areas in which troops were to operate—all within 10 weeks—and provide a measure of protection for vehicles from land mines. DSTO operations analysis teams also assisted defence forces in the Middle East. At home a Special Operations Technology Insertion Cell, formed as part of DSTO's Land Operations Division, was established at the Special Air Service Regiment's barracks at Swanbourne in Western Australia.[2]

But the Afghanistan war was only the more overt response to the increased terrorist action made possible by new technologies and advances in communications. The new situation demanded a review of Australia's defence priorities, though the Defence Force and the Australian Security Intelligence Organisation were initially slow to acknowledge this. The Australian Defence Force had been heavily involved in security matters associated with the Sydney Olympic Games in 2000 but considered terrorism to be essentially an internal security issue, more appropriately the responsibility of police and intelligence forces, with defence forces assuming a supporting role where appropriate. Nevertheless, Ian Chessell initiated an in-house study of counterterrorism measures as a means of identifying new areas of necessary research for DSTO scientists. Concurrently, DSTO became involved with Customs and CSIRO in developing face-recognition software as a means of increasing border protection.

At the same time the Chief Defence Scientist initiated closer collaboration with CSIRO and other agencies such as the Australian Federal Police that were also concerned with counterterrorism. In addition, he strengthened research undertaken under the Chemical, Biological, Radiation and Nuclear Defence Research Program and increased collaboration with various Cooperative Research Centres seeking to develop portable biosensors and other technologies now believed necessary.[3]

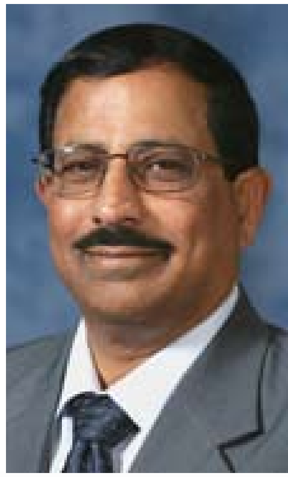
Moreover, DSTO, along with other agencies such as Geoscience Australia, the Australian Nuclear Science and Technology Organisation and CSIRO, was identified as an agency able to make a major contribution to science and technology support for national security and counterterrorism initiatives. Consequently DSTO participated in the formation of the Science, Engineering and Technology Unit within the Department of Prime Minister and Cabinet to coordinate research support for national counterterrorism capabilities. Dr Lynn Booth, a senior DSTO scientist, was appointed to head this new unit.



Neil Bryans.

Ian Chessell implemented another restructure of DSTO from 1 July 2002, following a new review of the organisation's activities: this was the most far-reaching reorganisation since 1994. When announcing the change, he acknowledged that some within the organisation may have become weary of change but believed it important for DSTO to survive and continue to fulfil its responsibilities to its clients:

> *I am aware that many of you may well be weary of change and I sympathise with you. However, I was concerned that an organisational structure that owed more to geography and history than fitness for purpose did not present your significant contributions to Defence in the best way possible. So, I consulted widely with our military and civilian partners within the Department and with the Minister. The structure described below meets their requirements and has their approval.*[4]



Dr Nanda Nandagopal

From 1 July 2002, DSTO was rationalised around three new laboratories focused on military platforms, electronic systems and information.[5]

The **Platforms Sciences Laboratory** was headquartered in Melbourne under director Roger Lough with the mission to support Australia's military, air and maritime platforms. There was to be a particular focus on research into extending the life of these platforms and minimising the cost of operating and maintaining them. The laboratory comprised Air Vehicles Division (with Chris Guy as chief), Maritime Platforms Division (David Wyllie as chief) and Scientific Engineering Services (Mick Bone as manager). The laboratory also became the site of the enhanced Chemical, Biological, Radiological and Nuclear Defence Centre under Brent Paul.

At Edinburgh (the name given to the former suburb of Salisbury from 19 October 2001), the **Systems Sciences Laboratory** was created under director Dr Doraisamy 'Nanda' Nandagopal to support the acquisition and operation of major electronic systems on platforms with a focus on radar and weapons systems technologies. Nanda had degrees from the University of Madras, the Indian Institute of Technology with his PhD from the University of Adelaide. He held various university appointments at the University of Adelaide, McMaster University in Canada, and the University of Melbourne before joining DSTO Salisbury in January 1989 as a principal research scientist. He was promoted through the organisation, becoming chief of the Weapons Systems Division in July 1996. The new laboratory was to be a centre of excellence in operational analysis, ship combat systems, avionics and battlefield command systems. The laboratory comprised Air Operations Division (with Colin Martin as chief), Maritime Operations Division (David Heilbronn as chief), Land Operations Division (Warren Harch as chief), Electronic Warfare and Radar Division (Len Sciacca as chief), and Weapons Systems Division (Bill Dickson as chief).

The **Information Sciences Laboratory** under director Neil Bryans at Edinburgh focused on research into communication and information technologies, support for command and control, intelligence and surveillance systems. Neil Bryans graduated as an engineer from the University of Adelaide and later took a Masters degree in Business Administration. He joined WRE in 1963 and spent his early career in radar research, including the Jindalee project. Later he was involved in information technologies and became chief of the Communications Division in October 1990 and chief of the Information Technology Division in October 1995. Divisions within the laboratory headed by Bryans comprised Command and Control (with Ian Heron as chief), Intelligence, Surveillance and Reconnaissance (Bruce Ward as chief), and Information Networks (Mark Anderson as chief).[6]

A new Defence Systems Analysis Division with Ken Anderson as the inaugural chief was formed to support defence operations and decision making.

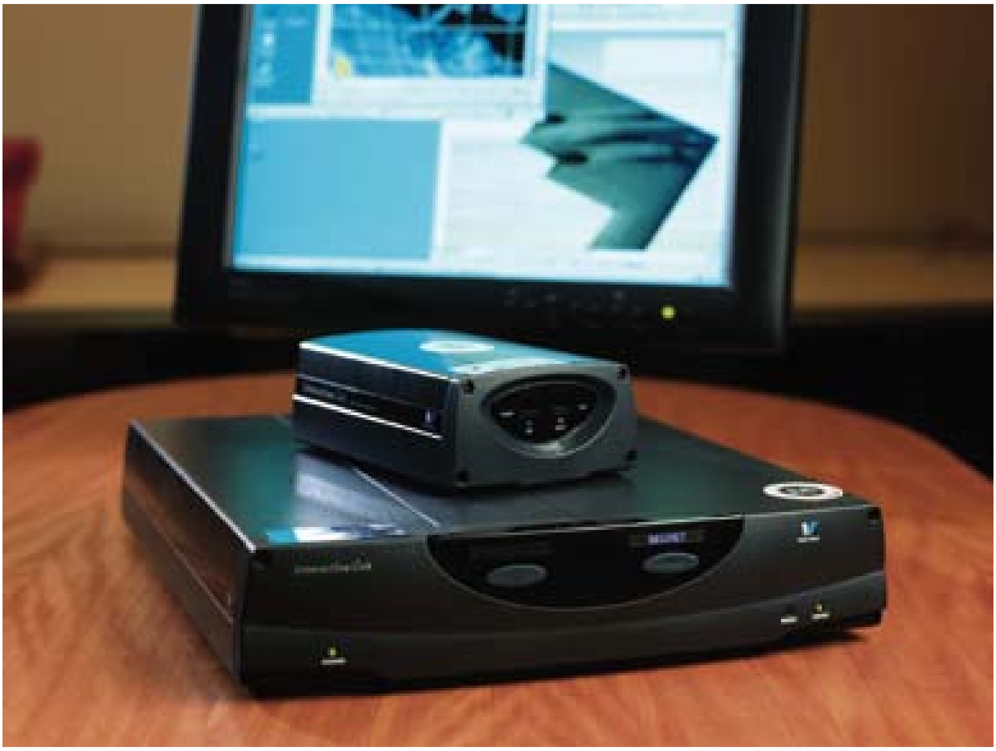
Important work continued to be undertaken in Sydney, Stirling, Scottsdale, and at Innisfail as the occasion arose; but these establishments remained associated with the major laboratories.

The Chief Defence Scientist continued to foster closer partnerships with industry though this always proved far more difficult than politicians imagined, in large part because of the relatively small sales potential of most local innovations. A major push was the development of a Continuing Education Initiative based on a masters program featuring courses specific to Defence requirements developed in consultation with universities. Private companies were invited to participate in the program.[7]

Collaboration with industry was primarily undertaken in accordance with a plethora of licensing agreements and collaborative research arrangements initiated by DSTO. In 2002, for instance, DSTO was associated with 66 licence agreements and 18 industry alliances. That year, on 16 May, DSTO concluded a 10 year agreement with Tenix Industries for marketing the DSTO-developed Starlight computer security technology. This was a unique, world-first system that allowed users of secure computers to access insecure networks, such as the Internet, without compromising their own security. The system was a development of STUBS, a computer security program invented by Dr Mark Anderson in 1991 and developed within the Trusted Computer Systems Group in the Information Technology Division of DSTO. The technology was licensed worldwide in 1996 to the Tenix Group that later formed the company Tenix Datagate to commercialise the products. By October 2002, more than 4500 such devices were in daily use around the world, with several Australian government departments including the Department of Defence and the Department of Foreign Affairs and Trade using the Interactive Link. Three years later the Starlight Interactive Link was granted the highest possible level of security certification by the National Information Assurance Partnership in the United States, the first time that any security device had received Evaluation Assurance Level 7 certification.[8]

DSTO also had agreements with BAE Systems, Caltryx and Thoughtweb Incorporated, the latter being involved in the development of intelligent agent-based tools for automating support to military command and control processes.[9]

DSTO traditionally kept a low profile in Canberra, but it repeatedly came under the scrutiny of politicians with little real understanding of the close links between DSTO and its defence customers and the relationship between defence science and industry in Australia. There was always the pressure to be seen to be accountable. It also came under scrutiny as an agency



Starlight computer security system.

Dr Mark Anderson (left) and two of his research team members John Yesberg (centre) and Brendan Beaham with the proof of concept prototype STUBS, forerunner of the Starlight security system. Dr Anderson won the 1998 Minister's Achievement Award for high quality and original research in the area of information security.

that might be privatised and asked to compete for its funds from clients. This occurred at much the same time as the CSIRO was being restructured, with those who suggested privatisation of DSTO failing to distinguish between the two organisations. One model being pursued by DSTO's critics was that of the United Kingdom's Defence Evaluation and Research Agency that was restructured into the Defence Science and Technology Laboratory and QinetiQ Ltd in 2001, with the latter being sold to private investors. The United Kingdom's Defence Science and Technology Laboratory's role was to provide research and advice to the government and the armed forces, while that of QinetiQ was to engage in commercial activity with industry.

Ian Chessell argued strongly that privatisation of DSTO was not appropriate in the Australian situation with the organisation having the role of supplying independent and expert advice to Defence. He received strong support from Secretary Allan Hawke, and Admiral Chris Barry, Chief of the Defence Force, who garnered support from the other Service chiefs and ensured that DSTO remained a government authority. But, in return, DSTO had to commit to engage more closely with the broader community and to be more transparent. At the Prime Minister's invitation, the Chief Defence Scientist became a member of the Prime Minister's Science, Engineering and Innovation Council. DSTO also made a contribution to determining that new defence technologies were included in the government's new National Research Priorities.

DSTO already had business offices in Melbourne and Edinburgh to facilitate industry cooperation, but Ian Chessell established a new Technology Transfer and Commercialisation Office in mid-2002 to focus on commercialisation of DSTO's intellectual property, leaving the Business Office to concentrate on managing relationships with industry and research partners. Technology Transfer and Commercialisation Office units were established at Edinburgh and Fishermans Bend to help identify and evaluate technology transfer and commercialisation opportunities.[10] The Defence patent portfolio was then transferred from the Defence Materiel Organisation to DSTO to facilitate the process of commercialising the work of DSTO scientists.[11]

Hidden benefits

DSTO had never been very active in promoting itself beyond those within the defence community, and had only recently become proficient at it. The organisation's primary mission was to support the Defence Force; and policy, regulations—and the science culture—meant that commercialisation and industry engagement probably did not receive the priority politicians imagined. In 2003, only one-third of DSTO's 61 licence agreements with industry produced revenue, with $4.3 million in royalties flowing to DSTO in the five years from 1998–99 to 2002–03. The royalties came principally from sales of the Australian Mine Sweeping System, the system for composite bonded repairs, and the Laser Airborne Depth Sounding System.[12]

Nevertheless, DSTO made significant contributions to the nation's wealth and, following the latest threat to its existence, determined to demonstrate this. Consequently, in June 2003 the department engaged Robert J. Trenberth to complete the *Review of DSTO's External Engagement and Contribution to Australia's Wealth*. He found that DSTO made a significant contribution to national wealth in three basic ways, namely, 'it contributes to national security which in turn confers wealth on Australia and Australians ... it generates intellectual property that can and is being commercialised ... its strategic external engagements and collaborations are an increasingly important element of Australia's national innovation system.'[13]

Trenberth found that some of the value of DSTO scientists' work could be quantified because of the royalties and licence fees, but that other work was difficult to quantify in financial terms though it contributed to significant cost savings to Defence. Simply prolonging the life of aircraft, ships and other weapon platforms had immense return on investment. For instance, work on the fatigue testing of the F/A-18 Hornet fleet to prolong the life of the aircraft was calculated to realise a benefit valued at $1.36 billion, for a total cost of $50 million; development of a degaussing range for the Navy was calculated to create savings of $10 million, for a $160,000 outlay; extending the safe life of Mk48 heavy-weight torpedo warheads was judged to have saved $3 million, at a cost of $705,000.[14]

Trenberth commissioned sub-consultants to evaluate the DSTO's work over a 13 year period from 1990 when the organisation's cumulative budget amounted to $6.5 billion. Using most conservative assumptions, the consultants concluded:

> *[T]hat DSTO investment over the time period considered has almost certainly delivered to Defence benefits well in excess of costs while providing substantial wider benefits through its industry engagement processes and through interaction with other defence forces.*[15]

Formal endeavours to engage and nurture industry may not have been as successful as politicians had hoped, but there were many defence companies that either originated through exploitation of DSTO research or had an ongoing close association with DSTO. This was particularly evident in the smaller South Australian economy, where DSTO held a prominent position because of the state government's endeavours to foster a defence industry.[16]

Ration packs developed by DSTO Scottsdale, 2006.

DSTO did have one success in an unusual area. The Army ration packs continued to be developed at DSTO's Defence Food Science Centre at Scottsdale in Tasmania with an eye on the nutritional and energy needs of commandos on active service, and the requirement for packs to be rugged and lightweight. Advanced freeze-drying processes reduced the weight of fresh food by 75 per cent, but could be quickly reconstituted with the addition of hot water. The packs had evidently proved popular during the Gulf War where they were sought after by American and British troops. Later DSTO tested the packs among the civilian camping and adventure community in Tasmania. Support for the packs encouraged DSTO to dress the packs with a colourful cover and market them as 'Adventure Foods'.[17] The product targeted only a small niche market and did not reap great financial benefits for DSTO. This reflected the wider commercial world in which DSTO operated: the products of its research endeavour were undoubtedly significant, but were of limited commercial value.

Continuing innovation

Regardless of the degree of commercialisation, the work of DSTO scientists continued to be 'highly creative'—no less so than in earlier periods—though later work was far more closely identified with the demands of the Services and there are fewer high profile projects.

A great deal of the work continued to be derived from Service issues and the maintenance and improvement of weapons platforms. For instance, attention to issues associated with the Collins class submarine continued to exercise many DSTO scientists at the turn of the new century. Issues associated with hardware had been resolved, but software issues persisted.

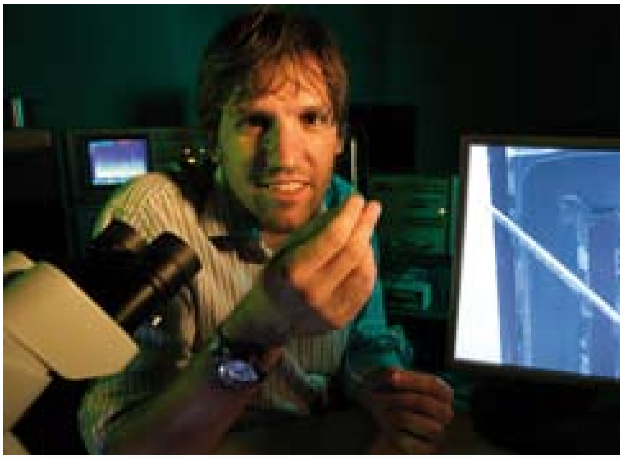
The conclusion of the International Follow-On Structural Test Project was marked by a ceremony in Ottawa, Canada in July 2006. Already, DSTO and BAE Systems, manufacturer of the Hawk Mk127 Lead-In Fighter in service with the RAAF, had entered a commercial business agreement to conduct comprehensive fatigue testing on the Hawk. These tests were conducted at DSTO's new state-of-the-art fatigue test facility at Fishermans Bend, the H.A. Wills Structures and Materials Test Centre. The agreement benefited both organisations through the sharing of expertise and the creation of intellectual property. BAE Systems was able to use such knowledge in future commercial enterprises, while DSTO had the opportunity to extend its expertise in the area of fatigue testing.

Another innovative development was a new Distributed Feedback Fibre Laser device for use in undersea sonar arrays to improve maritime surveillance. Since 2002, DSTO had been engaged in research into fibre optic acoustic sensing based on emerging in-fibre laser technology. In 2005, a 16-element multiplexed array of fibre laser sensors was demonstrated for the first time. Research continues in collaboration with Thales Australia to develop a deployable multi-channel fibre optic seabed array. The DSTO technology is based on photonics, and photonics-based hydrophones are simpler, more robust and cheaper to manufacture than existing devices. Hydrophones in towed arrays are used by submarines and ships to detect

Fatigue test of the Lead-in Fighter Hawk in the new H.A.Wills Structures & Materials Test Centre in Melbourne.

Water tunnel testing for the Joint Strike Fighter.

sound waves in water and to track other vessels. The DSTO technology has the potential to shrink the size of these hydrophones to no more than the thickness of a fishing line. An array of optical fibre hydrophones would be easy to deploy either manually or from unmanned underwater vehicles such as DSTO's *Wayamba.*



Fibre laser hydrophone.

Additional work flowed from the acquisition program outlined in the 2000 Defence White Paper, with the proposed acquisition of the Joint Strike Fighter aircraft prompting many studies.

Work was being undertaken on continuing projects: the Jindalee Operational Radar Network—possibly DSTO's greatest contribution to Australia's defence—was finally released to the RAAF by the contractors on 2 April 2003 and formally accepted in May 2003. It had suffered from long delays and cost overruns, but succeeded in performing in accordance with the design and in providing Australia with a surveillance tool of great utility.

Other work was associated with continuing innovations in information technologies, particularly in security sensitive areas with projects such as the Starlight secure computer device and the Shapes Vector computer network security system. Dr Mark Anderson was the principal inventor of Shapes Vector, a prototype system designed in 1996 to detect intrusions into computer networks. The system combined artificial intelligence agents and three-dimensional visualisation techniques to patrol and report on anomalies in wide area networks such as those in Defence. Developed by the Information Networks Division of DSTO, it represented breakthrough research in real-time visualisation of network attacks. Under an agreement with the United States Defense Advanced Research Projects Agency, a Shapes Vector system was installed at a site in the Washington DC area in 2003 for experimentation and evaluation. By 2005, the operational assessment of Shapes Vector both in the United States and Australia was completed and was shown to operate well beyond commercially available network security systems in its monitoring and surveillance of very large networks.[18]

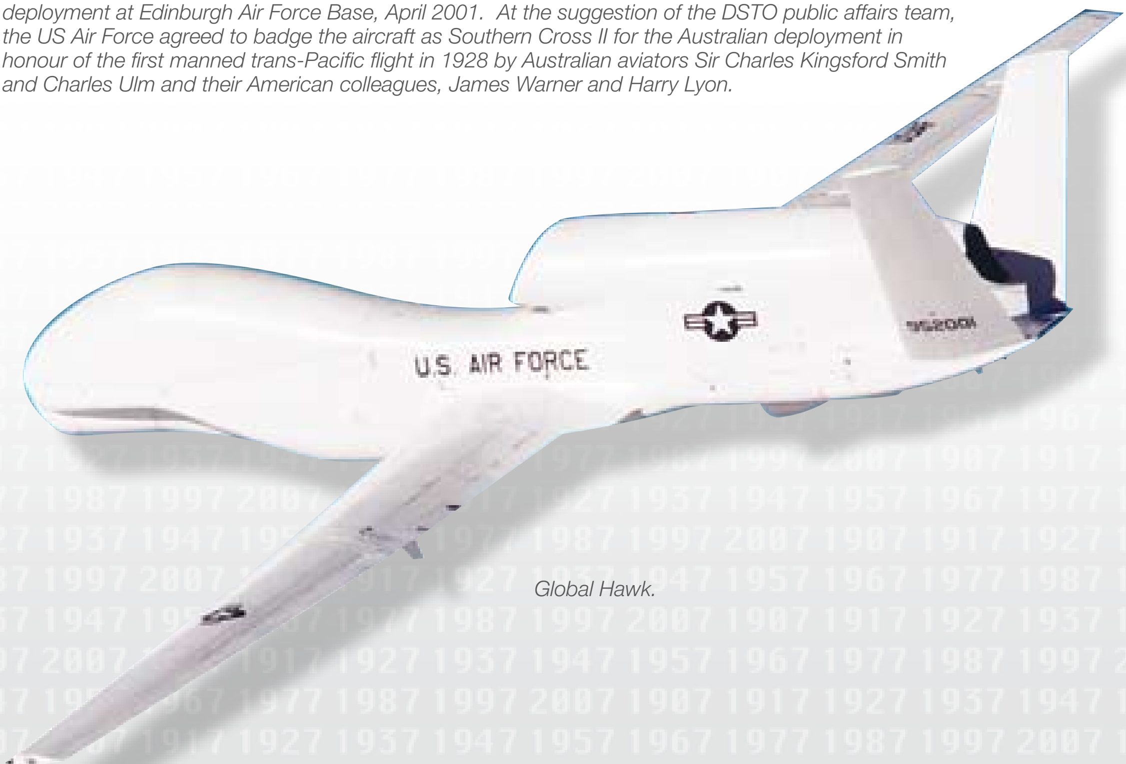
DSTO personnel continued to develop the Theatre Broadcast System that had performed so well in East Timor. They had noted that the United States and United Kingdom military versions of their respective broadcast systems used different operating standards that impeded their ability to exchange and share information. They sought to obviate this and demonstrated during the Joint Warrior Interoperability Demonstration exercise in 2002 that Australian sourced information could be delivered over the American system and vice versa, with commonly sourced information able to be delivered over both. A notable outcome of this demonstration was the United States' decision to change its global broadcasting system architecture to conform to the Internet Protocol DSTO used, thereby making this the standard architecture for allied and NATO forces: the United Kingdom also adopted this standard for its Defence Broadcast System.

The system, so successfully used in East Timor, was also used in the Middle East and the Solomon Islands, and in tsunami-ravaged Banda Aceh during the humanitarian relief operations carried out in 2005. Receive units and transmit/receive units incorporating a satellite request link were fitted to Navy ships including HMAS *Sydney*, *Melbourne*, *Manoora*, *Gascoyne* and *Kanimbla*.'[19]

DSTO scientists, particularly Dr Jackie Craig, were also engaged in a cooperative program with the United States that provided an enhancement for Global Hawk, the unmanned aircraft developed for surveillance purposes. After negotiations extending over two years the Australian and the United States Defence Departments signed the High Altitude Endurance Unmanned Aerial Vehicle Project Arrangement in early 1999. This authorised the joint development and testing of the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle system that included implementation of new sensor and system capabilities for maritime surveillance and improved mission flexibility based on DSTO research and advice. Following the enhancement program, Global Hawk made international aviation history when it successfully completed the first non-stop flight across the Pacific Ocean by a pilot-less aircraft, flying from Edwards Air Force Base in California and arriving at the RAAF Base, Edinburgh in South Australia, on 23 April 2001 having covered the 7500 nautical mile journey in 23 hours – a feat recognised by the Guinness Book of World Records as 'the longest flight ever undertaken by a full-scale unmanned aircraft.'

Global Hawk remained in Australia for six weeks and its system was integrated with a DSTO-developed ground station to allow Australian operators to control aspects of the Global Hawk sensor operations and to analyse the imagery data its sensors collected while flying over Australia. As many as 30 DSTO staff and 15 Australian contractors, in addition to RAAF personnel, were involved in the Global Hawk deployment. In addition to the purely technical aspects, DSTO provided detailed briefings to United States personnel to allow them to plan missions for the deployment that satisfied Australia's military objectives. It also worked with the RAAF to assess the potential of the Global Hawk system and other remote-controlled aircraft to enhance Australia's surveillance and reconnaissance capability.

Dr Jackie Craig, Global Hawk deployment Project Director, with Rod Smith, Project Manager for the deployment at Edinburgh Air Force Base, April 2001. At the suggestion of the DSTO public affairs team, the US Air Force agreed to badge the aircraft as Southern Cross II for the Australian deployment in honour of the first manned trans-Pacific flight in 1928 by Australian aviators Sir Charles Kingsford Smith and Charles Ulm and their American colleagues, James Warner and Harry Lyon.



Global Hawk.

A key figure in the Global Hawk deployment was Dr Jackie Craig who went on to receive the Defence Minister's Achievement Award for her leadership of the project and her contribution to the development of Defence's imagery capability.

The deployment was also a success for DSTO on another front. The public awareness campaign, led by Jimmy Hafesjee, generated extensive publicity in the Australian and overseas media, unprecedented for DSTO. He coordinated a communications team consisting of public affairs officers representing Defence, RAAF, the US Air Force and Northrop-Grumman, the US manufacturers of Global Hawk. The campaign won a highly commended award from the Public Relations Institute of Australia (ACT Chapter). A case study on the Global Hawk communications campaign was later selected by the US National Institute on Standards & Technology for a world conference on Best Practices in Communication.

Off Axis Viewing Device.

Almost immediately following the success of the Australian deployment with the local enhancements, the United States Air Force determined that the Global Hawk system should be deployed in the Middle East to support United States and allied military operations there.

As Australia joined the coalition of the willing in Afghanistan and Iraq the Defence Force's involvement in overseas deployments reached a level it had not seen since the end of the Vietnam war. Demand for DSTO support grew accordingly. In one year alone during 2005-06 the organisation responded to 15 major requests from the three Services for urgent operational support that required input from ten DSTO divisions. Scientists began to be deployed with military staff to provide rapid technical analysis on the ground and advice on capability options. Within weeks DSTO provided Australian troops with camouflage uniforms that were specially designed to suit the terrain in Afghanistan. Landmine protection kits for military vehicles were delivered within a month. To protect soldiers and armoured vehicles from improvised explosive devices in Iraq survivability enhancement kits and blast-proof materials were developed and fitted. A novel rifle attachment, developed by DSTO's Tom Chapman, was introduced into service in Iraq to provide improved cover for soldiers and the advantage of safely returning fire. Called the Off Axis Viewing Device, the attachment integrates with the weapon's sighting system, enabling the soldier to scan and engage targets around corners and over walls without being seen.

Operations analysts like Michael Dutton and Tim McKay from DSTO's Land Operations Division also offered front line support to Australian troops in East Timor and Solomon Islands. DSTO support extended to maritime operations, particularly in the Northern Arabian Gulf where a coalition task force was charged with maintaining security aound the Al Basrah and Khawr Al Amaya oil terminals.To provide the task force with a better understanding of the operational environment a number of simulation exercises and experiments were conducted with the data analysed by a DSTO team consisting of John Wendoloski, Genevieve Mortiss, John Brett, George Yiannakopoulos, Paul van der Schaaf, Andrew Krelle, Jane Cleary and John Holm.

Domestically, DSTO's expertise was sought in the organisation of the Sydney 2000 Olympics, the 2006 Commonwealth Games in Melbourne and the 2007 APEC leaders summit. By 2007 support to operations had become a very high priority for DSTO, so much so that a dedicated Operational Support Centre was established in Adelaide to coordinate the range of cross-divisional capabilities required in meeting the demand for scientific support from deployed commanders.

Relocation

DSTO's organisational structure had been under almost continual review since the 1980s: so too, there was the periodic refurbishment of the major establishments.

There was physical relocation in Sydney. The rejuvenation of the Pyrmont area raised doubts about DSTO's continued location there as commercial redevelopment increased land prices in the area. This occurred at a time when the Commonwealth government sought to divest itself of surplus and underused land. The prospective relocation had been one reason

Michael Dutton during Operation Astute in East Timor.

Dr Roger Lough.

Dr Ian Sare.

for Bill Schofield—since retired—reporting on the site. Should the relocation proceed, he had strongly recommended that the facility move to HMAS *Waterhen*, on the other side of the harbour to maintain the close relationship with the Navy. Matters moved apace when the Department of Defence sold the Pyrmont site in June 2003 to REVY Investments Pty Ltd. DSTO remained on site in accordance with the terms of a four year lease due to terminate on 25 June 2007, when the establishment was to be relocated to Australian Technology Park at Redfern, partly for the purpose of building closer collaboration with other organisations there, in particular the National Information and Communications Technology Australia Ltd (NICTA).

Under new management

Change at the top level continued when Dr Roger Lough became Chief Defence Scientist in October 2003. He had been born in London on 14 November 1945. He completed his secondary education in the United Kingdom before migrating to Australia in 1963 and joining WRE where he worked as a technical assistant involved in laboratory duties associated with testing chemical properties of rocket propellants. He began studies at the University of Adelaide, from where he graduated with a first class honours BSc degree in 1971 and a PhD in physical chemistry in 1974, after which he became a research scientist. He took up a Harkness Scholarship in 1976 when he was attached to the United States Army as a project engineer working on rocket motor design and improvement. On returning to Salisbury he became a section leader with responsibility for advanced weapon and propulsion system concepts. Later he served as the Defence Science Attaché at the Australian Embassy in Washington (1984–87). He returned to Australia to a range of senior appointments, first as chief of the Guided Weapons Division in 1987. Subsequently he was chief of the Air Operations Division and the Land Operations Division.

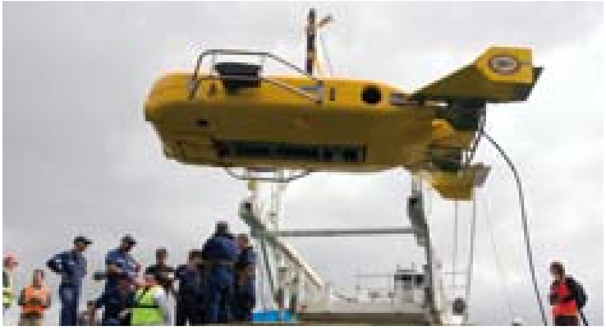
Roger Lough came to the Chief Defence Scientist's role immediately after serving as First Assistant Secretary, Science Policy from January 2000 and Director of the Aeronautical & Maritime Research Laboratory (later renamed Platforms Sciences Laboratory) in Melbourne from January 2002. So he was already familiar with the key issues facing DSTO. His appointment as Chief Defence Scientist continued the dominant practice of appointing from within DSTO. However, the appointment of Dr Ian Sare to succeed him as Director of the Platforms Sciences Laboratory on 16 February 2004 represented something of a departure from tradition. Ian Sare was appointed to the position after 28 years with CSIRO and was the first external appointment to a senior position since David Humphries of the United Kingdom Ministry of Defence became Director of the Aeronautical Research Laboratories in 1990, and Colin Evans was appointed Director of the Weapons Systems Research Laboratory. Ian Sare had trained as a metallurgist, gaining a BSc from the University of New South Wales and a PhD from Cambridge before joining CSIRO in 1975 for research into wear properties of ferrous alloys used in mining and minerals processing. He became officer in charge of the Adelaide laboratory of the Division of Manufacturing Technology before being promoted as chief of the division in 1995. He was responsible for merging the Manufacturing Technology Division and the Division of Materials Science and Technology, and in 1997 became chief of the new CSIRO Manufacturing Science and Technology Division. Ian Sare had been involved in three start-up companies to market

CSIRO technology.[20] His appointment reflected the direction in which the leaders sought to take DSTO, but also the wish to bring new ideas into senior management.

Appointment of the new Chief Defence Scientist followed the tabling of yet another report into Australia's defence policy, *Australia's National Security: A Defence Update, 2003*, that was essentially an update of the 2000 White Paper. The report reiterated the significance of the changes in the strategic environment since 2000, the heightened threats of terrorism, the proliferation of weapons of mass destruction, the increased challenges within the region and the consequences of the involvement in the operations of the 'coalition of the willing'.

The succession of defence reports acknowledged the importance of science and technology in the new strategic environment, but continued to emphasise the need for appropriate science and the need for greater liaison with industry. DSTO remained Australia's largest research and development organisation after the CSIRO, but an increasing amount of research was being undertaken in universities and within the defence industry.

At one level, the significance of the events of 11 September 2001 in America lay more in the response taken to them, than to the actual events themselves: acts of terrorism and the notion of 'asymmetrical warfare' already had a long history. Nevertheless, the new security situation enhanced DSTO's reputation and induced additional restructuring as it sought to meet its new responsibilities.



Wayamba underwater research vehicle.

Australian Light Armoured Vehicles fitted with bar armour, Iraq, 2006.

Future Operations Command Analysis Laboratory.

CHAPTER 11

Towards tomorrow: 2005–

The so-called ‘war on terror’ continued to exercise the government into 2005. As *The Age* defence correspondent wrote of the budget that year:

> *Again, a Howard Government budget has reinforced its national security credentials with budgetary largesse but shifted focus from massive military boosts to intelligence and security precautions more directly related to combating terrorism.*
>
> *Although the Treasurer’s speech highlighted border protection, intelligence capabilities and counter-terrorism expertise, the Defence Force received not a mention.*
>
> *As the military has remained Howard’s sacred cow, this represents a long-overdue revamp in the so-called war on terror. As many experts and even some of our own military leaders have observed, it is not possible to declare war on an abstract noun.*
>
> *Terrorism is a tactic, not a definable, defeatable enemy. The key weapon against its practitioners remains intelligence, then comes the hearts-and-minds battle for the potential supporters of groups resorting to terror tactics.*
>
> *About a quarter of a $1.1 billion national security increase goes to the intelligence agencies and the remainder towards civil and military protective security measures.*[1]

DSTO continued to be seen as a major agency to be involved in counterterrorism and national security initiatives. For instance, DSTO became a partner of the Australian Federal Police, CSIRO and the intelligence community in the National Security Science and Technology Unit. DSTO also became a partner in the Publicly-Funded Agencies’ Collaborative Counter-Terrorism Research Program established in March 2005, along with the Australian Nuclear Science and Technology Organisation, CSIRO and GeoScience Australia. And, in late 2005, DSTO signed a Memorandum of Understanding with the Attorney General’s Department to contribute to its Critical Infrastructure Protection Modelling and Analysis capability.

The new responsibilities meant an ongoing need to review DSTO’s structure and mission. Indeed, the organisation adopted a much broader mission as ‘the Australian government’s lead agency charged with applying science and technology support to protect and defend Australia and its national interests’ including the delivery of ‘expert, impartial advice and innovative solutions for Defence and other elements of national security.’ The new mission, endorsed by the government, was consistent with DSTO’s expanded role in national security. Similarly, its Chemical, Biological, Radiological and Nuclear Defence Centre was upgraded and

‹ Immersive environment for experimentation in the new Battlelab at DSTO HQ.

renamed the Human Protection and Performance Division in October 2005 to underscore this broader involvement. Another related development was the agreement between DSTO and the US Missile Defense Agency to collaborate on research in ballistic missiles. In July 2004 the Australian and the US governments had signed a Memorandum of Understanding (MOU) to participate in missile defence against the growing threat posed by the proliferation of ballistic missile capabilities and weapons of mass destruction. The R&D agreement was negotiated in 2005 under this umbrella MOU, allowing DSTO and the US Missile Defense Agency to conduct a program of experiments for validating relevant capabilites and supporting technologies.

DSTO's core responsibilities to the Australian Defence Force also fostered the need for change. Yet another major Defence review, this time into procurement practices, meant DSTO generally became more closely involved in all Defence acquisition projects. Consequently, a new process needed to be set in place to support the Defence Capability Plan and the Defence Materiel Organisation which became a 'prescribed agency' as a result of the review. In 2005 DSTO established a Capability Development and Acquisition Program 'to inject greater rigour into the capability development and acquisition processes' as recommended by the Defence Procurement Review of 2003 by Malcolm Kinnaird.[2] DSTO was now required to undertake technical risk assessments and mitigation activities in support of major projects throughout the capability life cycle.

Dr Roger Lough was keen to ensure that DSTO kept pace with the changes in Defence. He initiated reforms of the top level leadership structure to shift the focus from line management to program management. This change was a first step towards adapting to both the new business and governance processes in Defence as well as to the changing technological needs of the Australian Defence Force. Laboratory names fell out of favour. From 1 July 2005 laboratory directors were redesignated as Deputy Chief Defence Scientists to better reflect their new role — Neil Bryans (Information), Dr Nanda Nandagopal (Systems) and Dr Ian Sare (Aerospace). The First Assistant Secretary (Policy) Dr Ken Anderson became Deputy Chief Defence Scientist (Policy).[3]

However, a more substantial reorganisation occurred in mid-2006, following a Defence Capability and Investment Committee review of DSTO's investment strategy and relations with clients as well as a report from Ernst and Young examining the organisation's business processes. The aim of the reorganisation was to continue the push to build an agency more responsive to client demands. This was highlighted by the appointment of Dr Nanda Nandagopal to a new Canberra-based role as Deputy Chief Defence Scientist (Corporate, later Policy and Programs) to coordinate all DSTO client programs 'with a specific focus on science and technology support to the new Australian Defence Headquarters and Defence Materiel Organisation'. An Integrated Program Office was also created while many of the division chiefs were given additional responsibility as client program managers to liaise more effectively with their Defence customers. Dr Nandagopal was to oversee the work of Deputy Chief Defence Scientist Dr Ken Anderson whose mandate included Director General, Science Policy Development, Dr Lynn Booth; Assistant Secretary, Science Industry and External Relations, Alan Gray; Director General, Defence Scientific Support, Dr David Saunders; Acting Director General, Integrated Science Program, Phillip James; Chief of the Defence Systems Analysis Division, Dr Tim McKenna; and Assistant Secretary, Science Corporate Management, Martyn Taylor.

While Dr Nandagopal focused on the client program, the Deputy Chief Defence Scientists in charge of the two main facilities in Melbourne and Adelaide became responsible for raising, training and sustaining DSTO's science and technology capabilities.

Under the new arrangement, the Melbourne-based Deputy Chief Defence Scientist Dr Ian Sare took responsibility for Platforms and Human Systems that encompassed Air Vehicles Division (with Dr David Wyllie as chief), Air Operations Division (Dr Jennifer Clothier as chief), Maritime Platforms Division (Janis Cocking as chief), Maritime Operations Division (Dr John Riley as chief), Human Protection and Performance Division (Dr Simon Oldfield as chief) and Scientific Engineering Services (Mick Bone as manager). Jennie Clothier was the first woman to become chief of a division within DSTO when she was appointed successor to Colin Martin as chief of Air Operations Division in August 2005. She had joined DSTO in 1990, after migrating from the United Kingdom, where she had worked in the Admiralty Research Establishment. At DSTO she was one of the original staff members of the Information Technology Division at Fern Hill in Canberra. She came to the chief position after being Research Leader in the Research Planning and Guidance Branch within the Defence Systems Analysis Division in Canberra.[4] Five months after Jennie Clothier's promotion, Janis Cocking was appointed chief of the Maritime Platforms Division in January 2006, after coordinating the research and development program supporting undersea warfare. She was recruited by DSTO in 1975 and developed her expertise in submarine technologies and underwater platform systems. After a stint at the US Naval Research Laboratory in Washngton she was promoted to Senior Research Scientist and subsequently became Research Leader in Maritime Platforms Division.

Dr Ken Anderson.

In Adelaide, Neil Bryans was Deputy Chief Defence Scientist with responsibility for Information and Weapon Systems that included Land Operations Division (with Steve Quinn as chief), Electronic Warfare and Radar Division (Dr Len Sciacca as chief), Weapons Systems Division (Dr Warren Harch as chief), Command and Control Division (Dr Alan Burgess as chief), Information Networks Division (Dr Mark Anderson as chief), Intelligence, Surveillance and Reconnaissance Division (Dr Bruce Ward as chief) and Corporate Information Services (Paul Amey as deputy chief information officer).[5]

A significant initiative in forging closer links with clients had started a few years earlier with the appointment of former senior military personnel to lead various divisions. In 2002, Dr Tim McKenna, recently retired from the Army after 30 years' service with the rank of Brigadier, joined DSTO as First Assistant Secretary, Science Policy, and became chief of the Defence Systems Analysis Division in 2005. In February 2004 Steve Quinn, a graduate of the Royal Military College, Duntroon, who also rose to the rank of Brigadier and Director General of Land Development within the Army, became chief of the Land Operations Division. Jamie Watson joined DSTO in 1998 after a 10 year Navy career: he led DSTO's team within the inaugural Tactical Development Group to staff the Navy's operations research centre at Garden Island in 2003. He later joined the Defence Systems Analysis Division and late in 2006 was appointed Head of DSTO's Experimentation Initiative.

The reforms initiated by Dr Lough in 2006 went beyond structural changes. He committed the organisation to a comprehensive change program called DSTO Renewal aimed at establishing a client-focused structure, integrated research programs, timely delivery of capability, improved business processes and financial management, all to be underpinned by strong leadership and a culture of innovation and achievement. The vision was to create a more cohesive organisation (One DSTO) which would grow into an Agile DSTO, adaptive and responsive to the challenges of a changing Defence Force. A DSTO Renewal Implementation Team was established under Steve Quinn as project leader and Jim Smith as project manager to fast-track the changes. By July 2007 a new system had been put in place for planning

Dr Warren Harch.

and managing DSTO's client program along with a rationalised task system for delivering outputs. Staff were coming to grips with new business processes as well as cultural change. The magnitude of the change was enormous; the time short, and the process proved stressful.

In March 2007 Steve Quinn returned to his duties as chief of Land Operations Division while Jim Smith had been promoted as chief of the new Science Planning and Coordination Division in Canberra. Dr Alan Burgess, formerly chief of DSTO's Command and Control Division, took over as leader of the Renewal Implementation Team with Dean Bowley as the new project manager. On their recommendation the Chief Defence Scientist's Advisory Committee agreed to a review of the business processes implemented under the Renewal Program. The Renewal Review Steering Committee, chaired by Dr Ian Sare, examined a wide range of candid and constructive views from staff and clients. It made a number of significant recommendations to improve the administration of the new business processes.

Dr Jennie Clothier.

While Renewal was sweeping through the organisation changes to the senior leadership team continued with retirements and promotions. When his tenure as Deputy Chief Defence Scientist (Policy) finished in Canberra, Dr Ken Anderson returned to Melbourne as chief of Air Vehicles Division in January 2007 to succeed Dr David Wyllie who took over Special Projects prior to his retirement during that year. In July 2007 Jennie Clothier went back to Canberra to head the Defence Systems Analysis Division on the retirement of Dr Tim McKenna. She was replaced as chief of Air Operations Division by David Graham, a previous winner of the Minister's Award for Achievement in defence science and former scientific adviser to the Air Force.

There was movement also at DSTO in Adelaide. In March 2007 a new division called the Command, Control, Communications and Intelligence Division was created with the merger of the Command and Control Division and the Information Networks Division. Dr Mark Anderson was the inaugural chief of the new division which was established, to quote Dr Lough, "as an important step on the Renewal path to fully realising the synergies embedded in our diverse S&T capabilities."

In August 2007 Neil Bryans retired afer 44 years of service. Dr Warren Harch, chief of Weapons Systems Division, succeeded him as the Deputy Chief Defence Scientist in Adelaide. Dr Bruce Ward, chief of the Intelligence, Surveillance and Reconnaissance Division, transferred into Dr Harch's position, leaving a vacancy in his own division. This vacancy was filled by Dr Anthony (Tony) Lindsay who was DSTO's Defence Science Counsellor in Washington. A winner of the 2005 Minister's Award for Achievement in defence science, Dr Lindsay joined DSTO in 1988 and spent most of his career developing electronic warfare capabilities for the Royal Australian Air Force. He was recognised for his successful leadership of Project Arrangement 10, one of the largest joint R&D programs with the US to develop electronic warfare technologies for future-generation aircraft.

Another former winner of the Minister's Award for Achievement in defence science, Dr Jackie Craig, was also promoted at the same time and took the reins of the Electronic Warfare and Radar Division. Dr Craig was the first woman to become chief of a DSTO division in Adelaide. A graduate of Glasgow University with a doctorate from St. Andrews, Dr Craig joined DSTO in 1990 and 11 years later served as the Australian Project Director of the Global Hawk deployment in Australia.

The opportunity for Dr Craig's promotion resulted from a decision to appoint the then chief of the Electronic Warfare and Radar Division, Dr Len Sciacca, to a newly created position of Chief Operating Officer in October 2007. He had been a chief for five years but in this new role Dr Sciacca was given the task of operations management with a responsibility to develop and implement systems for delivering organisational outputs. Although he was an electrical engineer, Dr Sciacca had extensive experience working in R&D related roles in the CSIRO, the universities of Newcastle and Melbourne, the Cooperative Research Centre for Sensor Signal and Information Processing, and in Tenix Defence where he was the R&D Manager for Electronic Systems. Before joining Tenix he had worked for DSTO in the Weapons Systems Division. As Chief Operating Officer Dr Sciacca also inherited the leadership of the Renewal team with the impending retirement of Dr Alan Burgess in early 2008. Renewal was to become an integral part of DSTO's continuous improvement progam.

Janis Cocking.

The year 2007 began in typically busy fashion for DSTO with the organisation winning a design award for its exhibit at the Australian International Airshow at Avalon, the release of the much-awaited report on the North West Shelf Unmanned Aerial System trial, and the signing of a new strategic alliance with BAE Systems.

Dr Len Sciacca.

These events were followed in April by the opening of a new DSTO facility in Brisbane. The last time that DSTO had established an interstate presence outside of South Australia and Victoria had been more than a decade ago at HMAS Stirling in Western Australia to support submarine operations. Brisbane beckoned because it was a well established base for hypersonics research. The Brisbane facility, which was opened by Peter Lindsay, the Parliamentary Secretary to the Minister for Defence, was to be an Australian centre of excellence in hypersonics, the study of velocities greater than five times the speed of sound (Mach 5). Hypersonics is of particular interest to Defence because such a high-speed capability has the potential to dramatically reduce flight times and provide cost-effective access to space for launching satellites and other platforms. In

The Mariner Demonstrator during the 2006 North West Shelf Unmanned Aerial System trial in Australia.

During the opening of DSTO Brisbane, Parliamentary Secretary Peter Lindsay (centre) presents a souvenir to Ray Stalker (right), regarded as the father of hypersonics research in Australia. At left is Dr Allan Paull, research leader in hypersonics.

15 June 2006: Launch of the Hypersonic Collaborative Australia-US Experiment (HYCAUSE) which demonstrated ignition of a supersonic combustion ramjet (scramjet) engine at speeds close to Mach 10 during re-entry after climbing to an altitude of more than 450 km.

DSTO team responsible for HYCAUSE trial.

November 2006 DSTO and the US Air Force had signed a $70 million, 8 year agreement for a Hypersonic International Flight Research Experimentation project to advance the study of hypersonic flight. The US collaboration eventuated as a result of Australia's world-leading reputation in hypersonics research, including the University of Queensland's developments in scramjet technology, and DSTO's role in the Australian Hypersonics Initiative which brought together a number of interested R&D organisations, universities and government agencies to coordinate the hypersonics research effort in Australia. The hypersonics team from the University of Queensland, led by Dr Allan Paull, joined DSTO Brisbane and a new chapter began in the search for answers to the secret of high-speed flight. DSTO also established a chair in hypersonics at the University of Queensland.

Yet another new chapter was unfolding in Melbourne where DSTO's Maribyrnong facility (Australia's oldest working laboratory) closed after 85 years and its staff and operations were transferred to DSTO's Fishermans Bend site by mid-2007. The move to Fishermans Bend was a long-standing Defence initiative to consolidate DSTO's Victorian operations at the one redeveloped site equipped with advanced facilities to support future defence platforms such as the Joint Strike Fighter and the Air Warfare Destroyer. Another objective was to achieve efficiency gains by collocating and integrating compatible technology functions. The redeveloped Fishermans Bend complex, completed at at cost of $106 million, was officially opened by Parliamentary Secretary Peter Lindsay on 29 August 2007. The new three-storey building which houses the two divisions transferred from Maribyrnong was named as the Cecil Napier Hake building after the first defence scientist. A descendant of Hake and great niece of his wife, Mrs Joyce Welsh, was invited to unveil a commemorative plaque for the building. Dr David Warren who invented the black box flight data recorder during the 1950s was also honoured with the naming of the new auditorium on the Fishermans Bend site after him.

In Canberra, DSTO found a new home for its national headquarters at Fairbairn Business Park, the former RAAF base near the airport. While the move was driven by the need to ease accommodation pressure at defence headquarters, it gave DSTO the opportunity to bring together staff from its Russell and Fern Hill sites in a new building with an adjoining facility housing the state-of-the-art Joint Decision Support and Simulation Centre.

By the end of 2007, DSTO was on track to move early in the new year from Pyrmont to purpose-built facilities at the Australian Technology Park in Sydney.

A new start

Consolidation of the Melbourne laboratories at Fishermans Bend, the rationalisation and rebuilding at Edinburgh, the opening of a new facility in Brisbane, the transfer of DSTO Headquarters to Fairbairn in Canberra, and the relocation of the Pyrmont operations to Redfern in suburban Sydney mean that DSTO is virtually a new organisation.

Total staff numbered 2545 at 30 June 2007. This represents a major change from only 25 years previously when the organisation comprised as many as 4850 staff with less than 25 per cent working as scientists and engineers. The Edinburgh site remains the largest, with around 1430 staff. There are some 700 staff in Melbourne, 93 in Sydney, 44 at HMAS *Stirling* in Western Australia and 17 at Scottsdale in Tasmania. There are 13 staff in Queensland. DSTO remains headquartered in Canberra, where there is also a small research facility: there are approximately 200 staff in Canberra.

The move of the DSTO scientists and support staff from Pyrmont in Sydney to the Australian Technology Park at Redfern in 2008 means they will no longer be located on Sydney Harbour. However, they will be associated with a larger concentration of scientists, many working in allied areas. Indeed, in December 2003, DSTO entered an Umbrella Collaborative Research and Commercialisation Agreement with National Information and Communications Technology Australia Ltd (NICTA). Both organisations committed themselves to joint research on information and communications technology.

The demand to support non-Defence agencies with their national security initiatives continued to grow. In November 2007 DSTO established the Counter Terrorism and Security Technology Centre as a discrete function at Edinburgh to focus on developing relevant capabilities that were being sought by various government agencies. Neil Bryans, only recently retired, returned to head up the centre as its executive director.

Overview

Defence science in Australia in 2007 is a far cry from that of 1907. The pure sciences, chemistry and physics were originally considered the key sciences to support Australia's defence and were then primarily used in the production of ordnance. Australian scientists took their lead from those in Britain. The scope of the work broadened considerably after World War II to include aeronautical and oceanographic research and guided weapons research that required use of other sciences, not least mathematics and computing, during a period that Alan Butement believed 'defence science really commenced in Australia'. Even then, much of the work remained academic in its approach with tenuous links to defence issues. By the turn of the century scientists have had to accept that they were working in an applied science environment, with skills required in mathematics and modelling and operational analysis in addition to those of the traditional sciences. British links remain but Australian defence scientists now have closer links with those of the United States.

The attitude towards defence science and defence scientists has also changed. Service personnel considered the work of Australia's defence scientists to be peripheral to the business of waging war for most of the 20th century, while many scientists themselves did little to disabuse Service chiefs of this impression because of their academic approach to their work. Today, however, as other nations match Australia in the acquisition of new technology, the contributions of Australia's defence scientists are considered essential in maintaining the 'knowledge edge'. Their work is more closely focused on the needs of the Defence Force and plays a vital role in defence planning and execution; Service chiefs now acknowledge that this is of primary importance.

The work of defence scientists has been revolutionised by technological changes, most notably in computers. The early work of scientists associated with the Joint Project was constrained by the computers then available. Sixty years later the available technologies enable complex situations and expensive trials to be simulated.

Still, even with the closer understanding between DSTO and its customer, a measure of reservation between the two continues. The military culture remains one of 'command and control' that is uncomfortable with imagination and innovation. However, DSTO scientists are no longer overly concerned about greater academic freedom. In the new century, and in the light of different circumstances, their chief concern is about the need for flexibility and the ability

At the opening of the redeveloped DSTO Melbourne site in August 2007 (L-R): Dr Warren Harch, Dr Ian Sare, Dr Roger Lough, Mrs Joyce Welsh, a descendant of Cecil Napier Hake, Dr David Warren, inventor of the black box flight recorder, Parliamentary Secretary for Defence Peter Lindsay, Mr Neil Bryans and Dr Nanda Nandagopal.

LTGEN Henry Obering of the US Missile Defense Agency (seated centre) during the signing of the agreement on missile defence in 2006.

to deliver to the client what is required with the least constraint, while remaining part of the Department of Defence and close to the client.

The reservation also derives from the nature of the work required of DSTO. While concentrating on current issues and obviously playing an important role in Australia's defence, the organisation must seek to anticipate issues as far as 15 years into the future. Currently DSTO scientists are engaged in research in such areas as robotics, nanotechnology, biomimetics, photonics and quantum computing. As in the past, some projects already begun may prove impractical or be overtaken by research conducted elsewhere and must necessarily be abandoned with few evident benefits derived from the work. But this is the nature of research.

The work of defence scientists continues to benefit Australian industry. There are scores of small companies spawned from DSTO initiatives that continue to work in the defence industry, while larger companies such as Tenix Defence Pty Ltd, Thales Underwater Systems and BAE Systems Australia Ltd continue to manufacture systems originally developed by DSTO scientists. A key feature of Australian defence science in the 21st century is that it is no longer confined to government agencies but also includes industry and other research agencies.

Early collaboration of industry in the development of DSTO-conceived weapons and technologies may not be as close as successions of political masters would like—not always realistically—and there may be room for improvement.[6] Nevertheless, DSTO has been resolute in collaborating with industry through ever-growing numbers of collaborative arrangements that include strategic alliances, research agreements, and participation in Cooperative Research Centres. By 30 June 2007 DSTO had concluded as many as 85 licence agreements for the commercial development of DSTO technologies: nine new licences were negotiated in the 2006-07 financial year. In addition it had negotiated 11 alliances with industry and 22 collaborative agreements with companies and other research organisations.

As a strategic mechanism for collaboration, DSTO has established Centres of Expertise in various Australian universities focusing on specific research and technology areas of interest to Defence. Through these university-based centres DSTO develops capabilities in demand by Defence. In 2007 there were seven such centres in operation. They included Centres of Expertise in systems integration (University of South Australia), microwave radar and photonics (University of Adelaide), energetic materials (Flinders University), autonomous vehicle systems (University of Sydney), helicopter structures and diagnostics (University of New South Wales), aerodynamic loading (Royal Melbourne Institute of Technology) and structural mechanics (Monash University).

The Capability and Technology Demonstrator (CTD) Program remains an important means of encouraging industry to engage in defence science: since 2005 the program has been managed wholly by DSTO. Over $190 million has been committed since the program started in 1998. There are now 35 active demonstrator projects. Eight projects were supported in the latest round (Round 11) of government funding to companies like BAE Systems, Thales Australia, L-3 Nautronix, Tenix Systems, and Tectonica as well as the CSIRO. Their proposals included ideas for a flexible body armour, an early warning sensor system to protect military vehicles from small arms fire, a wearable battery system powered by body movement, a stealthy re-usable underwater surveillance system, a novel mechanism for producing oxygen from ambient air, and a diagnostic smart patch for continuously monitoring the health of aircraft structures. If successfully demonstrated, CTD projects have the potential to enhance military capability, deliver significant savings to Defence and diversify into civilian applications.

In another move to foster wider collaboration DSTO, along with the Defence Materiel Organisation and the Department of Education, Science and Training, announced plans in 2007 to set up a cooperative venture known as the Defence Future Capability Technology Centre program. This initiative, to be modelled on the successful Cooperative Research Centres program, would aim to bring together Australia's publicy-funded research organisations, pre-eminent universities and industry product developers to nurture the high levels of innovation essential for maintaining the nation's technological capability edge in defence. Government funding of up to $30 million over seven years was committed to this program. In December 2007 a consortium, based in Victoria, was selected to start up a new Defence Materials Technology Centre – the first to be established under the program. The new centre was to focus on research into high-tech materials for use in armour protection, propulsion systems and major Defence acquisitions such as the Joint Strike Fighter and the Air Warfare Destroyer.

Given the unending imperative to enhance defence capability, there will always be a need for Australian defence science. However sophisticated the overseas products, they must perform in accordance with Australian Defence Force requirements and the environments in which it operates. At the same time there will always be a requirement for Australian scientists to provide solutions when others are unable to do so. This is where DSTO excels.

DSTO national HQ in Fairbairn Business Park, Canberra.

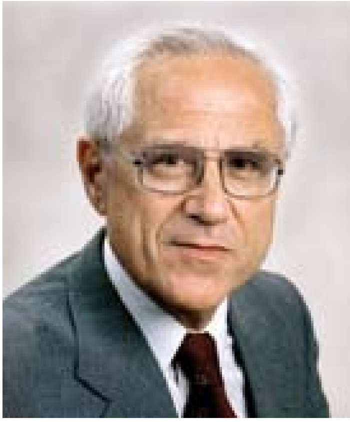
Carbon nanotube to create artificial muscle.

Working with the universities of Sydney and Adelaide, DSTO demonstrated the ability of an unmanned ground vehicle to operate autonomously in difficult terrain by downloading maps from an unmanned aerial vehicle.

Chief Defence Scientists

Dr J.L. Farrands
Chief Defence Scientist
1971 – 1977

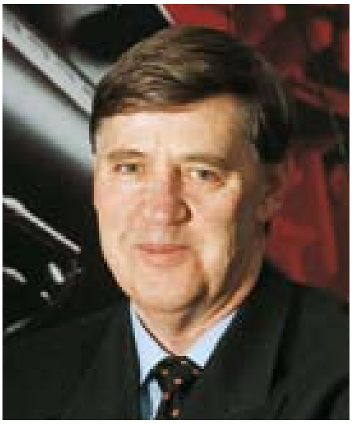
Dr W.A.S. Butement
Chief Scientist, Department of Supply
1949 – 1967



Professor P.T. Fink
Chief Defence Scientist
1978 – 1986

Mr H.A. Wills
Chief Defence Scientist
1968 – 1971

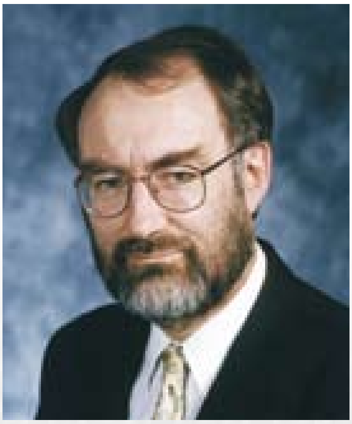
Mr H.A. d'Assumpcao
Chief Defence Scientist
1987 – 1990



Dr C.I. Chessell
Chief Defence Scientist
2000 – 2003

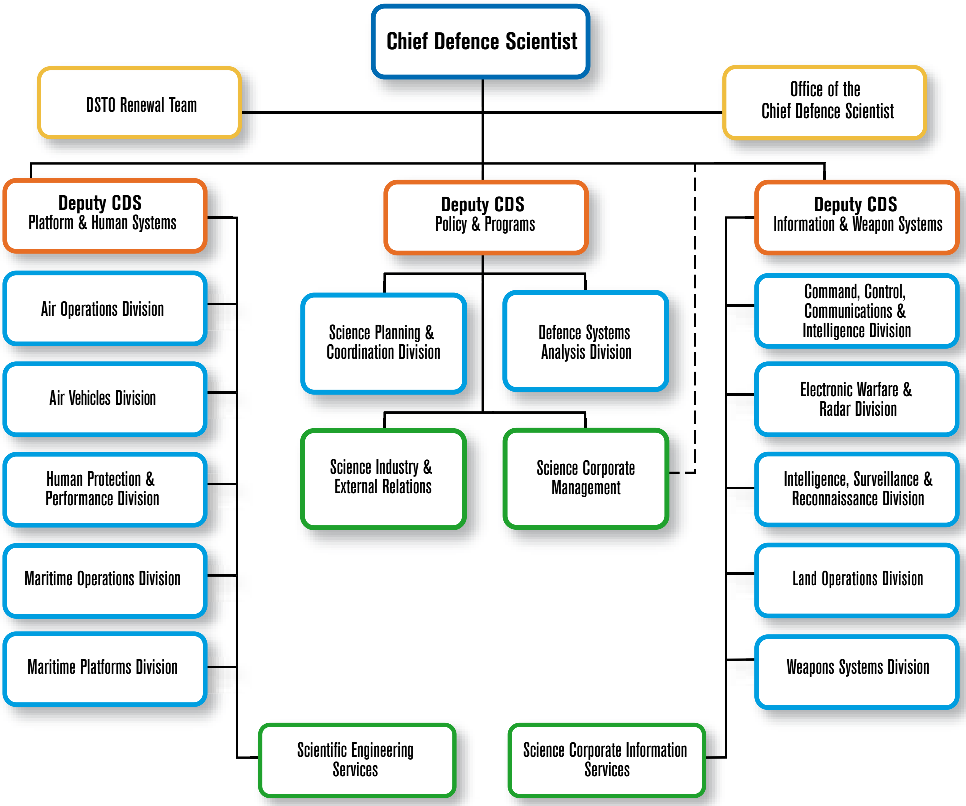
Dr R.G. Ward
Chief Defence Scientist
1991 – 1992

Dr R.M. Lough
Chief Defence Scientist
2003 –



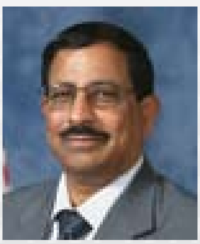
Dr R.G. Brabin-Smith
Chief Defence Scientist
1993 – 2000

DSTO organisation (December 2007)



DSTO Senior Leadership Team (December 2007)

Chief Defence Scientist
Dr Roger Lough



Deputy Chief Defence Scientist
(Policy & Programs)
Dr D (Nanda) Nandagopal

Deputy Chief Defence Scientist
(Platform & Human Systems)
Dr Ian Sare

Deputy Chief Defence Scientist
(Information & Weapon Systems)
Dr Warren Harch


Chief Air Operations Division
Mr David Graham

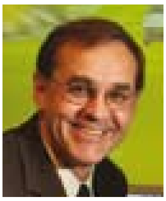

Chief Air Vehicles Division
Dr Ken Anderson


Chief Command, Control & Intelligence Division
Dr Mark Anderson

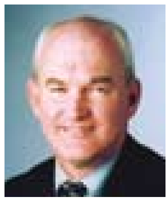

Chief Defence Systems Analysis Division
Dr Jennie Clothier


Chief Electronic Warfare & Radar Division
Dr Jackie Craig


Chief Human Performance & Protection Division
Dr Simon Oldfield


Chief (designate) Intelligence, Surveillance & Reconnaissance Division
Dr Tony Lindsay


Chief Land Operations Division
Mr Steve Quinn


Chief Maritime Operations Division
Dr John Riley


Chief Marititme Platforms Division
Ms Janis Cocking


Chief Science Planning & Coordination Division
Mr Jim Smith


Chief Weapons Systems Division
Dr Bruce Ward


Chief Operating Officer
Dr Len Sciacca


Asst. Secretary Science Corporate Management Branch
Mr Martyn Taylor


Asst. Secretary Science Industry & External Relations Branch
Mr Alan Gray

Timeline

1907	Commonwealth government instructs Cecil Napier Hake to proceed to England to gather information for a cordite factory. His report recommends the establishment of a cordite factory.
1908	Marcus Bell appointed as Assistant Chemical Adviser. On Hake's recommendation the Commonwealth government acquires land on the site of the old Maribyrnong Racecourse and construction begins on a Government explosives factory. Hake also recommends Arthur Edgar Leighton be appointed Manager.
1909	Leighton commences as Manager of the new Government Explosives factory at Maribyrnong.
1910	A dedicated Commonwealth Chemical Adviser's Laboratory (Australia's first defence Science Laboratory) begins operation in the bluestone guardhouse at the south entrance of Victoria Barracks in Melbourne.
1911	Hake retires from Public Service and is succeeded by Marcus Bell (7 February).
1912	The manufacture of explosives begins at the new Maribyrnong factory.
1920	Construction commences on building a new laboratory at Maribyrnong (August).
1921	Munitions Supply Board established (13 August).
1922	New laboratories opened at Maribyrnong and staff from Chemical Adviser's Laboratory relocated from Victoria Barracks. Chemical Adviser's Laboratory becomes the Munitions Supply Laboratories (MSL) of the Munitions Supply Board.
1939-40	Aeronautical & Engine Research Test Laboratory established at Fishermans Bend as part of the CSIR Division of Aeronautics.
1940-41	Change to Munitions factory built at Salisbury, South Australia.
1946	Laboratory established in Finsbury, South Australia (later known as Woodville North when the suburb name was changed) as a branch of Defence Research Laboratories.
1946	Cabinet of Chifley Labor government approves British proposal for a combined guided projectiles project and a supporting developmental establishment.
1947	Long Range Weapons Organisation (LRWO) formed in Salisbury, South Australia (1 April) to support guided weapons facility at Woomera.
1947	Arthur Wills of the CSIR Division of Aeronautics initiates a research program to develop a database on aircraft fatigue.
1947	First trials at Woomera: parachute testing by Royal Aircraft Establishment.
1948	Paper written by Arthur Wills, *The Life of Aircraft Structures,* published by The Institution of Engineers Australia.
1948	Munitions Supply Laboratories becomes known as Defence Research Laboratories (DRL).
1948	Design and development of a sub-sonic unmanned jet-propelled target plane prototype begins following a series of meetings held in London between representatives of the British and Australian governments. Two versions designed and built by the Government Aircraft Factories and later the Aeronautical Research Laboratories: a manned version 'Pika' (two only built) and an unmanned version 'Jindivik'.
1948	Salisbury 'welded into a single unit, the Long Range Weapons Establishment' (September). LRWE formally comes into operation (4 October).
1949	Arthur Wills presents his seminal paper, *The Life of Aircraft Structures*, at the Second International Aeronautical Conference, New York. The paper explained, for the first time, the technique for determining aircraft fatigue lives.
1949	Fishermans Bend laboratory transfers from CSIR to the Department of Supply and Development; renamed Aeronautical Research Laboratories (ARL).

1949	Lidcombe Branch of DRL transfers to Alexandria, NSW to undertake research in physical metallurgy and metallurgical chemistry areas (originally established at Lidcombe in 1942).
1950s	Research begins into the ionosphere at Weapons Research Establishment, Salisbury.
1950s	Research on uncooled infrared sensors begins at Weapons Research Establishment, Salisbury, with work on devices called resistance bolometers.
1950–1962	Alf Payne and W.W. Johnston, ARL, lead a pioneering research program into the fatigue behaviour of aircraft structures. Extending over a period of 12 years, 222 Mustang aircraft wings are tested. The research is the most extensive series of fatigue tests of a full-scale structure ever undertaken and the results are subsequently used as an authoritative reference by the aeronautical industry.
1950	Australian Defence Scientific Service formally established incorporating LRWE, DRL and ARL.
1951	Three new laboratories created at Salisbury: Electronics Research Laboratory, Propulsion Research Laboratory and High Speed Aerodynamics Laboratory (HSAL transfers from ARL).
1952	The first successful Jindivik test undertaken on 28 August 1952 from Evetts Field near Woomera, SA.
1952	Development of Malkara, a heavy anti-tank wire-guided weapon system, begins at Government Aircraft Factory in collaboration with Aeronautical Research Laboratories, Fishermans Bend, and Weapons Research Establishment, Salisbury.
1952	'Wet' electrophotographic process that becomes the basis of the modern photocopying industry invented and developed by K.A. (Ken) Metcalfe and R.J. (Bob) Wright at Defence Research Laboratories, SA Branch–Woodville North. New technology patented in 13 countries by Commonwealth government, with firms in the United States, England, Japan and Europe licensed to use the patent. Over 90 patents taken out in Australia and overseas with royalties reaching one million dollars a year paid to the Commonwealth at the peak.
1953	Electronics Research Laboratory and Propulsion Research Laboratory, Salisbury, merge to become Chemical and Physical Research Laboratories.
1953	Dr David Warren, Aeronautical Research Laboratories, Fishermans Bend, invents the first black box flight recorder. Dr Warren and his team— Kenneth Fraser, Lane Sear and Dr Walter Boswell—spend the next several years developing the technology.
1953	Defence Research Laboratories changes name to Defence Standards Laboratories.
1954	The Army Food Research Station, Melbourne, relocates to Scottsdale, Tasmania (mid-1954). Absorbed into DSTO in 1975.
1954–1975	The first firing trial using the Jindivik Mk1 as a target undertaken (1 October 1954) at Range E, Woomera, SA. Jindivik continues in service at Woomera until 27 June 1975.
Mid-1950s	Aeronautical Research Laboratories (Ron Cumming and Russ Baxter) and Department of Civil Aviation, Melbourne, begin work on T-VASIS (Tee Visual Approach Slope Indicator System) landing system. System adopted by Department of Civil Aviation after extensive evaluation both in Australia and overseas. First unit commissioned in Hobart in 1964 and subsequent units installed at major Australian airports during 1966-1967.
1955	LRWE and all the Salisbury laboratories amalgamated to form the Weapons Research Establishment (WRE).
1956	Navy establishes the Royal Australian Navy Experimental Laboratory (RANEL) at Rushcutters Bay, Sydney.
1957	Dr David Warren and his team produce a demonstration model of the black box flight recorder—not approved by Australian aviation authorities at the time.
1957	Minitrack system—first American space tracking station—established in Australia at Range G, Woomera, during the 1957 International Geophysical Year.
1957	Tripartite Technical Cooperation Program (TTCP) originates following agreement between

	President of the United States and Prime Minister of Great Britain to pursue defence initiatives in a collaborative fashion (25 October). Canada joins soon afterwards.
1957	Prototype of WRETAR (WRE Target Aircraft Recorder) designed and developed target camera manufactured by Fairey Aviation – 192 cameras made for initial production run.
1958	Dr Warren's demonstration model of black box flight recorder received enthusiastically in Britain where the device was taken for further development. Subsequently, British Ministry of Aviation announces that the recorder should be carried on all planes, at least for recording instrument readings.
1959	Government approval given for development of Ikara, DSTO-designed ship-borne long-range anti-submarine guided weapon (November).
1959	Fish-eye lens camera designed and developed by Weapons Research Establishment for Jindivik trials.
1960s	Dr Noel Burley, Defence Standards Laboratories, Maribyrnong, invents the highly stable nickel-base alloy, thermocouple nicrosil/nisil, that is now universally known as the 'Type 'N' Thermocouple System'. Ultimately results in the technology being accepted worldwide and international standards revised.
1960	Design and construction of Ikara begins at Aeronautical Research Laboratories and Weapons Research Establishment. Government Aircraft Factory, Royal Australian Navy and sub-contractors also involved. Testing undertaken at Fort Largs, SA.
1960	Malkara Mk1 successfully tested at Woomera in September. Deliveries to Britain commence.
1960	Following major aircraft crash, Australia becomes the first country in the world to make cockpit voice-recording in aircraft mandatory. Ultimately becomes mandatory in all major aircraft throughout the world.
1960	Muchea tracking station established in Western Australia, especially for NASA's Project Mercury. Initially responsible to Weapons Research Establishment, station closes in 1963.
1960	Island Lagoon tracking station established near Woomera, South Australia. Initially responsible to Weapons Research Establishment, station closes in early 1974.
1960	British government cancels Blue Streak program in Australia (13 April). ELDO (European Launcher Development Organisation) first mooted. ELDO included Britain, France, West Germany, Italy, Belgium, Holland and Australia and was focused on developing, constructing and launching a test satellite into orbit from Woomera.
1961	First trials on Ikara scale models carried out at Woomera, SA.
1962	Alf Payne, Aeronautical Research Laboratories, invited by the United States Air Force to undertake research program on structural reliability in fatigue with Professor Freudenthal, a world authority in that field at Columbia University. Expertise gained applied to major fatigue investigation on the F-111 by USA and Australia.
1962	Joint Tropical Research Unit (JTRU) established in Innisfail, Queensland and operated jointly with the British Ministry of Defence.
1962	First firing of three-stage Europa I rocket at Woomera under ELDO program (24 May). In all, ten firing trials of Europa conducted at Woomera, last on 12 June 1970.
1963	First full-size Ikara missiles launched at Woomera, SA (April). First full-scale Ikara trials conducted from HMAS *Stuart* off Sydney (August).
1963	Laser Group established at Defence Standards Laboratories, Maribyrnong.
1963	Carnarvon tracking station established in Western Australia replacing Muchea tracking station. Initially responsible to Weapons Research Establishment, station closes in 1974.
1964	Production of Malkara ceases.

1964	Weapons Systems Research Laboratory, Weapons Research Establishment, begins work on the Barra project initially known as Project Nangana. Task involved developing a new sonobuoy system able to be deployed from aircraft and helicopters to detect, locate and classify quiet submarines and surface ships.
1965	Australia joins the Non-Atomic Military Research and Development sub-committee of the Tripartite Technical Cooperation Program (TTCP). New Zealand follows in 1969 at which time the organisation renamed The Technical Cooperation Program (TTCP).
1965	Tidbinbilla Deep Space tracking station opens near Canberra, ACT. Initially responsible to Weapons Research Establishment, station remains in operation.
1965	Orroral Valley space tracking station constructed in Australian Capital Territory. Initially responsible to Weapons Research Establishment, station closes in 1985.
1966	First Ikara production version enters service on HMAS *Derwent* (January).
1966	First Sparta firing at Woomera, SA (28 November).
1966	Cooby Creek tracking station, near Toowomba, Queensland, opens in October. Initially responsible to Weapons Research Establishment, station closes in 1970.
1966	Down Range Guidance and Telemetry Station built at Gove, Northern Territory, to provide the third stage of the ELDO Europa rocket with radio guidance during the last part of its flight.
1967	Honeysuckle Creek tracking station, near Canberra, ACT, opens in March. Initially responsible to Weapons Research Establishment, station closes in December 1981.
1967	Ninth and final Sparta firing at Woomera, SA, bringing an end to tripartite agreement between the United States, Britain and Australia.
1967	The Royal Australian Navy adopts Jindivik for target service at the Jervis Bay Missile Range.
1967	First Australian TTCP panel meeting held in Melbourne (4-6 April) and Sub-Group meeting (10-14 April).
1967	Barra sea trials—initially in St Vincent's Gulf, SA (July and August) and later off Jervis Bay, NSW.
1967	Design work on Australia's first satellite, WRESAT, begins—a joint venture between Weapons Research Establishment, Salisbury, and Physics Department, University of Adelaide. United States Department of Defense, NASA and Ministry of Technology, UK, provide assistance. WRESAT launched at Woomera, SA, 29 November.
1968	WRESAT re-enters earth's atmosphere and destroyed by resultant high temperatures over Atlantic Ocean west of Ireland (10 January).
1968	First stage of transfer of Department's Central Office in Melbourne to Canberra completed.
1968	First public firing of Ikara takes place from HMAS *Perth*, off Jervis Bay (9 August). Delivery of modified Ikara system to the Royal Australian Navy commences (September). System withdrawn from Royal Australian Navy in 1991.
1968	Towed array research and development begins in Australia—Royal Australian Navy Research Laboratory, Sydney, purchases an array named 'Towflex' from the Chesapeake Instrument Company.
1968–1974	WREMAPS I designed by M.F. (Mike) Penny, Weapons Research Establishment, Salisbury. Leads team into developing the profiler to aid Department of National Development's Division of Mapping in its topographical survey of land surface profiles in Australia. In early 1970s, WREMAPS II developed out of WREMAPS I to produce an even more efficient system for use by Department of the Army, Royal Australian Survey Corps, to measure and record ground profiles from aircraft flying at altitudes up to 5000 metres above ground level. Fairey Australasia Pty Ltd ultimately appointed as licensed manufacturers.

1968	Scientific advice on F-111 to the Royal Australian Air Force commences at Fishermans Bend. Over the years, this has included structural integrity testing, bonded repair research, durability and damage tolerance analysis. With the planned withdrawal of the fleet in 2020, DSTO's expertise on life assessment and repair continues.
1969	RANEL becomes known as Royal Australian Navy Research Laboratory (RANRL).
1969	Experimental model of WREMAPS 1 constructed and installed into a Dakota aircraft (Spring 1969).
1969	Cooperative acoustic sounding program carried out between Weapons Research Establishment, Salisbury, and United States Environmental Science Services Administration under the Australia/U.S. Agreement for Scientific and Technical Co-operation.
1969–1971	Captain Cook's cannon and some stone ballast raised from sea floor near Cairns, Queensland, taken to Maribyrnong, Victoria, and restored by Defence Standards Laboratories. Australian Prime Minister John Gorton, hands the six restored cannons to representatives of the Commonwealth, Queensland, New South Wales, New Zealand, Britain and the United States (1970). Same restorative process used by the Laboratories on the anchor discovered and lifted from the sea in 1971.
Early 1970s	Exploiting new computer technologies, scientists at Maribyrnong develop original 'rabbit ears' Australian Army Disruptive Pattern camouflage designs to match the Australian terrain. Following successful trials, Australian Army adopts design for use in Vietnam.
1970s	Work undertaken into variable-thrust, solid-propellant rocket-motor technology that could be used with guidance commands to enable a decoy to hover in controlled flight. Becomes known as Project Winnin and later forms basis of Nulka technology.
1970s	Defence Standards Laboratories (and later the Materials Research Laboratories), Maribyrnong design, build and operate the first electron-beam-controlled carbon dioxide laser, the first continuous wave laser operating at atmospheric pressure and the first laser using plasma injection.
1970s	Fully operational high-gain sonobuoys developed with assistance of Australian industry after 1971.
1970s	Five-year study between Weapons Research Establishment, Salisbury, and US Defense Advanced Research Projects Agency (DARPA) undertaken on long towed arrays. Project named 'Boolee'. Knowledge acquired results in decision to focus on research and development of thin-line towed arrays with Kariwara slim-line buoyant fibre towed array the outcome (1980s).
1970	WREMAPS I installed in Grand Commander aircraft charted by Department of National Development (May 1970). Formal acceptance of the system occurs (12 July). Department uses profiler for ten years.
1970	Jindalee high frequency over-the-horizon radar (OTHR) becomes a core DSTO research project developed to provide surveillance across Australia's northern sea and air approaches.
1971–1987	Developing Jindalee from 'concept demonstrator' phase to proven operational capability continues (1971–1987) with funding for a scaled-up OTHR prototype approved (1971).
1971	T-VASIS landing system adopted as the international standard.
1971	Ken Metcalfe presented with an 'Excellence' Award by the Federation Internationale de l'Art Photographique, Brussels, for his work in electrophotography.
1971	Weapons Research Establishment, Salisbury, and Royal Australian Naval Research Laboratory, Sydney, undertake design study into British Type 177M sonars fitted to RAN 'River' class destroyers. Study outcomes influence Mulloka project that follows.
1972	Proposal to develop new Australian sonar system—Mulloka—accepted (early 1972).
1972	Delivery of modified Ikara systems to the Royal Navy commences.

1972	Initial investigations begin at Weapons Research Establishment into developing a technology that could be used by the Royal Australian Navy's Hydrographic Service to conduct hydrographic surveys of Australia's continental shelf. WRELADS (Weapons Research Establishment Laser Airborne Depth Sounder) project follows.
1972	Dr Alan Baker and his team at Aeronautical Research Laboratories, Fishermans Bend, begin pioneering research and development into use of composite bonded repair technology to prolong fighter aircraft life. DSTO becomes world leader in the technology.
1973	The Federation Aeronautique Internationale awards the Diplome d'Honneur to Aeronautical Research Laboratories, Fishermans Bend, and Department of Civil Aviation for the invention and development of T-VASIS.
1973	Research begins into the use of towed permanent magnets for mine sweeping purposes at Royal Australian Naval Research Laboratory, Sydney.
1974	Mulloka prototype completed and fitted to HMAS *Yarra*.
1974	As a result of Defence restructuring, the Defence Science & Technology Organisation (DSTO) is created by integrating the Australian Defence Scientific Service, and later the in-house R&D units of the Armed Services and the Science Branch of the Department of Defence. Defence Standards Laboratories becomes the Materials Research Laboratories (MRL).
1975	Official transfer of all Defence R&D activities to DSTO in the Department of Defence.
1975	Army transfers Armed Forces Food Science Establishment (AFFSE), Scottsdale, Tasmania, to DSTO.
1975	Navy transfers Royal Australian Navy Research Laboratory to DSTO.
1975	Navy transfers Royal Australian Navy Trials and Assessing Unit (RANTAU), North Sydney, to DSTO.
Mid-1970s	First experimental over-the-horizon radar—Jindalee 'A'—designed and built by DSTO, constructed at Alice Springs, central Australia.
1975	First phase of WRELADS I program begins under leadership of Mike Penny.
1975	Sea trials of Mulloka medium-range active sonar system commence in March.
1975	Australia enters an agreement with United Kingdom relating to Barra sonobuoy: Australian scientists design and manufacture the passive sonobuoy while United Kingdom scientists design, develop and manufacture the airborne processor (9 August).
1976	Joint operation of Joint Tropical Research Unit with British Ministry of Defence ceases.
1976	Government White Paper on Australian defence tabled in Federal Parliament (4 November).
1977	Royal Navy takes delivery of the thousandth Ikara missile.
1977	AWA Limited awarded initial contract to produce Barra sonobuoys.
1977	Royal Australian Navy seeks assistance from Materials Research Laboratories, Maribyrnong, to find an alternative material for the depleted uranium penetrator for the Phalanx, a close-in weapon system that was to be fitted to guided missile frigates to counter a threat from sea-skimming missiles. Research results in first suitable non-depleted uranium penetrator material developed for this application: environmentally friendly and some penetration advantages over the original depleted uranium alloy.
1977	Royal Australian Air Force places request with Defence Research Centre, Salisbury, to investigate glide bomb technology — leads to General Test Vehicle (GTV) program, later known as Kerkanya.
1977	Joint Tropical Trials and Research Establishment established (JTTRE), merging JTRU and Tropical Trials Establishment situated at Cowley Beach in Queensland.
1977	MRL, Woodville North transferred to CSIRO Division of Manufacturing Science and Technology.

1978	WRE reorganised to become Defence Reserach Centre Salisbury (DRCS) with four laboratories: Weapons Systems Research Laboratory (WSRL), Electronics Research Laboratory (ERL), Trials Research Laboratory (TRL) and Advanced Engineering Laboratory (AEL).
1979	Royal Australian Navy accepts prototype Mulloka sonar system as an operational unit (17 August).
1979	Contract to design and manufacture production model of Mulloka sonar system let to EMI Electronics (Australia) in December.
1979	DSTO scientist John Curtin conducts a study exposing limitations in the Orion Electronic Support Measures (ESM) system. Goes on to play a major role in the development and redesign of a new ESM system, the ARL 2001, with AWA Defence Industries (now part of British Aerospace Australia) that has significantly enhanced the Orion's maritime surveillance capability.
Late 1970s	DSTO scientists begin advising Australian government on chemical disarmament and protection.
Early 1980s	Jindalee 'B' over-the-horizon radar constructed.
Early 1980s	Research begins at Aeronautical Research Laboratories, Fishermans Bend, into helicopter gearbox failure.
1980s	Tony Collins, DSTO Sydney, invents PIPRS (Ping Intercept Passive Ranging System), a technology that determines the range of active acoustic transmissions of the kind used in anti-submarine warfare to locate possible targets.
1980s	DSTO develops Seamark — a marine dye marker — as a safe, effective and longer-lasting alternative to flares and smoke signals for search and rescue at sea.
1980	Project Winnin development study approved — later becomes known as Nulka.
1980	First production Barra presented to the United Kingdom's High Commissioner for Australia (25 February). Marks the beginning of deliveries of Barra sonobuoy to UK and Australian Air Forces and Navies.
1980	Research begins at Materials Research Laboratories, Maribyrnong, into tracked vehicle elastomer and associated technologies. Includes a new rubber formulation and process to manufacture blended rubber stock for military tracked vehicles and other applications, and a road-wheel-tread rubber formulation.
1980	Anglo-Australian Joint Project officially concludes (30 June).
1981	Following successful trials, Nulka hovering rocket motor developed in consultation with Explosives Factory, Maribyrnong, and Ordnance Factory, Maribyrnong (subsequently part of Australia's ADI Limited).
1982	Trials Research Laboratory, Salisbury, merges with Advanced Engineering Laboratory.
1982	DSTO transfers Royal Australian Navy Trials and Assessing Unit to Navy.
1983	DRCS becomes known as DSTO Salisbury.
1983	Royal New Zealand Navy adopts Ikara system when it acquires HMNZS *Southland* (ex HMS *Dido*) from Royal Navy.
1983	LADS laser developed by Dr James Richards and his team.
1983	Australian patent granted for The Pilot's Force Measurement Glove invented by DSTO's Dr Garth Morgan, William Menadue and Robert Clarke at the request of RAAF's Aircraft Research and Development Unit (8 June). A world first for Australian engineers and an invention that revolutionised in-flight testing procedures.
1983	Royal Australian Navy calls for expressions of interest for the provision of mine sweeping capability. Leads to development of AMASS (Australian Minesweeping and Support System).

1983	DSTO Salisbury, in conjunction with Adelaide's Queen Victoria Maternity Hospital staff, develop Aeromed Retrieval Unit for evacuation of premature and sick babies from outlying areas in the state.
1985	DSTO transfers Branch of Materials Research Laboratories, Alexandria, NSW to Army.
1985	Feasibility study into Kariwara slim-line towed array concludes favourably (early 1985). Project Definition Study begins in partnership with industry to develop and test the technology (late 1985).
1985	DSTO's Dr Jim Sparrow initiates research into Thermoelasticity by studying stresses generated by different loads at different temperatures.
Mid-1980s	David Forrester, Aeronautical Research Laboratories, Fishermans Bend, continues work into helicopter gearbox failure and becomes the first person to apply time frequency analysis to machine fault diagnosis. Wins international recognition.
1986	Minister for Defence, Kim Beazley, announces approval given for the design and development of the OTHR network.
1986	Australia and United States agree to undertake a full-scale collaborative engineering development on Nulka active missile decoy (August).
1986	Royal Australian Navy nominates slim-line Kariwara towed array 'as Australian Government Furnished Equipment' for the Collins class submarines (December).
1987	Federal government launches Policy Information Paper—*The Defence of Australia 1987*—placing a high priority on establishing a network of Over-The-Horizon-Radars (March 1987).
1987	Operational radar—Jindalee 'C'—handed over to the Royal Australian Air Force.
1987	Five year restructuring of DSTO laboratories begins. At DSTO Salisbury this results in abolition of the Advanced Engineering Laboratory, the creation of a new Surveillance Research Laboratory (SRL) and reorganisation of Electronics Research Laboratory (ERL). Use of name RANRL ceases and becomes known as DSTO Sydney.
1988	Royal Australian Air Force takes decision that a full-scale structural test on the empennage of the F/A-18 Hornet required in order to establish its economic safe life.
1988	AWA Defence Industries (now part of BAE Systems) awarded contract for engineering development of the Nulka system and hovering rocket vehicle. ADI Ltd sub-contracted to develop and manufacture the rocket motor, and separate contract awarded to American company Sippican Inc. to develop the electronic payload for the decoy.
1988	Defence Minister's Achievement Award presented to Mike Turner for development of a more flexible concept for minesweeping.
1989	Towed Array Development Project Office established within Department of Defence to meet Royal Australian Navy's requirements for managing the development of Kariwara towed array technology (early 1989).
1989	BHP Engineering and its partner Vision Systems Ltd awarded contract for the construction of LADS, and trials of an operational version for the Royal Australian Navy (May).
1989	Project AuSAR (Australian Synthetic Aperture Radar) begins — in an advanced state of design by 1992.
1989	ATM (Asynchronous Transfer Mode) — a joint development of DSTO and Telecom Research Laboratories, Melbourne — begins using the national civil telecommunications infrastructure in the development of the system.
1989	Defence Minister's Achievement Award presented to Dr Fred Earl for his work on the Jindalee over-the-horizon radar.
1989	Jindalee team awarded CSIRO Gold Medal (in non-CSIRO work category) for outstanding contribution to science.
1989	Secretary of Defence Award for Achievement presented to Dr Malcom Golley for his role as a fundamental player in the development of Jindalee to operational capability.

c. 1989	Pilot's Force Measurement Glove technology transferred to Normalair-Garrett Australia to undertake development and manufacture. Company markets the glove as the 'Control Stick Force Measurement Glove'.
Late 1980s	DSTO establishes research program to investigate the environmental impact of the anti-fouling biocide tributyltin (TBT).
Late 1980s	Prototype of PIPRS successfully tested. DSTO licenses SonarTech Pty Ltd to commercialise the system. The company subsequently supplies PIPRS equipment to Royal Australian Navy's fleet of Oberon class submarines and those of other navies around the world, including the United States. An enhanced system, the Submarine Acoustic Transistory Event Processing System (SATEPS), deployed in the Collins class submarines.
Late 1980s	DSTO scientists, Maribyrnong, begin work on side scan sonar surveillance.
Early 1990s	DSTO begins testing more than 150 anti-fouling products from all over the world with new and experimental products being evaluated and assessed under Australian conditions.
1990s	Co-planar Pumped Folder Slab or CPFS laser, based on laser-diode pumped solid state laser technology, invented, patented and developed by DSTO's Dr Jim Richards and Alasdair McInnes. Laser licensed for use in the improved Laser Airborne Depth Sounder (LADS), since marketed worldwide.
1990s	DSTO begins development into high frequency surface radar — evolves out of JORN technology.
1990	DSTO licenses Australian-owned private company, Helitech Industries Pty Ltd, to market and develop composite bonded repair technology.
1990	Defence Minister's Achievement Award presented to Dr Alan Baker for research into bonded composite repair technology and its application to RAAF aircraft.
1991	Commonwealth awards Telecom (now Telstra) a prime contract worth $860 million to design and construct JORN (Jindalee Operational Radar Network). Contract requires Australian production of more than 70 per cent of the contract value.
1991	DSTO involved in first UN Special Commission inspection team to the Gulf to investigate Iraqi chemical weapons facilities (June).
1991	Dr Mark Anderson invents STUBS, a computer security program, precursor to the Starlight program.
1991	Defence Minister's Achievement Award presented to Dr David Oldfield for research into anechoic materials to make the Australian Collins class submarine harder to detect.
1991	WSRL abolished to leave four laboratories in DSTO.
1992	Minister for Defence Personnel Gordon Bilney launches LADS. Ceremony marks completion of its manufacture and installation in a Fokker F27 aircraft, and beginning of optimisation trials and acceptance tests program (28 January).
1992	Seamark marine dye licensed to Melbourne-based company Pains Wessex Australia Pty Ltd to develop, manufacture and market the technology world-wide.
1992	DSTO and Australian company ADI Limited, sign licence agreement to further develop AMASS technology.
1992	The UK-Australia Tropical Research agreement terminated.
1992	Invention of Starlight, a unique, world-first system that allows users of secure computers to access insecure networks, such as the Internet, without compromising their own security. Dr Mark Anderson, principal inventor.
1992	Defence Minister's Achievement Award presented to Dr Stuart Anderson for his contribution to the Jindalee over-the-horizon radar, particularly its ocean surveillance and meteorological capabilities.
1992	DSTO signs a licence agreement with Melbourne-based Mackay Consolidated Industries Pty Ltd to develop, manufacture and market DSTO's tracked vehicle elastomer and associated technologies.

1992	DSTO's Dr Tom Ryall and Dr Albert Wong conduct pioneering research and develop FAST (Focal-plane Array for Synchronous Thermography), an infrared camera system designed for analysing stresses in metal and composite structures. First of its type in the world.
c. 1992	DSTO and AWA Defence Industries develop to concept demonstrator stage the ALR-2002 Radar Warning Receiver — first such complex receiver to be designed and built in Australia to meet the RAAF's operational requirement for a replacement radar warning receiver for the F-111 aircraft. Developed over a period of 15 months.
1993	AMASS enters service with the Royal Australian Navy.
1993	Royal Australian Navy accepts LADS for operational use (8 October). LADS system ahead of any other comparable system in the world.
1993	DSTO contributes to drafting the final text of the United Nation's Chemical Weapons Convention 1993.
1993	Asynchronous Transfer Mode launched at DSTO open day, Salisbury, when words and video images swapped over an optical fibre link between Salisbury and Telecom Research Laboratories (30 November). Link ultimately extended to Canberra and Sydney. ATM research becomes key part of the Defence Organisation Integrated Communications (DORIC) program.
1993–2003	DSTO plays a highly significant role in the 'get well' and 'fast track' programs for the Collins class submarines during construction. Includes research in areas such as noise reduction; signature reduction; high strength steel and welds; combat systems; shock trials; failure mechanisms for hoses; batteries; closed loop degaussing system; towed arrays; submarine acoustic transitory event processing system; the diesel engine; sonar systems; hull damage; flare trajectory; air quality; and smoke modelling.
1993	Defence Minister's Achievement Award presented to Dr John Ritter for his contribution to the development of high performance steel and welding techniques for the Collins class submarine.
c. 1994	Armed Forces Food Science Establishment becomes known as Defence Food Science Centre.
1994	ARL and MRL merge to form the Aeronautical & Maritime Research Laboratory (AMRL). Surveillance Research Laboratory and Electronics Research Laboratory merge to form the Electronics & Surveillance Research Laboratory (ESRL), leaving only two laboratories in DSTO.
1994	Department of Defence and AWA Defence Industries sign licence agreement for Nulka Active Missile Decoy (January).
1994	Minister for Defence receives DSTO's first royalty payment of $250,000 from Helitech Industries Pty Ltd for composite bonded repair technology (April).
1994	Vision Systems buys BHP's share of LADS business and establishes its subsidiary, LADS Corporation, to operate and maintain LADS under contract to the Australian Defence Force and to hold the licence to exploit the LADS technology commercially on the international market.
1994	Project name of AuSAR changes to 'Ingara', an Aboriginal word for 'long way'. Ingara system used for first time in a military exercise and the following year used during Exercise Kangaroo 95.
1994	Defence Minister's Achievement Award presented to Mr Brian Andrews for his contribution in leading the development of the Defence Organisation Integrated Communications program.
1994	Research begins into the DSTO-developed computer software tool MEXANS (Maritime Exercise Analysis System).
1995	DSTO opens new facility at Stirling, W.A.
1995	Helitech Industries Pty Ltd, in collaboration with DSTO, develops a composite bonded repair for the United States Air Force C-141 Starlifter heavy transport aircraft.

1995	Full-scale testing of major components of F/A-18 Hornet commences at Fishermans Bend under The International Follow-On Structural Test Project, a joint venture between Canada and Australia. On completion, 24,000 hours of test 'flying' had been carried out in a specially designed rig that duplicated the stresses and loads that an F/A-18 Hornet would experience in real flight.
1995	AWA Defence Industries (later taken over by BAE Systems) signs an exclusive agreement with DSTO to assess the worldwide market potential for Kerkanya technology. Soon thereafter, AWADI acquires the rights to commercialise the technology of the DSTO glide bomb design.
1995	United States Navy acquires AMASS system (mid-1995) and begins trials under the United States Foreign Comparative Test Program.
1995	Defence Minister's Achievement Award presented to Dr Thomas Ryall and Dr Albert Wong for their pioneering research into thermoelastic stress analysis. The DSTO researchers were able to show that Kelvin's theory that had existed since 1853 was incomplete.
1996	Australia signs a Memorandum of Understanding with the United States Navy on the joint production of Nulka decoys for Royal Australian Navy for use on its FFG and ANZAC class ships.
1996	Royal Danish Navy acquires AMASS system (early 1996) — becomes the first European country to do so.
1996	DSTO enters into a 10 year licensing agreement with Telstra Applied Technologies to develop and commercialise high frequency surface wave radar system — also involves AWA Defence Industries and GEC Marconi Systems. Advanced trials held in Darwin in 1998.
1996	Starlight technology licensed worldwide to Tenix Group which later forms the company Tenix Datagate to commercialise the products.
1996	Work begins on Theatre Broadcast System (TBS) one of first 'Compact Receive Suites' designed and developed at DSTO and built by Scientific and Engineering Services.
1996	Shapes Vector, a prototype system to detect intrusions into computer networks, invented. Principal inventor Dr Mark Anderson.
1996	Defence Minister's Achievement Award presented to Mr John Curtin for his contribution to improving the operational capability of the RAAF's Orion fleet with the development and installation of one of the world's most advanced ESM (electronic support measures) systems, the ALR 2001.
1996–1997	DSTO's Brian Rebbechi carries out work into gearbox condition analysis on the Aircraft Mounted Auxiliary Drive (AMAD) gearbox of the F/A-18. His work leads to the redesign of the gearbox, ultimately saving Royal Australian Air Force and United States Navy millions of dollars in operational costs.
1997	Defence Food Science Centre becomes known as Defence Nutrition Research Centre.
1997	DSTO Salisbury complex rationalised and new ESRL Headquarters (incorporating the Knowledge Systems building) officially opened.
1997	RLM Management Company, a 50:50 joint venture of Lockheed Martin and the Tenix Group (formerly Transfield Defence Systems) assumes full management responsibility for the JORN project.
1997	First three Kariwara towed arrays delivered by industry: one for further trials and development, other two for trials with the first two submarines of the Collins class.
1997	DSTO and Australian Defence Force sign alliance agreement with Thales Underwater Systems Pty Limited (TUS) to exchange information on sonar systems technology and trends. Alliance benefits Collins class submarine and the TUS Spherion B anti-submarine sonar aboard the ANZAC frigates.
1997	DSTO develops a Long Range Ultraviolet (UV) Stimulator for electronic warfare testing and training by the Australian Defence Force.

1997	Defence Minister's Achievement Award presented to Mr David Graham for leadership management and technical expertise during the International Follow-On Structural Test Project (F/A-18 fatigue test).
1998	DSTO develops Rain Gear using a DSTO-developed fabric. Worn over a soldier's normal clothing, the Australian-made Rain Gear permits a soldier to keep dry in the rain whilst allowing perspiration to be freely evaporated into the outside environment. Technology transferred to Australian industry.
1998	New-generation LADS MkII, built by Vision Systems in a $24 million research and development program, commences commercial operations.
1998	DSTO licenses Long Range Ultraviolet (UV) Stimulator technology to Elettronica Systems Ltd, and Australian company, Vision Abell (now part of Tenix Defence Systems Pty Ltd).
1998	Defence Minister's Achievement Award presented to Dr Mark Anderson for work in information security.
1999	DSTO and BAE Systems sign a technology licence agreement for Anti-Ship Missile Simulation Software incorporated into a Nulka Tactics Generation Model.
1999	Nulka in full production by May for Royal Australian Navy, United States Navy and Canadian Armed Forces.
1999	Contract to provide JORN to the Commonwealth novated from Telstra to RLM Management Company (October).
1999	Licence for gearbox vibration monitoring technology bought by American company Chadwick-Helmuth, world's largest producer of aviation vibration analysis equipment. Licence allows Chadwick-Helmuth to commercialise DSTO technology and market the product worldwide.
1999	High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) Project Arrangement (PA) signed. Negotiated under the auspices of the Deutch-Ayers Memorandum of Understanding, the PA authorised the joint development and testing of the Global Hawk HAE UAV system which included the implementation of new sensor and system capabilities for maritime surveillance and improved mission flexibility based on DSTO research and advice.
1999	Defence Minister's Achievement Award presented to Dr Ian Doherty for research leadership and personal contributions toward the development of secure communications systems for the Australian government.
Late 1990s	Project Arrangement 10 (PA-10), a bilateral research, development and engineering program undertaken between Australia and the United States Army on aircraft survivability begins. One of the largest defence research and development projects undertaken between the two nations and extends over a period of six years.
2000	The P-3 Service Life Assessment Program, a major international collaborative effort involving DSTO, commences at Fishermans Bend. The program involves full-scale fatigue tests and associated analysis on the complete P-3 Orion aircraft. The data provided will enable the RAAF to safely manage the structural integrity of the fleet until the planned withdrawal date of 2018.
2000	Tenix Defence Systems Pty Ltd acquires Vision Systems' defence business, including LADS Corporation, and company renamed Tenix LADS Corporation Ltd in June.
c. 2000	Starlight Interactive Link products first in Australia to obtain formal certification to the highest security standards possible (E-6 level) under Department's Australasian Information Security Evaluation Program and in 2000 were one of only a handful of products in the world to have achieved this standard.
c. 2000	DSTO designs and builds a military imaging laser radar, known as LADAR, as a concept demonstrator for battlefield surveillance — emerges from the highly successful LADS (Laser Airborne Depth Sounder) technology.
2000	Royal Society of Arts Hartnett Medal presented to Dr David Warren in recognition of his work as inventor of the black box flight recorder.

2000	Defence Minister's Achievement Award presented to Dr Chris Norwood for his outstanding scientific leadership and his contribution to the management and control of noise and vibration in maritime platforms, particularly the Collins class submarine.
2001	DSTO Salisbury becomes known as DSTO Edinburgh.
2001	Royal Aeronautical Society Lawrence Hargrave Award presented to Dr David Warren and his team — Ken Fraser, Lane Sear and Dr Walter Boswell — in recognition of their work on the black box flight recorder (February).
2001	Global Hawk makes international aviation history by successfully completing the first non-stop flight across the Pacific Ocean by an autonomous aircraft. Flies from Edwards Airforce Base, California, and arrives at RAAF Base, Edinburgh, South Australia, on 23 April 2001. Remains in Australia for six weeks where its system is integrated with a DSTO-developed ground station to allow Australian operators to control aspects of the Global Hawk sensor operations and to analyse the imagery data collected by its sensors while flying around Australia.
2001	DSTO, Royal Australian Air Force and the Institute for Aerospace Research, National Research Council, Canada, jointly awarded the Von Karman Award by the International Council of the Aeronautical Sciences for the F/A-18 Hornet fatigue project under The International Follow-On Structural Test Project.
2001	Within a six-week period, DSTO designs and develops desert camouflage uniforms for Australian troops being deployed to Afghanistan. The suits rolled off the production line with three days to spare. Technology transferred to industry.
2001	Defence Minister's Achievement Award presented to Dr Jackie Craig for outstanding contribution to the development of the Australian Defence Organisation's imagery capability, and leadership of Global Hawk project.
2002	DSTO and Tenix sign a Technology and Product Licence, ensuring Tenix Industries' access to Starlight technology up to at least 2012.
2002	DSTO restructured, resulting in three laboratories: Platforms Sciences Laboratory, Systems Sciences Laboratory and Information Sciences Laboratory.
2002	Defence Minister's Achievement Award presented to Dr Graeme Egglestone for introducing a range of world-leading protective combat clothing for Australian soldiers.
2003	Phases 3/4 of fully-fledged JORN Defence network operationally released to Royal Australian Air Force by contractors on 2 April 2003 and formally accepted in May 2003.
2003	Tenix LADS Inc, the United States subsidiary of Tenix LADS Corporation, signs a US$12 million contract with the US National Oceanographic & Atmospheric Administration to survey territorial waters around Alaska.
2004	Defence Minister's Achievement Award presented to Dr Todd Mansell for his work in information fusion, network centric warfare experimentation and combat systems engineering, especially in assisting Navy and DMO in the acquisition and replacement of the combat system for the Collins class submarine.
c. 2004	High frequency surface wave radar technology further developed by Daronmont Technologies as Surface-wave Extended Coastal Area Radar (SECAR) and formally accepted by Australian Government for trial.
2004	H.A.Wills Structures and Materials Test Centre officially opened at Fishermans Bend.
2004	CBRN functions transferred from Maribyrnong to Fishermans Bend.
2004	Torpedo Systems Centre and Maritime Experimentation Laboratory opened at DSTO Edinburgh.
2004	DSTO and other Publicly-funded Research Agencies (CSIRO, Geoscience Australia, ANSTO) sign agreement to collaborate on counter-terrorism R&D projects.
c. 2005	DSTO and Melba Industries develop a lightweight Chemical Biological (CB) suit suited to hot and humid environments and meeting the Australian Defence Force requirements for durability and functionality.

2005	DSTO and BAE Systems, manufacturer of the RAAF's Hawk Mk127 Lead-In Fighter, enter a commercial business agreement to conduct comprehensive fatigue testing on the aircraft. To be the largest full-scale fatigue test ever conducted by DSTO, the testing is being conducted at DSTO's H.A. Wills Structures and Materials Test Centre at Fishermans Bend.
2005	Starlight Interactive Link granted highest possible level of security certification by the National Information Assurance Partnership in United States; first time that any security device receives Evaluation Assurance Level 7 certification.
2005	Secretary of Defence Award for Achievement presented to Paul Amey for his exceptional contribution in the transitioning of the Jindalee radar capability into the broader Jindalee Operational Radar Network (JORN) system.
2005	Secretary of Defence Award for Achievement presented to Owen Williams for outstanding performance in developing tools and techniques for the design and testing of infrared systems and missiles.
2005	CDF/Secretary's Environment and Heritage Award (inaugural) presented to John Lewis and his team for their work in antifouling paints for the Navy. 'The team's success in developing a replacement antifouling compound for use on ships' hulls is an outstanding, internationally recognised contribution to the protection of the marine environment.'
2005	Defence Minister's Achievement Award presented to Dr Tony Lindsay for outstanding contribution to defence science in the fields of electronic warfare modelling and simulation, advanced countermeasures development capabilities, and photonics. Dr Lindsay led PA-10 for six years.
2006	DSTO and Australian Shipowners Association collaborate in Commercial Vessels Biofouling Project to determine risk posed by niche area biofouling on commercial vessels.
2006	DSTO celebrates 50 years of defence science in Sydney.
2006	Ceremony held in Ottawa, Canada, to mark the conclusion of The International Follow-On Structural Test Project between DSTO Australia and Canada.
2006	Australian ASRAAM (Advanced Short Range Air-to-Air Missile) Software Support Capability (AASSC) established by DSTO in Edinburgh.
2006	Unmanned Aerial System trials undertaken over Australia's North West Shelf to test the feasibility of using such systems for maritime surveillance in the future.
2006	DSTO and US Air Force sign a $70 million agreement to advance research in hypersonic flight. The HIFIRE project, an eight-year program, is one of the largest collaborative ventures between DSTO and United States. University of Queensland and University of New South Wales at the Australian Defence Force Academy also involved.
2006	Defence Minister's Achievement Award presented to Dr Stephen Cimpoeru for his work on the ballistic protection and survivability of military vehicles.
2007	DSTO celebrates the centenary of defence science and technology in Australia.
2007	DSTO Maribyrnong closes and remaining staff relocate to Fishermans Bend site.
2007	DSTO opens new facility in Brisbane (April), principally to undertake hypersonics research. DSTO establishes a Chair in Hypersonics at The University of Queensland.
2007	Scramjet rocket launched in HyCAUSE trial, reaching speeds upto 10 Mach.
2007	DSTO HQ moves from Russell offices to new, purpose-built facilities in Fairbairn, near Canberra airport (July).
2007	Redeveloped DSTO Melbourne complex officially opened in August. One of the new buildings named after Cecil Napier Hake, first Australian defence scientist. New auditorium named after Dr David Warren, inventor of the black box flight data recorder.
2007	Defence Minister's Achievement Award presented to Dr Bruce Hinton for his work on aircraft corrosion control.

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