The State of Research in Australia: Brain Drain, University Research Funding and the Microelectronics Industry.

Dr. Chris Nicol[1]

Bell Laboratories Research
Lucent Technologies
Level 5, 15 Talavera Rd, North Ryde, 2113, AUSTRALIA
chrisn@lucent.com (+61 29352 9143)

A paper written specifically for the Prime Minister's Science, Engineering and Innovation Council, (PMSEIC), June 2000.

This paper addresses several issues considered by the author to be crucial to the competitiveness of Australia in microelectronics research. The author has spent 10 years in pure research and is the first person to establish a privately funded pure research microelectronics facility in Australia. The author has therefore had to confront all of the obstacles for such a facility from within a major multi-national corporation.

The paper focuses on the three main issues:

1. ***Brain Drain.***
2. ***University Research and funding.***
3. ***Stimulating an internationally competitive microelectronics industry.***

Two secondary issues are also discussed and are included in an appendix for the benefit of other R&D labs in Australia.

a) Publishing as a priority for industrial R&D laboratories.
b) Connecting engineers to customers.

[1] This paper contains the opinions of the author – who is representing Lucent Technologies – and more specifically the Bell Laboratories R&D organization in Australia. None of the opinions expressed in this paper are necessarily those held by Lucent Technologies.

Lucent Technologies and Bell Laboratories

Australia has been awarded the first Bell Labs Research facility in South-East Asia.

Lucent Technologies is the world's largest manufacturer of telecommunications equipment. We have 150,000 employees world-wide, annual revenues of approximately $US 40B, and a 75 year history of R&D excellence. The heart of R&D at Lucent is the well-known Bell Laboratories division. Bell Labs, has a history of innovations including the transistor, the laser, the telecommunications satellite, the C and C++ programming languages, the UNIX operating system, the CCD, the solar battery – and many others. 11 of our researchers have been awarded the Nobel Prize – more than most countries. At Bell Labs, we make a clear distinction between research and development. Bell Labs employs 25,000 people in 24 countries and most of these have product development roles associated with our various business units. Bell Labs Research however is not associated with any single business unit – and is funded as a percentage of Lucent revenues. Bell Labs Research has over 1000 researchers, all with the Ph.D. degree. It considered by many to be the finest industrial research laboratory in the world – and is often ranked (together with Stanford University) as the most-desirable laboratory in which to conduct IT&C research.

Much of Lucent's brand-equity comes from the reputation of our Bell Labs Research activities. Therefore, as we globalise our R&D activities, considerable attention and care is given to the establishment of Bell Labs Research facilities – to ensure that the brand name and reputation of Bell Labs is not diluted in any way.

There are only a handful of Bell Labs Research centers located outside of the U.S; indeed there are only a few U.S. Bell Labs Research facilities located outside of New Jersey. Silicon Valley was awarded a Bell Labs Research group only two years ago. There are a few Research groups in Europe, one being considered for Japan and another for China. Australia was recently awarded a Bell Labs Research team that is part of a global wireless research department. This is very significant for Australia. Arguably, it represents the first time that Australians with the Ph.D. degree can obtain highly-paid industrial research positions – conducting pure research in the academic sense.

Why establish a Bell Labs Research facility in Australia?

As an international market, Australia barely makes the radar screens of most multi-national corporations. If the location of R&D centers were decided by market size (or potential market size), Australia would not have many R&D centers at all. So what factors led to the establishment of a Bell Labs Research facility in Australia?

Australia has a large, relatively untapped pool of highly qualified engineers. In contrast, it is very difficult to locate good people in other countries like the U.S., the U.K., Japan and Singapore. The reputation of the Universities in Australia is very good by international standards. Australia has economic and political stability, a work-ethic similar to the U.S. and the highest quality of life index in the world. Relative to other countries, R&D costs in Australia are quite low and the quality of the information infrastructure is world-class.

These factors alone justify the establishment of an R&D center - as already acknowledged by many multi-nationals. But a Bell Labs Research site is different. A Bell Labs Research facility must attract the best Ph.D. graduates in the world. Factors like quality of life, cost of living, salary scales, income taxes, health and education system are very important. For local content, the availability of local

Ph.D. graduates is also important. Australia is an ideal location by all these criteria. Furthermore, the research culture in Australia is very similar to that in the U.S. and is somewhat unique within the Asian region.

Brain Drain

What is it? And how does it happen?

Consider my own experience. Upon completion of my Ph.D. degree at The University of New South Wales, I accepted a position at Bell Labs Research in New Jersey, U.S.A. At the time there were very limited opportunities in the field of microelectronics in Australia. Most graduates in my field left Australia for the brighter shores of the US. Brain Drain is a major problem for Australia – it is very bad in computing fields – especially at the Ph.D. level - and it is particularly bad in my field - microelectronics. Some graduates want to leave Australia to travel and obtain international experience. Many leave Australia to achieve new heights in research labs around the world. Often they sit there watching the environment back home – waiting for things to improve. Those that are married before they leave will probably return at some point, but those that get married while overseas are less-likely to return.

Brain Retain, Brain Gain and Brain Re-gain

Brain Retain is our ability to retain our brightest graduates. Clearly, creating exciting research job opportunities is the way to keep our smartest graduates from leaving the country. These job opportunities also need to pay competitively. If we are to compete in an international market – we must compete with international pay-scales. It is not clear that this will necessarily make Australia any less-attractive for R&D. The cost of R&D will rise, but our ability to recruit the best people will also rise. (A graduate with a Ph.D. can demand a $AUS 100K salary in the U.S. but ½ of that in Australia - if they can find a job at all). These are difficult goals for us all, but they are needed to achieve Brain Retain.

Brain Gain is our ability to attract the brightest graduates to our shores from foreign Universities. When recruiting the Australian Bell Labs Research team I intentionally reserved one position for an exceptional US candidate. This candidate accepted a position in Australia – even though the salary was the lowest of all his offers (he had competing offers from IBM, Intel and U.S. Universities). This candidate understood that a position in Bell Labs Research in Australia was going to accelerate his career into the international spotlight. This has demonstrated to US executives that a Research laboratory in Australia is capable of recruiting the best people from the toughest market (the U.S.A.) and still operate at 2/3 the cost.

Furthermore, word is now travelling around the top US schools that there is something hot happening in Australia (coupled with the Olympics and other obvious attractions). We are now receiving resumes from Ph.D. graduates from a number of leading US colleges. This is Brain Gain.

Brain Re-Gain is our ability to attract Australians that have previously left the country to return home. We have received a few resumes from Australians living overseas. Although we can offer very interesting work, the salaries are still comparatively low. It is difficult to convince someone to take a 50% pay cut. I suspect there are many Australians around the world – maintaining their

citizenship in the hope that the right environment will open up thereby creating the right opportunities for them to return.

To facilitate the process of Brain Re-Gain, a Government-maintained database (www site) could be established containing the resumes of Australians working overseas. Access to this database could be made available to R&D centers in Australia who could also use the site to advertise R&D opportunities in Australia.

Achieving Brain Retain, Brain Gain, Brain Re-Gain are goals that Australia should be aggressively pursuing if we are to be competitive in the information-based economy of the future.

University Research

Australia has the best Universities in Asia. A 1998 survey in Asia-Week magazine ranked all of the Universities in Asia (including Japan, China and India). Australia had 5 out of the top 15 Universities when ranked by reputation, and 4 out of the top 15 Universities when ranked by research output. Australian Technical Institutes were equally highly ranked.

There is no doubt that international competitiveness in science starts with Universities. If we are serious about establishing a "Silicon Valley" in Australia – we should invest heavily in University research, Co-operative Research Centers and other initiatives that help to transfer research into successful start-ups.

Another issue is that Universities need to pay their academic staff at levels that are competitive with their industry and international academic counter-parts. To achieve internationally competitive research – we need to compete internationally for the best researchers and this means paying them well, providing them with adequate funding – and then the right environment to enable their research to be transferred into competitive products.

We also live in a world of stock options. In the US, it is rapidly becoming the only way to keep people for more than 12 months. So how do Universities plan to compete with this? It should not be surprising that University academics want to be rich, know what is happening in the world, and have many good ideas, and if given the right environment, they will create start-up opportunities.

Universities should plan to have a high turnover of academic staff rather than maintain the tenure system. Universities should instead offer some incentive scheme to keep their best teachers. Like other "traditional" research institutions (Bell Labs, DSTO and CSIRO) Universities need to plan – and *potentially even encourage* - a high turn-over of academic research staff. For example, Bell Labs has a program where researchers with an exceptional idea for a startup can venture out to start a company with seed funding from the corporation and continue to draw a salary for some time until the company gets going. Australian Universities could have similar programs. This will stimulate start-up environments in the vicinity of the University.

There are many examples of this type of activity. The most notable is Stanford. The city of San Jose owes its existence to Stanford University – as does the whole Silicon Valley story. Professors in Stanford are continually creating successful start-up companies. They keep their professor's chair (and therefore create future employees for their startup company by supervising students) while also founding a company. When the company is successful, they leave the University and buy a big house in the hills. There are many examples - the founder of RAMBUS is Prof. Mark Horowitz at

Stanford. The founder of Broadcom is Prof. Samuelli of U.C.L.A. Samuelli recently donated $50M to U.C.L.A and other Californian Universities. It is getting to the point where a Professor is doing something wrong if they don't have a multi-million dollar startup brewing on-the-side.

Of course we also need the right venture capital environment to support these activities.

I suspect that there is a trend to cut-back on University funding in Australia. Why would any country that plans to play a key role in the information economy cut back it's funding of University research? Why would Australia reduce its commitment to funding of IT&T and Communications areas in the CSIRO? There are so many problems that need to be solved – so many IP-generation opportunities that can translate into revenue-generation. It is also an unacceptable argument that Universities and other research institutions should not compete with industrial research. It is true that in the competitive world of IT&T, industrial research is often exceptional and difficult to compete with. However monopolies breed mediocrity and complacency. Where would we be if U.C. Berkeley and Stanford didn't develop the Reduced Instruction Set Computer (RISC) computer architecture? IBM had already invented it and shelved it because it competed with their then-profitable mainframe platforms. Now almost every computer uses RISC in some form.

University Collaborations with Industry.

University – Industry collaborations can play a key role for small companies. Universities have the resources to solve problems that can translate into success in a small business. Such contract research is valuable to both the University and the company. This type of research is less-likely to be of great value to multi-national companies with their own R&D facilities.

There are rules in some countries that require multi-nationals to invest in local R&D. There are generally two ways to do this: a) invest in University Research and b) establish a local R&D presence. One would normally expect that establishing a local R&D team would be the preferable option for Government because it implies job creation and a deeper commitment on the part of the multi-national. Governments should therefore look favourably upon companies that are creating R&D jobs. One way to do this would be to allow these companies to enter into collaborative research grants and CRC programs with only in-kind funding. However, by cutting back on University funding, we are encouraging the Universities principally to seek cash funding from multi-nationals. It leads the Universities to pressure the companies that have R&D presence for cash support and this pressure is understood, but unwelcome.

While cash donations may seem to solve the University funding problem, it serves little purpose because it doesn't create job opportunities for the University graduates. Furthermore it has the undesirable effect of University laboratories being "locked-in" to partnerships with multi-national companies that provide their funding. From the perspective of Bell Labs, Australian Universities produce excellent R&D graduates that we would like to recruit. We understand that to be good citizens we should put something back – but this should be in the form of thesis co-supervision, guest lecturing, access to equipment and other in-kind contributions.

When approaching Universities for graduates to employ, we were often confronted with pressure to provide cash funding. If we want access to the graduates we are encouraged to fund the University laboratory to match our competition. Not all our competitors are offering research jobs in this country that prevent Brain Drain. However, if companies like Lucent Technologies are providing the

real jobs – we need more access to the Universities (and the Co-operative Research Centers) because we need the graduates.

Much of the research funding for University – Industry collaborations are also Government funded. There is a requirement that the Industry partner be in Australia. This initiative unfortunately has a major flaw. Clearly the objective is to sponsor collaborations between small companies and Universities. However, significant Government funding is also given to collaborations that involve large multi-national corporations. While this is good in principle (especially if the industry partner is creating job opportunities for the graduates), it is sometimes exploited by multi-nationals that do not have a strong R&D presence in Australia.

So why would the Australian Government sponsor University – Industry collaborations if the industry partner has no Australian R&D presence related to the project? This occurs when a Professor applying for a grant can collaborate via a regional sales or marketing office of the partner. The actual research collaboration may even be with an off-shore R&D facility, and this off-shore R&D facility may subsequently recruit the graduates with the blessing of the Professor because that off-shore R&D facility is essentially funding their research – and providing graduates will likely increase the funding stream.

One way to solve this would be to exclude large multinationals from these Government-sponsored research programs. Make them employ people in R&D positions instead. Take this money and give it to University research programs. We still need ways for corporations to influence University research – by inviting or even requiring R&D managers to participate in the reviewing of University research proposals.

Cultural Issues

In Australia, Universities have low social status and we have few (if any) academic icons. We need a plan to make Australian Universities more prominent in Australian society. U.S. colleges enjoy a far greater profile in the community. Graduates are proud of their University education and advertise this on their cars but in Australia it is almost a point of embarrassment. And to do a Ph.D. must mean that you are not interested in money. Head-hunters in Australia encourage people to take post-graduate degrees off their resumes because it makes it easier to find a high paying job – or even any job at all.

Criticism of Australian Ph.D.s

Many Australian Ph.D.'s are badly managed. Often a Ph.D. is not considered a degree in Australia – but more of a lifestyle choice – where people venture out on their own to advance mankind's understanding of the world. The student attempts to define their own research topic – which is generally open-ended and tries to solve much (with the best of intentions) but then reality strikes after 6 years and the Dean tells them to submit a thesis in 6 months. The student rushes something together and the final result is often incomplete and unprofessional.

U.S. Ph.D. programs on the other hand tend to be more controlled – with careful planning by the supervisor and thesis committee. An industrial representative is important too – to guide the student through the process of delivering a piece of research on time, and on budget. The project is defined at the beginning of the program and a schedule agreed upon. All examiners sign to say that they

agree with the project, the goals, and the schedule. All the student needs to do is carry out the experiments, produce the publications and defend the thesis. The thesis is essentially a done-deal before it commences. One drawback with the U.S. system is that it does not provide much room for the student to explore other research interests and grow as a researcher – it is treated like a degree – and after all, that is all it is.

The Microelectronics Industry

Australia has no perceived presence in the trillion-dollar microelectronics industry. A common misconception is that it requires Billions of dollars of investment in integrated circuit manufacturing facilities. This is not true at all. The future power-houses of the microelectronics industry will be those without fabrication facilities. They will have the best people that design the integrated circuits. A corporation's greatest asset is its employees. The job market is so competitive in the US, that brain drain in the microelectronics industry will only continue to get worse unless we start competing.

Simply put, a microelectronics industry is the bricks-and-mortar of the information economy. It is the first point in most technology value chains and where the very high margins can be achieved. Australia has the expertise but it is rapidly diminishing due to the shortage of good people in the US. The lack of an industry has reduced the training in microelectronics at Universities. The situation is so critical that we risk losing any chance of getting back into the microelectronics industry at all. This would be a great shame because Australians have had a significant impact in this industry[2].

What are the really high-growth opportunities in microelectronics?

Right now there are huge opportunities in the global microelectronics industry. Key high-growth areas are:

1. Internet technologies
2. Embedded systems and sensors
3. Wireless Technologies

Internet Technologies

As the use of the internet grows – so too will the internet itself. And very few people really understand what the internet is. Other than connecting a computer to an ISP and starting a browser – most people have no idea how the internet works. There are probably no more than 1000 people in the world who know how to make the components (i.e. the microelectronics components) that make up the internet infrastructure. And these people currently work for less than a handful of companies. They make the bricks-and-mortar of the internet. And the bandwidth requirements of the internet do not scale linearly – because the internet is constructed in a hierarchy. Increase the bandwidth into

[2] Few may know that the text-book on the shelf of every IC designer at Intel, Motorola, Texas Instruments, IBM, and in the hands of every student studying IC design, was written by two Australians. Every time a microprocessor, modem, mobile phone or any other digital arithmetic IC multiplies or adds two numbers – it uses techniques invented by Australian academics. The so-called Third Generation (3G) mobile phones in the near-future will use techniques invented by Australians to achieve data transmission of near-optimal quality. To name just a few …

peoples homes, and the bandwidth required in the backbone of the internet explodes. In such a high-growth industry, it is not too late to build expertise in this area and start securing market share. These technologies require comprehensive understanding of signal processing, fiber optics and microelectronics. Australia is well-positioned to do this.

Embedded Systems and Sensors

It is estimated that every person interacts with as many as 25 different microprocessors every day – only one of these is likely to be in a desktop PC. The growth of companies like Intel that manufacture microprocessors for computers is likely to slow-down in the future – and the growth of companies that manufacture embedded systems is likely to explode. The performance of ARM's stock (ARMHY:NASDAQ) is representative of this. The next silicon giants will be those that make miniature computers that assist with every aspect of our daily lives.

Wireless Technologies

Technologies that provide us with the information we need – on an anywhere, anytime basis will become common-place in the future. The foundation of these technologies will be silicon chips that process wireless signals. This includes mobile phones that offer data services, wireless networks, wireless PDA connectivity etc. In these systems, the value chain always starts with the silicon chips. It is here that the advanced signal processing techniques will be needed. To be successful in these markets, companies will be searching the world for highly skilled engineers that have a combination of signal processing communications and microelectronics skills. Once again, Australia is generating many graduates in these fields – we either find ways to keep them – or they will leave.

Getting it going!

There are a few issues that we need to address before we can get a microelectronics industry started in Australia: the shortage of talent, the prohibitive cost of CAD design tools, and the right venture capital environment.

The shortage of talent can be solved by Brain Retain, Brain Re-Gain and even more Brain Gain as well as stimulating the microelectronics training programs in Universities. Our Universities already have comprehensive "Computer Engineering" courses that produce graduates that are ideal for this industry.

Knowing how to design chips is no-longer sufficient. Today, graduates need a mix of skills – including communications engineering, signal processing, computer architecture, programming and software development. There is a massive shortage of these types of engineers in the U.S. – and it is these engineers that we should continue to create. Australian Universities had the foresight to recognise the need for these skills and were among the first to offer computer engineering degrees – but the high-paying opportunities for these graduates are mostly found overseas.

The cost of microelectronics CAD tools prevents small companies and design teams from entering into the microelectronics industry. CAD tools are the software systems needed to design a computer chip. Whereas it costs about $US 100K to fabricate a computer chip, it will cost almost $1M per person to design it (and only $US 100K of this is the cost of the employee). A small design team in Australia is unlikely to be able afford this. Universities are also unlikely to be able to afford these

design tools. It is unfortunate that Australian graduates are likely to miss-out on an essential part of their training – the use of advanced CAD design tools.

Another problem is that although the tools cost a fortune to license, you tend to only need them for small periods at a time. A small company designing 1 chip per year would only use some of these CAD tools for about 2 months of the year. The rest of the year – the license would not be needed.

A proposal that the Australian Government should consider supporting is for the non-profit Australian Microelectronics Network (AMN). The idea of the AMN is to collect the licenses of these CAD design tools into one place (the AMN is proposing to establish and maintain this pool with funding from the Government). The AMN will rent them out to small design teams on an as-needed basis (i.e. 2 months per year). This will help reduce the cost of getting a design team started – and therefore help to establish an industry.

To demonstrate our support for this initiative, I am planning to make our CAD tools available to the AMN free-of-charge – so that the AMN can rent these out to small design teams in Australia at very reduced rates when my team is not using them. I am also encouraging other multi-nationals with design teams in Australia to do the same. Although the AMN offers little near-term benefits to multi-national R&D facilities (that have their own CAD tools), it makes sense for multi-nationals to assist with any program that helps to grow the industry.

Unfortunately, Government funding of these types of initiatives requires equal support from Industrial partners before being approved for funding. The AMN is finding it difficult to obtain industrial partners for this initiative because the AMN is attempting to establish the industry in the first place. It is difficult to find industrial partners if there is no industry.

Establishing the right venture capital environment is crucial to establishing a high tech industry of any kind. The government already has incubation programs which are a step in the right direction – but we also need to provide additional funding for promising startups that need to grow – to prevent them heading to the U.S. for venture capital. If we invest in the research, we should make sure that the benefits of the Intellectual Property (IP) stay in Australia. This means stimulating the venture capital to support startups with potential.

Getting into the Microelectronics Industry.

Consider an Australian startup company called Radiata Communications (a competitor of ours[3]). This company makes chips for high-speed wireless networking and is positioned well to achieve major success. Radiata was founded by Professors at Macquarie University and is staffed mostly with Ph.D. graduates from their laboratory. The model that Radiata uses – and the model which seems to be the most successful - is to establish an office in Silicon Valley. There Americans are employed to sell your products to U.S. markets with U.S. accents and U.S. business cards. All the R&D is kept in an Australian branch. Having a U.S. address also makes it easier to attract U.S. venture capital. Once the company achieves success, it can float on NASDAQ.

[3] Radiata is a competitor of Lucent Technologies, and we will do our best to compete with Radiata in the market place. However it is important to champion Australian startup companies in this report because we believe a competitive industry in Australia is a healthy industry and certainly better than no industry.

Australia should be supporting Radiata and encouraging more companies like it. We probably only need about 10 of these companies to kick-off successful self-sustaining industry. However, considering the state of the Australian microelectronics industry today, if Radiata needed to grow very rapidly, they would probably have to shift some of their R&D to the U.S.

Why an I.C. fabrication plant is not essential.

Consider Broadcom Corp, Irvine CA (another competitor of ours[4]). Broadcom was co-founded by Prof. Samuelli at U.C.L.A. with several Ph.D. graduates from his laboratory. Broadcom quickly dominated the market for chips in cable modems. This company had 350 employees the day they went public on NASDAQ in 1998. They now have about 450 employees, a market cap of $US 34B and almost no assets. But this is not to be mistaken as a *"dotcom"* company. They recruited some of the best people in the industry – and offered exceptional stock-option packages. On their IPO day, they created over 300 Millionaires. ***Broadcom do not have IC fabrication facilities*** – their chips are manufactured in Asia. This type of fab-less IC company can be done anywhere (or in any country) that you can recruit top people.

So how does a company like Broadcom attract good people?

1. Stock options for employees – the chance to get rich.
2. They publish. If you join Broadcom you won't disappear into obscurity. This model is also used by Bell Labs. (see Appendix for notes on the benefits of publishing).

Conclusion

This paper has discussed three issues: Brain Drain, University funding and the establishment (and growth) of a flourishing microelectronics industry. Brain Drain can be converted to Brain-Retain, Brain Gain and Brain-Regain by creating the right opportunities in Australia. The opportunities will be created by a self-sustaining industry and the industry will come from initiatives like:

- The Australian Microelectronics Network that provide startups the expertise and tools they need.
- Continued Investment in Co-operative Research Centers and their spin-off companies.
- Significant investment in IT&T-related research at Universities.
- Sponsoring microelectronics training and research programs in Universities.
- Abolishing government sponsored industry research grants for companies without enough R&D presence in Australia to recruit the graduates.
- Internationally competitive pay-scales for academic staff and R&D engineers.
- Incubation and Venture Capital funding programs for establishing and keeping start-up companies.
- A government – maintained database (www site) of Australians working overseas that is available to R&D centers in Australia to facilitate Brain Regain.

[4] Broadcom is a competitor of Lucent Technologies, and is championed in this report because they are one of the few startups in the microelectronics industry that do not have their own IC fabrication facilities. They therefore rely on their ability to design competitive chips. At the same time they also publish their results – making them unique as a startup.

Appendix

Publishing as a priority for Universities AND INDUSTRY.

Australian R&D groups (local and multi-national alike) need to take advantage of the enormous benefit from publishing in the international academic community. It should be a top-priority, as encouraged as patenting. Not only does it benefit the careers of the employee's that author the paper (which should be reason enough), but it also benefits the R&D group, the company and the industry in this country.

There is tremendous benefit in having an engineer presenting their best work to an international audience. It sends out a message that exciting research opportunities exist in Australia. It also promotes the careers of the engineers in the international community – and keeps the option of a University academic career available for the employees.

Some corporations prefer to encourage "internal publications". These do not benefit the employee or the country to the same extent as external publications. To work for such a company is to disappear into obscurity. Often the main reason companies discourage external publications is because it makes their engineers available as targets for head-hunters. However a company that promotes the careers of its employees is likely to attract more people by publishing – particularly if they pay their engineers well. The employees will be happily promoting their company as an exciting place to work. Another common reason for discouraging publication is to protect proprietary information. This argument is also flawed. The intellectual property should be protected by patents prior to publication. Any competitor that relies on your publications to find out what you are doing is likely to be too far behind to be worth worrying about. Furthermore, the thought of publishing encourages engineers to seek the best solution to a problem because it must stand-up against public scrutiny by their peers. In the US it has been discovered that many defense projects (which are not published for security reasons) are often very technically disappointing when finally made public.

Lucent Technologies gets significant benefit from the brand equity of Bell Labs that has been built up from over 75 years of research excellence. This commands a level of respect among our academic peers and this is why Bell Labs is such a desirable place to conduct research. Publishing forces our engineers to remain up-to-date. An engineer must know the literature intimately to determine if the work they are doing is publishable.

Connecting Research to Customers

Australian companies have yet to discover the tremendous selling power of research engineers. Engineers as a rule will do almost anything for a free shirt, a free hat, a free meal or the opportunity to talk about their work. The last point is particularly potent. Customers enjoy listening to research engineers discussing their research with passion. The customer feels like they are doing business with people that love what they do – that will therefore go the extra mile to serve their needs to the best of their ability. Another advantage is to demonstrate to the customer that their future needs are taken care of – that the business relationship will therefore be long-lasting and productive. It also forces the research engineers to come down from their ivory towers and interact with the real people that keep them employed – and learn about their specific needs.

The following slides are included for the benefit of other R&D Groups in Australia .

Bell Laboratories

Lucent Technologies
Bell Labs Innovations

– "If you won Nobel prize in IT&T - enabling you to join any Lab in the world - where would you go?" †
  1. Stanford University
  2. AT&T Labs
  3. Lucent Bell Labs
– 75 Years of research excellence
– 11 Nobel Prizes
– 3.5 patents awarded every working day
– Inventions that have helped to shape the modern world
  • The Transistor
  • The Communications Satellite
  • Cellular Mobile Communications
  • The Laser + Optical Fibre Communication
  • Unix Operating System
  • C/C++ Programming Languages

† Business Week Survey of Academics: http://www.businessweek.com/1997/25/b353221.htm

Bell Labs - We have both Research and Development

Lucent Technologies
Bell Labs Innovations

Bell Labs Development

- R&D Arm of Lucent Technologies
- 24 000 employees in 24 countries
  - **~ 160 in Australia** Hardware + Software

Bell Labs Research

- 1000 Researchers - all Ph.D.s
- Research groups in US (NJ), UK (20), Netherlands (8) , Germany (20), **Australia (5)**
- Opening Groups in China and Japan.

Asia's Best Universities

Lucent Technologies
Bell Labs Innovations

By Reputation

By Research Output

Lucent Technologies
Bell Labs Innovations

Top Universities '99

By **Reputation** (best 14)

1. University of Kyoto (20 out of 20)
2. National University of Singapore (19.77)
3. **Australian National University** (17.96)
4. Seoul National University (19.55)
5. **University of Melbourne** (19.38)
6. University of Hong Kong (18.96)
7. Taiwan University (18.87)
8. **University of Sydney** (18.18)
9. Waseda University (17.78)
10. **University of New South Wales** (17.49)
11. Keio University (16.99)
12. University of Auckland (16.44)
13. **University of Queensland** (16.37)
14. Tohoku University (16.28)

Australia: 5 Japan: 4 Taiwan, Korea, Hong Kong, Singapore, NZ: 1 each

Source: Asia-week, May, 2000. Universities rank each other.

Lucent Technologies
Bell Labs Innovations

Top Universities'97

By **Reputation** (best 14 out of 65)

1. University of Tokyo (20 out of 20)
2. University of Kyoto (18.65)
3. University of Melbourne (17.96)
4. Australian National University (17.79)
5. National Taiwan University (17.51)
6. National University of Singapore (17.32)
7. University of Hong Kong (17.12)
8. Seoul National University (17.09)
9. University of Sydney (16.69)
10. Keio University (16.41)
11. University of New South Wales (16.39)
12. Waseda University (16.11)
13. University of Auckland (15.97)
14. Monash University (15.42)

Australia: 5 Japan: 4 Taiwan, Korea, Hong Kong, Singapore, NZ: 1 each

Source: Asia-week, May 15, 1998. Universities rank each other.

Lucent Technologies
Bell Labs Innovations

Top Universities'97

By **Research Output** (best 14 out of 65)

1. Tohoku University (10.50 out of 20)
2. University of Tokyo (10.34)
3. Australian National University (9.16)
4. University of Melbourne (9.41)
5. University of New South Wales (9.38)
6. National University of Singapore (9.16)
7. Seoul National University (8.46)
8. Yonsei University (8.27)
9. University of Hong Kong (8.25)
10. University of Adelaide (8.17)
11. University of Western Australia (8.12)
12. National Cheng Kung University (8.01)
13. University of Sydney (7.73)
14. Kyoto University (7.42)

Australia: 6 Japan: 4 Taiwan, Korea, Hong Kong, Singapore: 1 each

Source: Asia-week, May 15, 1998. Based on **published articles per faculty** in International Academic Journals (all disciplines)

Top Technical Colleges'97

By **Reputation** (best 10 out of 30)

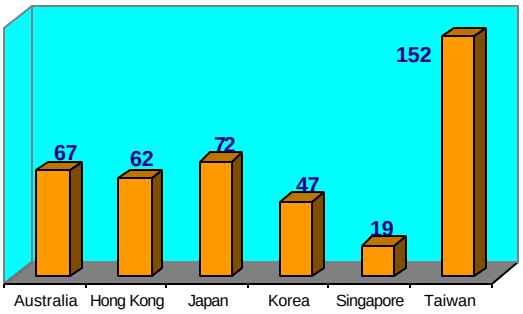
1. University of Science and Technology (China) (20 out of 20)
2. Korea Advanced Institute of Science and Technology (19.09)
3. Curtin University of Technology (Australia) (18.75)
4. Indian Institute of Technology (Delhi) (18.50)
5. University of Technology (Sydney) (18.33)
6. Royal Melbourne Institute of Technology (18.33)
7. Science University of Tokyo (17.27)
8. Nanyang University of Technology (Singapore) (17.27)
9. Pohang University of Science and Technology (Korea) (17.22)
10. Queensland University of Technology (Australia) (16.88)

Australia: 4 Korea: 2 China, India, Japan, Singapore: 1 each

Source: Asia-week, May 15, 1998. Universities rank each other.

Publications

International Journal Publications from Universities



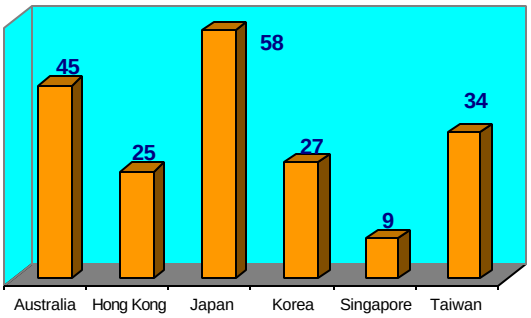
Microelectronics and Computer Science Journals.

From a study of IEEE Journals 1996 and 1997: JSSC, JSAC, CAS I&II
1997 Transactions on Computers, Software Engineering, PAMI, Parallel & Dist Systems, Visualization, Knowledge and Data Processing. ACM Wireless Networks 96-98

Publications

Lucent Technologies
Bell Labs Innovations

International Conference Publications by Universities



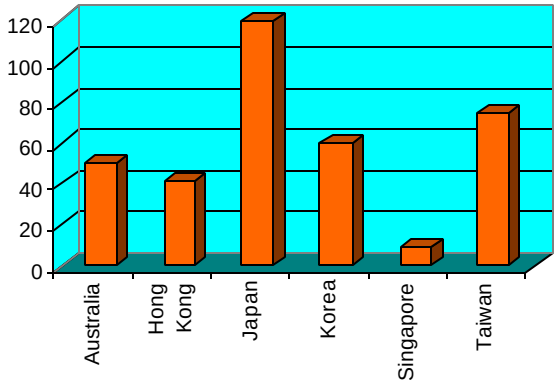
Microelectronics and Digital Signal Processing Conferences.

From a study of IEEE conferences over 95 - 98, microelectronics and signal processing: ISSCC, CICC, VLSI Symp, ICASSP, ISLPED

Ph.D. Graduates

Lucent Technologies
Bell Labs Innovations

In communications, computer engineering and microelectronics

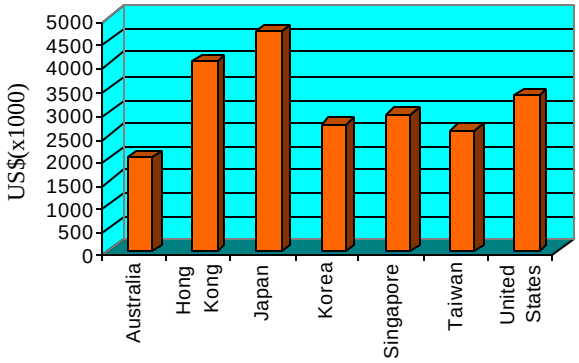


Source: Contacting each school in each University separately.

Cost of R&D

Lucent Technologies
Bell Labs Innovations

Estimated annual R&D Cost for 15-person R&D Team

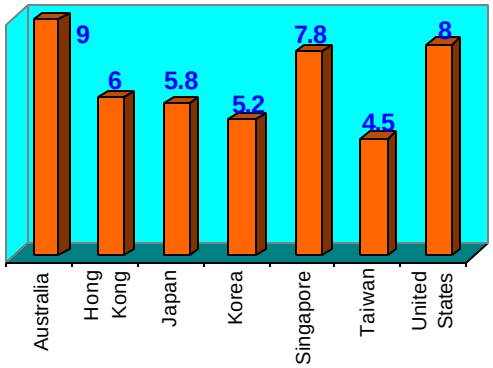


Includes:
- labor costs
- expat costs
- occupancy
- utilities
- telecomms
- misc. costs

Source: "R&D Costs and Skills Study", Report by Australian Strategic Industry Research Foundation and HayGroup August 1997. (Adjusted to fit data from BCS in USA and Australia)

Quality of Life Index

Lucent Technologies
Bell Labs Innovations



Like the US, the high quality of life in Australia and Singapore makes it difficult to hire talent out of these countries.

Source: World Economic Forum: 1997 World Competitive Yearbook - rank of 10 is best