Australian Innovation - Learning from 10 Cases[1]

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1 Introduction

1.1 Purpose of this working paper

For over 30 years, commentators have noted the apparently low rates of innovation in the Australian economy (Jones, 1982). Analyses have ranged from statements that commodity endowments so insulate the entire country from changes in the outside world that key economic actors fail to realise the importance of innovation for a developed economy, to concerns that the country gives too much focus to science and not enough to commercialization of that science (which, in itself may have more to do with the debate in the USA twenty years ago (Gomory, 1989) than empirical reality in Australia), to statements that the country is good at creating new ventures, but lacks the managerial and institutional capabilities to grow them. On the other hand, some commentators, pointing to the pre-eminence of particular sectors (e.g. mining, merchant banking, food and restaurants, specialist agriculture) suggest that the rate of innovation may be relatively high, but that Australia is so different from other countries that existing metrics do not capture its innovation.

One way to resolve the apparent contradiction of high wealth coupled with low rates of innovation, or to understand whether or not there is a problem, would be to look for the causes of this apparently low rate of innovation. If we survey the existing commentary, however, most of the causal analysis is surprisingly superficial and is based on gross international comparisons. That is, people will look at the Australian economy, compare it to a distant burgeoning economy – typically Silicon Valley -- observe obvious differences, and then claim that those differences are the source of the problem. For instance, it is common for people to note the paucity of venture capital in Australia, and immediately blame Australian investors – particularly superannuation funds – for their inability to embrace high-technology opportunities.

Such a causal analysis suffers from two problems, however. First, we don't really know if there is a shortage of venture capital in Australia (or whatever other deficiency one might wish to pick), or whether plenty of capital is available but investors cannot identify good opportunities to embrace. Second, if investors cannot identify opportunities, is it because they lack the skills to embrace high-technology opportunities, because the infrastructure to deliver those opportunities to them is not present, or is the problem that the opportunities are technically there, but certain structural factors make Australian investments particularly unattractive?

In order to get at some of these questions – or at least to work out what questions we should be asking – a team based at the Melbourne Business School decided to conduct a carefully grounded set of studies examining innovation in the Australian context. Our approach was to pick eight representative and interesting cases of innovation in Australia with a view to trying to understand how the participants went about managing innovation, where they were successful, where they weren't, and particularly, why they experienced the successes and failures they did. To those eight cases, we added two more, written by Professor Jonathan West while he was at the Harvard Business School. This working paper presents the insights we gained across the 10 cases.

Our sample frame – only ten cases selected with interestingness as an important criterion -- means that the analysis which follows cannot, in any way, be considered systematic or representative. That said, we are convinced that there are many cases like the ones discussed in this document. Given the non-systematic nature of our sample, all of the points which follow should not be considered to be conclusions about the strengths and weaknesses of innovation in Australia. Rather, the aim in writing this paper is much more to gain insights that will stimulate debate and raise questions. We hope to have two impacts. First, we aim to broaden the thinking of researchers about Australian innovation so as to help them understand areas in which Australian innovation might differ from that overseas, and consequently to identify important areas for careful systematic research with a distinctly Australian character. Second, for entrepreneurs and those who support them, the aim is to throw up some issues which may, or may not, be relevant to them. They can watch for them in their own circumstances and adjust their behaviour accordingly.

The next part of this introduction lays out the research methods used for the preparation of this working paper and locates the cases in the context of Australian innovation. Section 2 presents brief summaries of the ten cases. Sections 3 and 4 present the analysis. Section 3 considers the management of the ten ventures, and is organised in terms of six broad topics: strategy, marketing, risk management, leadership and culture, organisational design, and intellectual property management. Under all five topics, the analysis presents a theoretical framing before discussing whichever of the ten cases are relevant – either because the performance is exemplary, or because it could be improved upon in interesting and noteworthy ways. Section 4 then moves the focus from the organisations themselves to the context in which they operate. It examines four topics: boards of directors, markets, the financing environment, and other contextual issues. In that section, we will see that many of the pathologies observed within the cases appear to have their origins not in the management of the organisations, but in the broader Australian environment and the way that Australia differs from other countries. In particular, it appears that companies operating in Australia face significant additional risk. Section 5 presents concluding remarks and identifies key areas for systematic research.

1.2 Data collection

This research project has its origins in a closely related project to develop teaching materials about innovation in Australia. The teaching project, which was funded by the Victorian Government Department of Industry, Innovation, and Regional Development, was a collaborative effort between the Melbourne Business School and the Australian Institute of Commercialisation to produce 12 teaching cases about innovation in Australia. This project, which was additionally funded by the Intellectual Property Research Institute of Australia, aims to draw lessons from the research which went into the eight Victorian cases, along with International Catamaran and Proteome Systems.

In order to select the cases, a research assistant (Adam Waites) conducted an extensive set of interviews with a spectrum of people associated with innovation in Australia. He also reviewed a broad range of material which featured Australian innovation, such as Government information booklets. In addition, he reviewed all cases about innovation in Australia which he could find. This research is summarized in more detail in Appendix 1. On the basis of this research he proposed a short list of cases to a small committee comprising representatives of the Victorian Government, the Australian Institute for Commercialization and the Melbourne Business School. From that short list, eight of the ten cases below were selected. The other two cases were researched by Jonathan West while he was at the Harvard Business School. The ten cases are summarized in table 1, along with its principal researcher.

Case	**Primary Researcher**	**Brief Description**
Ausmelt	David Warwick	Company which develops equipment for smelting metals
Compumedics	Tom Greenwood	Company which develops amplifiers for use in sleeping disorders diagnosis
Computershare	Leonore Ryan	Provider of share registry and other related services to publicly listed companies
Extended wear contact lens	Peter Cebon	Project for development of contact lens which can be worn in the eye continuously for 30 days
Falcon	Peter Styles	Project to develop airborne technology for detecting gravity anomolies
GBC Scientific	Ben Thompson	Manufacturer of atomic absorption spectrometers and related scientific measuring equipment
International Catamaran	Jonathan West	Manufacturer of ocean-going catamarans for use as ferries and naval transportation
Micronisers	Tom Greenwood	Company with capacity to produce 'nano-sized' particles of particular chemical compounds
Proteome Systems	Jonathan West	Company attempting to commercialise proteomics research
Vesda	Peter Styles	Company which produces advanced smoke detection technology

Table 1: The cases

1.3 Data analysis

To extract insights from the cases, we conducted two series of workshops – some in the middle of the research process, and one at the end of the case development. The workshops held in the middle of the research process were used principally to open up research avenues within the cases. That is, by discussing the cases as a group, the individual researchers helped each other and gained insights and raised questions for their own cases. The workshops at the end of the case analysis aimed to bring the various strands together and extract any further issues.

At the workshops held during the data gathering process, the relevant researcher presented his or her findings up to that point in time to a group comprising the other researchers and some members of the faculty. The group would then discuss the case at length, drawing out themes and proposing theoretical issues the case could address and identifying new lines of inquiry.

At each of the workshops at the end of the case analysis, the author of each case presented the case to the group (all the members of whom had read the case), framing their comments in terms of the question, "What does this case tell us about innovation in Australia?" One member would then comment on, and elaborate upon, the presentation. The discussion would then be thrown open to the group, and would sometimes stay restricted to the case, but would more often range across the cases and sometimes into the researchers' experience beyond the cases. Because the team had extensive experience in innovation in Australia (see table 2), that experience could flesh out the discussion, not only in terms of elaboration of comments, but also in terms of critique and refinement. Such a methodology is appropriate if the aim of the exercise is to obtain insight, rather than to conduct a systematic analysis (Daft & Weick, 1984; Weick, 1995).

Team member	Innovation-related experience
Peter Cebon	Extensive teaching, research and consulting in innovation.
Tom Greenwood	-
Leonore Ryan	Employed as Commercialisation Officer at Monash University and secondee at Starfish Ventures (Venture Capitalists).
Peter Styles	Co-founder of Southern Innovation – a company set up to commercialize gamma ray detection equipment. Previously R&D project manager engineer with Ericsson.
Ben Thompson	Management consultant with practice in financial services innovation.
Michael Vitale	Extensive teaching, research, consulting, and governance in innovation
David Warwick	Founder of Komodo Pty Ltd, a software company.
Jonathan West	Extensive teaching, research, consulting, and governance in innovation

Table 2: Participants in the workshops at the end of the case analysis, and their innovation-related experience

The two workshops at the end of the case analysis were recorded and transcribed. The transcripts were then read and re-read to extract themes. These themes were coded using the N-Vivo Qualitative Data Analysis program using a free coding categorisation scheme. That is, the author simply attached thematic descriptors to each piece of text according to the meanings embodied in the text and his understanding of likely theoretical issues. Some pieces of text were given as many as three or four codes to cover the various themes which applied. For example, text which talked about the relationship between corporate strategy and organisational culture within a particular case would have been coded for the particular case, "corporate strategy", and "organisational culture". Where appropriate, passages were given codes that already existed for prior text, and code descriptors were changed so they could encompass prior coded material and new material. For example, the code "governance" was changed to "boards of directors" in response to material which discussed the role of boards of directors in strategy formation and the hiring of executives. Those codes were then aggregated into the meta-level categories which are used to organise this working paper: Strategy, leadership and culture, organisational design, and so forth.

A completed draft was then circulated back to the researchers, who provided final comments, not only on the draft but were also asked to comment on each of the categories and ideas in the light of their broader experience. This draft was also sent to three professors of innovation management at Australian Universities, who met with the author and made suggestions about changes, and additions, as well as adding additional perspectives. The modified draft was then sent to all the people above, and also to two people with broad, but different, innovation-related experience in Australia. They were asked to comment on the text, and particularly on the extent to which the findings resonated with their experience. On the basis of the comments of these three groups (the authors, the professors and the practitioners), the draft was modified a final time.

1.4 Locating the cases in the Australian context

One of the concerns with a paper such as this is with generalisability. Consequently, in this section we briefly locate the cases within the Australian context. In order to do that, we need to answer two questions:

To what extent are projects of this type representative of innovation in Australia?

To what extent are the cases here representatives of projects of this type?

In answer to the first question, these projects represent a very small portion of innovation in Australia. The overwhelming majority of innovations in product and process are minor and mundane, or what researchers call incremental innovations (Tushman, Anderson, & O'Reilly, 1997). The key attributes of incremental innovations is that they neither fundamentally change an organisation's capabilities nor fundamentally change the way it interacts with its markets (Abernathy & Clark, 1985). Of the incremental innovations, the overwhelming majority are so small that they are not even documented.

In contrast, the companies discussed here are generally developing fundamentally new capabilities, seeking to transform the markets in which they operate, or both. Only in one case (GBC scientific) did the company's start-up involve entry into an existing market with existing technology. The ten cases are summarized in the following table:

		Technological capabilities	
		Existing (builds on capabilities readily available)	New (develops radically new capabilities)
Market interaction	Maintain existing market (Existing category, perceived as incrementally new by customer)	GBC Scientific (early years)	GBC Scientific (later) Proteome systems
	Transform existing market (Existing category, perceived as radically new by consumer)	Computershare	Extended wear contact lens Ausmelt Falcon International Catamaran Micronisers
	Create new market (new product category)	Compumedics	Vesda

Table 3: Amount of technological and market change associated with each venture.

To answer the second question, we asked a number of people who were familiar with the history of new venture creation in Australia about the extent to which these cases were representative of scientifically-based new ventures in Australia over the past twenty-odd years. These people were generally familiar with the case ventures independent of our research. While they were hesitant to comment on the representativeness of the cases, they had no difficulty naming several organisations which were similar to the ones discussed here, and could easily name ventures that were better and worse managed.

Consequently, it is important to note that the findings presented in this working paper do not necessarily generalize beyond the ten cases presented and the broader professional experience of the project team and the commentators on the draft. Notwithstanding, given the breadth of the reviewers of the text, we are reasonably confident that the text captures important aspects of the reality of innovation in Australia.

1.5 Some important caveats on the analysis

The analysis which follows ranges beyond the published cases. There are several reasons for this:

We have brought in material from outside the cases, but from within our broader professional experience.

The researchers gathered a significant amount of data which was not included in the final case because it was outside the narrative flow, but which could be included, analytically at least, in this working paper.

There is some material which we don’t wish to attribute to particular organisations, and therefore is not included in the individual cases, but which is included here in a more disguised form.

2 Overview of the cases

2.1 Ausmelt

Ausmelt was incorporated to commercialise smelting technology developed by Dr John Floyd in the late 1960s and refined over the next ten years. Floyd's innovation involved using an upright cylindrical smelting bath with a vertical submerged lance through which gases were applied to the ore. Compared to traditional flat bath techniques, Floyd's approach was faster, contained the reaction better, produced higher quality reaction products and could deal with more difficult ore bodies. It is considered by many to be the most effective smelting technology in the world. It is, however, extremely complex (hence the 10-year development time), has to be customized to a particular ore body, and requires highly skilled operators. Furthermore, the entire smelter has to be built around the technology. It is not a modular substitute for a traditional flat bath operation within a larger smelting operation.

The company was formed when CSIRO, having supported the technology development for ten years, and having found no-one willing to buy it, terminated the project. Consequently, Floyd decided to take the project outside. CSIRO continued to market the technology (as SIROSMELT), and subsequently developed the technology further (without Floyd) and gave a license to Mount Isa Mines (MIM) (which marketed it as ISASMELT). MIM continued to develop the technology to suit its refining operations (mainly for Lead). CSIRO then gave an open licence to Ausmelt.

The company listed on the Australian Stock Exchange in 1994. It used the funds raised to explore many technical applications (about 30). However, low cash flows meant this research work had to be curtailed. Following a change in management, the company focussed more narrowly on copper smelting and a project in South Australia to use the Ausmelt technology to produce steel from low-grade SA coal and low-grade SA iron ore (the SASE project). Subsequently, the company expanded into other metals such as Platinum. With the collapse of the South Australian project, the company changed management again. More recently, the company has modified the technology to be able to reprocess spent pot linings from Aluminium smelters.

The company has been, at best, moderately successful commercially. The technology is hailed internationally as ground-breaking, and is seen as one of the most important innovations in metallurgy in the last 50 years. Dr Floyd is very highly renowned globally. The company has also managed to sell about 30 smelters. Notwithstanding, the company's cash flows have been insufficient to sustain it commercially. The company has had to fund itself by selling off its assets (particularly its interest in the SASE project) and by issuing additional equity.

2.2 Compumedics

Compumedics was co-founded by David Burton, an acoustics engineer who built sound studios, and John Murray, his doctor, who also conducted sleep research at the Epworth Hospital in Melbourne. Following a conversation during a consultation over a sore throat in 1987, Burton set about developing equipment that executed digital data capture, storage, and preliminary analysis, instead of relying on analogue chart recorders. The equipment was designed for use in the diagnosis of sleep apnoea. The first system, installed at the Epworth, was a huge success.

Burton shrunk down the system and made it portable. With this machine he penetrated the growing Australian sleep research market very effectively, and then started to look overseas. The company then successfully won contracts for a large US study examining the relationship between sleep apnoea and congestive heart failure and for sleep monitoring equipment for use in space by NASA. These high-profile uses attracted significant interest and the company expanded rapidly.

The company's first big obstacle was to develop effective distribution for its product, particularly into the U.S. market. Burton was uninterested in venture funding, public listing, or a trade sale to Resmed (an Australian manufacturer of sleep apnoea treatment equipment). Consequently, Compumedics formed distribution agreements with U.S.-based third-party distributors. All three distribution agreements collapsed within a couple of years. Eventually, the company took funding from Jafco/Nomura to establish its own distribution (which resulted in a public listing a couple of years later in 2001). To ensure their distribution channels, respond to changes in the buying behaviour of U.S. hospitals, and to broaden their product offering, they purchased Neuroscan and consolidated manufacturing in Melbourne in 2004. Neuroscan manufactured diagnostic equipment for neurological disorders, particularly epilepsy, and so the technical core of its equipment was quite similar to that of Compumedics.

Compumedics is the only company in the sleep diagnostic area globally that has not integrated vertically, either into sleep clinics, or into therapeutic equipment for sleep apnoea. Its stock price has declined, essentially monotonically, since its listing on the stock exchange. At the time of writing it was trading at approximately 10% of its price at listing.

2.3 Computershare

Computershare, the largest operator of share registries in the world, started as a partnership between Chris Morris and Ken Milner in 1978 to provide computer services to share registries. Their program, SCRIP, ran on mainframes and maintained share registrars' databases. This enabled companies to automate share registry management. Until that time, share registries were completely manual, and were run by the company issuing the shares. Major accounting companies, particularly Ernst & Young, KPMG and Coopers & Lybrand saw scale economies in share registry management, and used Computershare's software to offer registry services to their clients. By 1990, Computershare was processing 80% of Australian share transactions on behalf of these accounting companies.

The company listed on the stock exchange in 1994 and used the capital to fund a not-particularly-successful international expansion. In 1997, however, a New Zealand registry became available, and Computershare bought it, mainly to prevent competition on its home turf. Until then, it had never occurred to the management to go into the registry business itself. Once it acquired the registry, the managers saw many strategic opportunities. In the next two years, regulatory changes forced the Australian accounting firms to divest their registry businesses, and Computershare acquired the largest two (it could not acquire more without running foul of the anti-monopoly laws). It then started to look overseas. As the only company globally focussed exclusively on the registry business, it had a greater strategic interest in registries that came onto the market, and was able to run them better than potential competitors. Consequently, it had little trouble acquiring registries in Canada, the USA, the UK, Ireland and South Africa. Generally it was able to integrate these registries into its business with little difficulty.

Subsequently, the company has expanded its services to include registry-related offerings such as financial market software consulting, assistance with demutualisations and floats, analysis of data associated with share registries, polling of shareholders before company meetings or announcements to assess shareholder sentiments, design and printing of corporate materials, running Annual General Meetings, running employee share plans, and so forth. Virtually all of this expansion has been through either joint ventures and subsequent acquisition of the joint-venture partner, or through direct acquisition.

2.4 Extended Wear Contact Lens

The extended-wear contact lens is the “holy grail” of contact lenses. It can be worn in the eye for 30 days, without removal, and without causing redness, swelling, or irritation. The lens was developed by a joint venture of the CRC for Eye Technology, the CSIRO, Ciba-Vision (an Atlanta-based wholly-owned subsidiary of Novartis) and Novartis Central Research laboratories (in Basel), and represents two radical innovations – one in the design of polymers for the use of lens materials and one in the intellectual property protection strategy pursued.

It is notoriously difficult to manage joint ventures between two organisations, let alone four organisations on three continents with a potential for divisive rivalry between any given pair. Consequently, the case focuses on the process used to develop the lens. In particular, the leadership group (comprising two members of each organisation) put tremendous effort into communications, governance, and trust, so as to explore the technical space both efficiently and effectively. They divided the project into several teams which worked on different strategic approaches in parallel. Those teams were in constant electronic communication and would review their work in a telephone conference every couple of weeks. Every three months the entire project would meet for three days. At those meetings the scientists would review the work of the prior three months and discuss possible directions for the next three. The steering committee would then set directions for the next three months, and the teams would be required to adhere to those new strategic directions. Trust was managed extremely actively by a number of means including contractual arrangements which made it in each party's interest to trust, rather than not, extensive visitation between laboratories, and many symbolic acts by the senior managers in the project to indicate their trusting of each other.

In the first 18 months of the project, the teams appeared to make no progress towards the design of an effective lens polymer. In the subsequent 3.5 years they managed to develop a set of about 80 compounds which were suitable for use in a lens. This was a radical technical breakthrough. The polymers will form the basis for the next generation of contact lenses of all types. In addition to producing novel lens materials, the scientists led the patent attorneys towards a patenting strategy which was much more powerful than would have been the case if a conventional patenting strategy had been pursued.

2.5 Falcon

Falcon is a piece of equipment which is carried on a light aircraft, and is designed to detect gravity anomalies – differences in the size of the gravitational force between two locations. It is so sensitive that it can detect the gravity anomaly created by a three year-old child standing several metres from the machine. It has been described as one of the most significant developments in mineral exploration in the past 50 years.

Falcon was developed by the R&D group within BHP exploration in Melbourne. It is an adaptation of technology developed by Bell Aerospace to guide Trident submarines. The idea was that submarines could negotiate underwater obstacles (such as mountain ranges) by measuring changes in the gravitational field. Unlike Sonar, this technology would not aid detection of the submarine. With the collapse of the USSR, the US decided to create a ‘peace dividend’ by selling off the technology.

BHP identified the technology in 1991 as promising, and started a feasibility test in 1993. At that point, the project was halted because senior managers in the BHP exploration group thought that their budget should be spent on exploration, not the development of exploration technology. Other senior managers in BHP wanted the project to go ahead, so it was moved to another division. Feasibility flights were flown in late 1994, and were very successful. At about that time, Bell Aerospace decided to exit the technology, and BHP realised the US government would be unlikely to license the technology to a non-US company. So, BHP partnered with the U.S. firm Loral, and commenced the development process.

Falcon has made it practical for high-resolution airborne gravity surveying to be used in conjunction with the two other principal airborne geophysical surveying tools: magnetic and electromagnetic surveying. Each of these three different surveying techniques provides different information about the target area and when they are used in combination, there is a significant synergy. This synergy improves the ability of airborne surveying to refine the target area, reducing the amount of ground-based work which needs to be done, and thereby reducing the overall cost of exploration. With Falcon, an exploration team can survey 20,000 square kilometres in three months, whereas the same area would take two to five years using conventional ground-based technology.

The technology development was slow and difficult, but was carried out by a focussed, talented, and well organised team. The first Falcon system took to the air in December 1997. At the time of writing, there are four systems in use, but BHP was yet to announce any new mineral deposits discovered using the technology.

2.6 GBC Scientific

Ron Grey, Ivan Bartlett and Peter Charlton left Varian-Techtron to found GBC Scientific Equipment (GBC)(an acronym of their initials), as equal partners, in 1978. They manufactured Atomic Absorption Spectrometers, building on their knowledge building Atomic Absorption Spectrometers at Varian. They built the first machine in Bartlett’s garage and on Grey’s dining room table.

After an unsuccessful early distribution arrangement which almost bankrupted the company, GBC managed its own international distribution, and slowly built an international market. In 1981, Bartlett left and sold his shares. Clive Davenport joined and bought a 16.6% share. Grey and Charlton bought the remainder of the shares (with Grey buying most of them). The three partners took responsibility for different parts of the business.

Over time, the company increased the geographic extent of its markets (up to 106 countries by 2004), with a strong emphasis on emerging economies in the Middle East and Asia, particularly India. It also expanded its range of products. Until 1985, it simply produced different types of Atomic Absorption Spectrometers. In 1986, it introduced its first spectrophotometer. In 1990, 1993, 2002 it added Inductively Coupled Plasma Optical Emission Spectrometers, High Performance Liquid Chromatographs, and X-Ray Defractometers through acquisition. In 2001 it released an internally-developed Inductively Coupled Time-of-Flight Mass Spectrometer.

ICI purchased half of each partner's shares 1985. Soon after, the company was beset with internal conflicts. At one point, the board of directors was completely dysfunctional, the three non-ICI partners were not talking to each other, and the three operational areas of the company (R&D, Manufacturing, Sales) were not communicating. Sales and product quality suffered. These conflicts were resolved first with an overhaul of the manufacturing operations in 1993, which led to Peter Charlton and all his direct reports leaving the company. The R&D function was similarly restructured in 1998, resulting in a significant diminution of Clive Davenport's role. Clive left the company shortly afterwards, but kept his shares.

Between July 1997 (when ICI announced its wish to divest its shares) and January 2000 (when Grey bought ICI's shares for $1.00), conflict between ICI and the executive directors increased dramatically and sales fell precipitously. In between, various purchasers were identified, but all declined to buy the ICI share. Shortly after the divestiture (which left Grey with 92% of the shares), the company introduced the time-of-flight spectrometer to the market, and started to rebuild its market share.

2.7 International Catamaran

International Catamaran (INCAT) was founded in the 1970's by Robert Clifford, a scallop fisherman. It manufactures light-weight high-speed catamarans propelled by water jets (rather than propellers). Clifford started building and operating single-hulled ferries. TheTasman Bridge collapse gave Clifford a virtual monopoly in trans-Derwent traffic, and he invested the consequent windfall in his boat-building business. He started building 20 metre Catamarans for tourist operators, and expanded the business so that at the time of writing, the company was building boats in excess of 110m. The boats are large (one boat is larger than seven quarter-acre housing blocks side-by-side), fast (they have a top speed in excess of 40 knots), and highly manoeuvrable (the boats can move sideways and turn on their axis). When configured as vehicle ferries, they can enter a port, unload, reload, and leave again in 12 minutes. The boats are used as civilian ferries and as military logistics and supply ships.

There are only two manufacturers of large Aluminium catamarans in the world, INCAT (which is privately held), and Austal (which is publicly listed). Austal is based in Freemantle, Western Australia. In addition, Fincantieri (an Italian shipbuilder) has recently entered the market. At its peak (just before September 2001), INCAT employed 1000 people, which included approximately 1/3 of the world's Aluminium welders. The production techniques for these boats, being built of Aluminium, are much more like aircraft production than conventional ship building.

INCAT was known globally as an extremely responsive company. The company has been known to act on a request from a client to change a design within three days – with two of those being on a weekend. Such a change would require the organisation to determine whether the change is feasible and safe, design it, and have it ready for implementation. This tremendous flexibility was achieved by having a very highly skilled workforce, a very strong organisational culture, and an organisation with very limited formal structure but a very well developed informal structure. It also had an extremely good understanding of its customers and their needs, so it could anticipate the types of changes that will be requested and build a capability for them into the basic architecture of the boats.

The company's bank forced it into receivership after Sept 11, 2001 when it's debt levels rose to about 50% of the value of its equity, and it had five ships (new and used) neither sold nor leased. Although the company sold one boat within a month, and another six months later (eliminating the original debt), and secured leases for two ships from the U.S. military, its supply of orders dried up, and it eventually laid off 75% of its staff. The company's situation improved dramatically a couple of years later.

2.8 Micronisers

Micronisers was founded by a single entrepreneur, Michael Bos. In the late 1980's he developed a method for manufacturing Zinc Monoglycerate (ZMG), a substance which can be used as a nucleating agent in the manufacturing of polypropylene, and has subsequently been identified as an effective agent against Herpes Simplex Virus (cold sores). His early product, while increasing the speed of polymerization and improving the properties of the polypropylene, made the plastic cloudy. This problem could be solved my producing smaller ZMG particles, so he spent the next 10 years developing technology to mill the particles down from *micron* size ($\sim 10^{-6}$m) to *nano* size ($\sim 10^{-9}$m). This work was funded by Unilever Chemicals, under the sponsorship of Ken King, the Australian manager (who joined the Micronisers board).

Micronisers' contract with Unilever gave Unilever global distribution rights and Micronisers global manufacturing rights to ZMG. Micronsers passed the finished product to Unilever, which started to distribute it in South-East Asia. Unilever Australia hoped the global parent would pick up the product. However, Unilever globally was not in specialty chemicals, and was not interested in doing the safety and performance testing needed for global marketing. Micronisers could not afford to underwrite this testing itself. Unilever then sold its entire chemicals business to ICI. Things looked good until ICI decided it wasn't interested in specialty chemicals, and licensed its specialty chemicals business to Ciba Speciality Chemicals (a spin-out from Novartis). Under that agreement, ICI would manufacture and Ciba Speciality Chemicals would market the chemicals.

Ciba Speciality Chemicals finished testing the chemical in 2003, and took the product to market. At the time, Micronisers felt it was positioned wrongly.[2] However, Micronisers' initial contract with Unilever gave Micronisers no right to contact Ciba Speciality Chemicals directly. Furthermore, while ZMG was very important to Micronisers, and of minor importance to Ciba Specialty Chemicals, Micronisers was of trivial interest to ICI. Finally, during the research process, Micronisers discovered first, that their contract with Unilever gave it the right to exit the distribution contract on the sale to ICI, and second that Unilever had never actually transferred the patents to ICI. However, when they tried to find someone in Unilever to help them sort out the mess, they couldn't find anyone who knew anything about the product. They were also worried about offending ICI and Ciba Speciality Chemicals, who were the likely distributors of future products, since significant funds had now been invested in product testing.

In the meantime, the company has used its milling technology to provide contract milling services, and to develop a number of other products, principally in the areas of sunscreens and UV protection – for people, plastics, and fabrics.

[2] A search of the Ciba Speciality Chemicals website indicates that the company is no longer marketing ZMG as a nucleating agent at all, so the fears appear to have been borne out.

2.9 Proteome Systems

Genomics is the study of the genes which make up DNA. Proteomics is the study of the proteins for which those genes code. Proteomics is a significantly more complicated branch of science than genomics. This is because only ~22,000 genes in the human genome code to create ~400,000 proteins. This diversity is created by three mechanisms. First, proteins are created by combining elements coded by different genes, second, some proteins combine their various elements in different orders, and third, a given gene will code for a different protein depending on its biochemical environment, such as occurs if it is located in a different organ, at a different stage of the lifecycle, or in different environmental conditions (http://www.wikipedia.com).

Proteome Systems was founded in early 1999 by a group of scientists at the forefront of Proteomics. They had developed significant intellectual property at Macquarie University, but were unable to negotiate its release from the university. Consequently, they resigned their jobs and started a new company, developing new intellectual property from scratch. By 2003, Proteome Systems was the largest privately-held biotechnology company in Australia, with 120 employees. It had developed a range of products which spanned the length of protein analysis. They sold Proteomic analysis platforms, the component instruments within the platform, and consumables. In addition, it had a host of drug discovery and diagnostics programs in niche disease areas. They also provided consulting services. The company had partnerships with IBM, Shimadzu, Charles River Laboratories, Millipore, Sigma-Aldrich, and others. With the exception of a small sales presence near Boston, all of the company's operations were located in Sydney.

The company listed on the Australian Stock Exchange at a price of $1.20 per share in October 2004, much earlier than would normally be expected, given the company's cash flow and level of business development. Not only did they not raise as much money as they would have liked, and the share price was not supported by the stock market. It fell progressively to a nadir of $0.16 in July 2005. Around that time, the founding CEO and one of the two major share holders, Professor Keith Williams, resigned, and was replaced by Mr Stephen Porges, a CEO who was much more sensitive to the interests of shareholders and their desire for a change in corporate strategy that would increase cash flow in the shorter term. He changed the company's strategy by dropping the instrumentation business, and focussing on drug discovery.

2.10 VESDA

VESDA (Very Early Warning Smoke Detection Apparatus) is the "better mousetrap" of smoke detection. It works by taking air from a protected area, running it through a pipe, and then using a laser/detector pair to sense for smoke particles in the air. Compared to conventional smoke detection, it can detect fires much earlier, and therefore dramatically reduce the amount of damage done (since fires grow at an exponential rate). The basic technology was developed by the CSIRO in the 1960's as a technique for measuring smoke from bushfires. Shortly thereafter, following a fortuitous barbeque, CSIRO worked with the Postmaster-General's Department (the national telephone carrier at the time) to adapt the technology to create a smoke detector for use within telephone exchanges.

Despite strong international interest in the technology, CSIRO and PMG were unable to find a satisfactory local company to commercialise the technology, so they issued a tender in which they offered $60,000, an order for 60 systems, and free licenses to the relevant patents to the company which would commercialise the technology. Although the tender was won by a joint venture of British Aerospace and Fire Fighting Enterprises, a small start-up, IEI, worked around the patents and developed a cheaper, more effective system (which eventually became VESDA). The PMG bought its 60 systems from the British Aerospace joint venture (and possibly even installed them), but then purchased exclusively from IEI. The VESDA system took the market, and the company grew very strongly through the 1980's and early 1990's, maintaining a market share of over 60% in its niche. By 1994, however, following a leveraged buy-out by one of the founders and a dramatic shift in the market which left it with excess inventory, the company was insolvent.

In 1995 the company was purchased by Vision Systems. Vision Systems revamped and successfully re-launched the product in 1997. Sales boomed from 1998 to 2001 with the IT sector accounting for 85% of sales. They plummeted when the IT bubble burst. The company then moved into utilities, public transport, banking, and warehousing, with moderate success.

By 2004, the industry was consolidating, both within fire systems, and between fire systems and other building systems (e.g. security, internal communications). Sales were strong, but not growing quickly, and management felt that the value of the VESDA business was not reflected in the company's share price. Vision Systems sold the business to a private equity fund in late 2005.

3 Internal dynamics: Management of the ventures

The leader of an innovative enterprise (whether a start-up or within an existing organisation) must solve two problems simultaneously. The first is the technical problem of innovation. This often involves an inventive step and always involves an entrepreneurial step. Invention either comes about through study and experimentation or it comes about by bringing together types of knowledge that have not been brought together before. Entrepreneurship always involves bringing together resources that have not been brought together before. That is, an entrepreneur takes sets of resources (e.g. a technical invention, peoples' skills, social networks, capital, factories, distribution channels, and an understanding of marketing) and attempts to combine them in such a way as to give them greater value (allowing for risk) than they had separately. In order to solve this first problem, the successful innovator must construct a strategy which will both attract the necessary resources and which will enable them to be combined in such a way as to produce that additional value and manage the resultant risk. The second problem is the problem of organisation. That is, the innovator must build an organisation which is capable not only of combining the resources to enact the strategy for the first product or service, but also of enacting subsequent innovations and sustaining the ongoing production which occurs as a consequence of a successful initial innovation. Such an organisation must be capable of going through fundamental changes as it expands – from a small team, to a large team which can be led by one person (up to about 50 people), to a formally-organised company in which everyone knows each other (up to about 300 people), to a large corporation. The innovator who solves both these problems not only commercialises a product or service, but also builds a business.

This section provides an overview of the management practices in the ten cases. It focuses on six areas. The first four look at the strategic problem, examining strategic orientation, marketing behaviour, strategic risk management, the management of intellectual property. The final two examine internal organisation by considering leadership and culture, and organisational design. We will see the way that the internal characteristics of the organisation and its strategic behaviour are intimately linked.

3.1 Strategic orientation

The basic strategic problem is one of linking technologies to markets. That is, given a market opportunity, can the organisation develop a technology (and consequently product or service) to match it? Alternatively, given a technology, can the organisation identify a market which will buy it, if it is appropriately configured in a product or service? Given this basic strategic problem, it is no surprise that companies vary in the extent to which they are technology-oriented or market-oriented. A technology-oriented company will be very focused on its technology, and will generally operate under the assumption that the market will beat its way to the company, i.e. "if we build it, they will come". A market oriented company will generally focus very strongly on the demands articulated by the market, and will develop products and solutions designed to meet that demand.

Technology oriented companies face two major risks. The first risk is that the market will not be ready for their product when their product is ready for the market. For example, Ausmelt developed fantastic technology for smelting spent pot lines from Aluminium smelters. This technology could dramatically reduce the amount of hazardous waste coming from those facilities. Unfortunately, however, there is no demand for the technology. The Aluminium companies don't want it, and governments, who compete for smelters and are vulnerable in other ways to this powerful constituency, are unlikely to demand it. The second risk is that there will be demand for the technology, except that certain complementary assets are not available. For example, Proteome systems faced the problem that, because it was producing equipment for the new area of Proteomics, very few companies had the skills to use its equipment. However, if companies used the equipment successfully, that would create significant demand for further equipment.

Being market-oriented tends to be much less risky, but there are risks, nonetheless. The first risk is that the company will only respond to demand as it has been expressed by the market, rather than anticipate future market demand, especially when the market cannot express demand for products and services that have not yet been created. For example, a commentator, who was involved in the very early stages of VESDA, recounted to the author that, at the time, there was a possibility of adapting the technology to create smoke detectors for domestic and/or commercial use -- smoke detectors were not widely used at the time – but that the founders had chosen to focus exclusively on the well defined market of telephone exchanges and computer installations. Potentially, VESDA could have become the pervasive smoke-detector technology, and not just the preferred technology for high-end applications. The second risk is that the company will not have particularly differentiated technology, since many other companies are responding to the same market demand and have approximately the same capabilities. Consequently, the company will expend extensive resources on development, but may not be able to attract sufficient margins to justify the expense.

Table 3 ranks the ten cases approximately on the technology:market orientation dimension. Interesting consequences are discussed below.

Ausmelt	Strong technology orientation
Compumedics	↑
Micronisers	
Proteome systems	
Falcon	
Vesda	
GBC Scientific	↓
Computershare	
Extended wear lens	Strong market orientation
International catamaran	

Table 4: Ten cases and the approximate technology/market orientation of their management

The relatively strong technology orientation of Ausmelt, Compumedics, Micronisers, Proteome systems, and Falcon has been one of the contributing causes to a number of the problems which the organisations have faced at various times in their lives.

Ausmelt arguably produces the best smelters in the world. However, up until the time the cases were written, it was surprisingly insensitive to the needs of the market. While the smelting unit is only a small part of the smelter, which itself is a small part of an entire mining operation, the company employed a selling strategy which appeared to not acknowledge that at all. In particular, it made its initial sales as if the technical performance of the core component of the system is the most important thing to the customer when, in fact, most customers were probably much more interested in performance characteristics of the system as a whole, and in particular the marginal risk versus the marginal benefits of using an Ausmelt system.

Compumedics purchased Neuroscan (a manufacturer of neurological diagnostic amplifiers) around the time of the data collection. At one level, the acquisition made sense in that the core of both companies' products was an amplifier, and that amplifier could be common to both products. At another level, this was an unusual acquisition. If both companies could produce portable amplifiers for the medical market, then presumably there are many companies that either produce amplifiers, or could if they wished. What differentiates a company like Compumedics is either the software embedded in its products, or its distribution network. It is unlikely that there are many synergies in the software (sleep apnoea and epilepsy are presumably quite different in terms of the diagnostic algorithms used). Similarly, researchers and diagnosticians for sleep apnoea are likely to be sleep specialists, while Neuroscan's customers are likely to be neurologists. Consequently, it is hard to see synergies in distribution. In contrast, Compumedics' competitors have all either teamed up with a provider of sleep apnoea therapy devices or with a provider of sleep clinics.

Falcon provides a slightly different example, in that the proponents met tremendous resistance from the current market for the technology – the exploration group within BHP. A number of powerful people within that group felt that the money would be much better spent on exploration using existing technology. The R&D group saw otherwise, in part because their research indicated that their competitors were attempting to develop similar technology and they feared being left behind. Consequently, they persisted with the technology – even though doing so required them to move the project to a different division of the company. In the end, the R&D group prevailed, and is seen as having created a number of very valuable strategic options for the company.

At the other end of the spectrum are projects like the Extended Wear Contact Lens project, which was directed explicitly at a particular product and a particular market need. Similarly, International Catamaran was extremely market-focused within constraints it set on customers. On one hand, it was very inflexible. It would only supply boats the same size or larger than the largest boat it has ever made. Similarly, the founders had very strong views about certain aspects of the market, and in some respects understood it better than their customers. For instance, the company lost customers because it refused to provide boats with a door in the bow. Whereas conventional ferries pull up alongside the wharf and load through the stern and unload through the bow, the Incat boats are designed for the boat to back up to the wharf and have all the vehicles drive in at the stern, with the first half of the load doing a U-turn at the bow, and then driving back out towards the stern ready to unload while the second half drives in and faces forward to do the turn on unloading. The company believed that loading and unloading is so much faster by this means that the bow door, which created a number of safety and sea-worthiness issues, could be justified. In other respects, however, the company was extraordinarily flexible. In particular, every boat was unique, and, within the constraints of seaworthiness, the company would work with clients to configure the boat any way they wished. Furthermore, they would make changes very quickly. The major internal reconfigurations it designed, simulated, checked, and prepared for within a few days would take months in a conventional organisation.

Well managed innovators strike a balance between technology and market focus (Dougherty, 1996). Although the appropriate balance will depend on the particular market concerned, for a given market, an excessive focus on marketing can undermine sustained technology development by addressing only the needs which potential customers can articulate, while an excessive focus on technology means that the firm often misunderstands the market. As a general rule, a stronger market orientation is less risky than a strong technology orientation, and therefore preferable (Cooper, Edgett, & Kleinschmidt, 2004; Leonard-Barton, 1995; Maidique & Zirger, 1985; Moore, 2002). An excessive technology focus is a very high-risk strategy which occasionally pays off handsomely, but, on average, pays off quite poorly. However, excessive technology focus is a common problem in firms (Dougherty, 1996). While a tipping of the balance towards a technology focus is, to some extent, to be expected, that does not mean that does not need to be explained. In the next sections, where we discuss marketing behaviour, risk management, leadership, culture, and organisational design, we will see how these strategic orientations are inextricably linked to the internal workings of the organisations. Later on we will see how those internal workings appear to be, in large part, a product of the institutional environments of the individual firms.

3.2 Marketing behaviour

Operating at the level below the way a company engages with the market strategically is the question of how it engages it in practice. Does it sell its core product, or does it sell a service derived from the core product? Does it make its money from the product itself, or from the consumables which users must purchase throughout the product's life? Does it aim for the entire market, or just for a specialised niche? Does it start in a specialist niche and then not bother to try to take on the whole market, once it has established a beach-head?

Not surprisingly, the companies which had a stronger marketing orientation tended to have a much better understanding of exactly how they provided value to the market they were targeting, and therefore could be more flexible and more effective in their marketing behaviour.

For example, after it raised money from its Initial Public Offering, Ausmelt tried to develop applications for its technology for as many markets as possible (about 30) instead of focussing on the few niches it could afford to market to, given the capital it had available. While this gave them a broad and deep understanding of the science, it also meant they ran out of money. Similarly, an important component of the smelters is the lance tip. A lance will last 15 minutes in the hands of a poor operator and six weeks in the hands of a good one. This suggests that there are significant revenue opportunities available in replacement lance tips and in operator training and other consulting services. However, we are led to understand that the company did not exploit this essentially captive market as well as it could.

Similarly, when Compumedics began, its core market was sleep researchers. These people sought the highest-performing equipment available. As sleep apnoea became better understood, the main market moved from sleep research to sleeping disorder diagnosis and treatment, and so we might have expected the marketing focus of the company to move from meeting the needs of the high-end researchers to meeting the (somewhat different) needs of diagnosticians. The focus of the company did not shift, however. This was not simply a case of failing to recognise that the main market required more reliable equipment than the investigator market (Moore, 2002). Rather, it appears that the developers within the company failed to realise that customers in the main market were interested in a dramatically different set of performance attributes than researchers. In particular, purchasers in the general hospital market were not particularly interested in having the machine with the highest possible technical performance, but were very interested in whether or not they could reduce their overall number of suppliers. The company responded to this by entering into a series of arms-length distribution arrangements, all of which failed.

IEI, can be considered an intermediate case. The company was extremely successful in establishing itself as the dominant supplier for high-risk installations such as telephone exchanges and museums. However, once it dominated that niche it appears to have made no attempt to transcend it. It did not, for instance, develop a derivative product for commercial buildings, or a derivative domestic detector (home detectors were not common at that stage). Its management also appears not to have attempted to market to high risk applications that were not associated with new construction. Consequently, when the I.T. bubble burst in 2000, so did most of its market.

Falcon also represents an intermediate case. Although it was initiated defensively, BHP has found that it is a tremendous strategic weapon. It can be used to purchase options in exploration projects at very low cost. That is, by having this technology, people conducting exploration are often interested in having BHP as an exploration partner so they can get access to Falcon. BHP, in turn, can use that interest to negotiate favourable rights (such as a right of first refusal), should the exploration partner find a deposit.

At the other end of the spectrum are companies like GBC scientific and Computershare. The founders of GBC scientific understood the marketing strategy of Varian-Techtron perfectly and deliberately targeted a niche which Varian could not address well. Similarly, Computershare started out trying to sell its software to individual registry managers, and then worked out that it could provide higher quality service with higher margins by offering a bureau service.

3.3 Risk management

Innovation involves risk, and another key element of strategic management is the way that the organisations manage that risk. Risk arises because innovation is highly emergent. That is, the way to solve a problem, or possibly even the definition of the problem itself, may well only become apparent during, or even after, the problem-solving process (Weick, 1995). If that were not the case, then innovation would not be innovation; it would just be engineering. Consequently, it is extraordinarily difficult to predict what is going to happen as a development project proceeds or a product goes to market. An innovation project faces many types of risk, including technical risk (will the company actually be able to produce the product), financial risk (will it be able to maintain adequate cash flow until getting to market), market risk (will people buy it at the projected margin), IP risk (will the company be able to maintain freedom to operate), etc.

To the extent that innovators can control this risk, they can also make both their financial returns and the tasks demanded of their organisations more predictable. As with technology orientation, some of the organisations we studied managed risk extremely well, while others took on levels of risk which would be considered unacceptable in places around the world where the market for innovation is well developed. Of most interest to us is the level of market and financial risk, since none of the projects would have reached the point where we could even study them if the other forms of risk had been managed badly. These differences are summarized in Table 5. We will see below that the nature of the environment they face explains some of the differences in behaviour.

International Catamaran	Higher risk
Ausmelt	

Compumedics	
Proteome systems	
Computershare	
Micronisers	
Vesda	
GBC Scientific	
Extended wear lens	
Falcon	Lower risk

Table 5: Ten cases and the approximate level of risk they have taken on.

Computershare has taken on relatively high levels of risk, and has managed it well. It diversified enormously, both geographically and in its product offering, in the 10 years prior to data collection. Not only did it move into the share registry business in several countries, but it also dramatically increased the number of products and services it offered, to offer everything from printing and annual report authoring to polling of shareholders in advance of strategic decisions and mining of its shareholder database. Its strategy for this expansion involved carefully hedging the risk. For example, virtually all of its diversification out of share registries has involved entering into a joint venture of some sort. If the venture did not work, then it would be dumped. If it did work, then it would buy out the venture partner.

Proteome Systems took on excess risk, in part because of the environment it was operating in. It pursued four different business models at once: being a researcher and developer of novel drugs, being a developer and marketer of scientific instruments, providing support for purchasers of its instruments, and providing consumables for its instruments. Normally a company would pursue one of these, or at most two, since such a broad strategy creates an inordinate amount of complexity for the organisation to manage (and hence risk). In part, it chose to pursue all four because Celera, one of the founding companies in Genomics, started with a similar strategy. When Keith Williams was asked why he was pursuing such a complex strategy, he would reply that the four elements were highly synergistic, and so the company needed to pursue all four if it was going to survive. That is, it needed to develop drugs to push the capabilities of their instruments, and their better understanding of their instruments gave them an edge in drug development. Similarly, their consulting helped both their instrument development and their drug development. While this sounds eminently sensible, and Celera had done the same, one needs to be aware of the extent to which this answer is contingent on the particular context in which the company was operating. If the company had been in San Diego, or Boston, or San Francisco, rather than Sydney, and had been spun out from a university which spun out many companies, such a strategy would have been a choice, rather than something which, to all intents and purposes, was forced on the company. It would have been possible to reap at least some of those synergies from companies in its immediate environment. For instance, if it had chosen to be an instrument manufacturer, the same research group at the university would have undoubtedly spawned drug discovery companies which would have provided the necessary learning for improved instrument manufacturing, and, as an instrument manufacturer, it could have helped those drug development companies get the most out of the instruments. So, in contrast to Celera, which was working in the field of Genomics (which is generally considered to be more straightforward scientifically than Proteomics), had vastly more capital and better access to capital, had a CEO who was extremely prominent in the scientific and broader community, and which was tied into the dense innovation networks of the cities in which it had facilities, Proteome systems was operating in a city with limited biotechnology, and the scientists all had to leave Macquarie University to start the company, which meant that no further complementary companies would be spun out.

Micronisers faced a similar problem to Proteome Systems, albeit on a different scale. Because there was no established market for its products, it needed to embark on market-creation activities. This often involved moving down the value chain towards completed products – with all the complexity that brought with it. For instance, in order to create a market for its nano-sized Zinc product, the company considered actively vertically integrating to become a manufacturer of UV-insensitive flags for car dealerships. This might be a sensible strategy if it was designed to enable the company to capture a greater proportion of the value it generates than would otherwise be the case (see Ausmelt example below). On the other hand, if such a strategy is driven by a need to generate sales, then there is a great risk of creating extensive confusion and coordination difficulties without the attendant margins to justify it.

Compumedics and Ausmelt also took on excess risk, but in different ways. For various reasons, Compumedics was only interested in entering the US market by using a distribution agent (rather than by raising venture capital to establish its own distribution channel or being bought by a company with a distribution network). It attempted three such arrangements, and all failed nominally for different reasons. Looking across the three attempts, it appears that all had the same characteristics. These arrangements made sense at the time they were consummated, but within about a year, shifts in either technology or the market meant that Compumedics' machines were of much less interest to the partner than they had been. It was only after this happened twice that Compumedics started to construct contingency plans. This suggests that the company paid no attention whatsoever to the risks associated with these distribution arrangements until after the fact.

Ausmelt took on excess risk because of the way it sold its smelters. In particular, only about 10% of the cost of a smelting facility is the cost of the smelter itself (and it is a much lower proportion of the total operation including the mine). The remaining money is spent on appurtenant equipment (control systems, materials handling, buildings, etc.). One might expect that a major construction company or equipment manufacturer would tender for a job, and then sub-contract the smelter to Ausmelt. In Ausmelt's case, however, it worked the other way. It would bid for the entire project, and then contract out 90% of the work. This change in roles had significant impacts on the risk the company took on, and the risk associated with the project as a whole. First, it dramatically increased the risk the company was taking on, since it was exposed to things going wrong in the entire project, without creating a compensating increase in its return. Second, it dramatically increased the risk of something going wrong, since the company was not particularly expert in project management. Its expertise was in smelter design.[3] The company would have managed the risk much better if it had found a way to sell the smelters so that it took on the risk associated with the smelter, and used its expertise to sell the smelter, but did so in a context in which another company took on the project risk, and had overall responsibility for selling the project. This would have been quite difficult to achieve, since it is unclear how strong the incentive is for a major construction organisation or equipment manufacturer to support the technology with its higher technical risk and more difficult implementation.

[3] More recently, since potential clients have learned that the technology works, they have managed to get the project owner to take on all the risk, and to serve a much more traditional sub-contracting role. They have not managed to increase the company's proportion of the total cost of the facility, or escape from responsibility for the overall sale, however.

If International Catamaran had put its business plan to a venture capitalist, it is extremely unlikely that it would have been funded. The business model was extraordinarily risky. It involved creating a new class of boat (high-speed catamarans), constructed out of a new material (Aluminium), using a novel propulsion and steering system (water jets), and requiring skills not found before in Hobart. (At one point it employed 30% of the skilled Aluminium welders globally. This required that it persuade the local TAFE colleges to offer courses to train them.) Furthermore, Hobart has virtually no history of ship building. In addition, Bob Clifford, the founder, insisted that the company not standardize the designs of its boats. Rather, every boat was essentially a one-off, and every boat incrementally improves on the boat before. All of this was done with an extraordinarily flexible and loosely structured work organisation. Finally, in order to maintain acceptable utilization of staff and equipment, the company would start boats without firm orders and then customize them after the order was finalized. This made the company very vulnerable to a global cataclysmic event which affected all markets (such as the September 2001 World Trade Centre bombings). If Bob Clifford had set out from the start to build the business he has, he almost certainly would have failed. It would not be possible to obtain external support for any of these elements, let alone the combination. It is hard to tell whether he has been extraordinarily lucky or whether he has skilfully built the business one step at a time, taking on only a modicum of incremental risk at each step.

3.4 Intellectual property management

Intellectual property management in the ten cases is fascinating. If there is any general conclusion that is to be drawn, it is probably that our normative expectations about how intellectual property should be managed are dramatically different from the reality of how it is. Most noteworthy is the fact that the intellectual property takes on a life of its own – a life that is highly circuitous. We discuss the four most interesting cases in alphabetical order.

Ausmelt is interesting in that the intellectual property has, through the history of the company, resided in three different places. The technology was originally created in the CSIRO, and commercialized as SIROSMELT. CSIRO, which holds the original patents, then gave open licences to Mount Isa Mines (ISASMELT) and to Ausmelt (AUSMELT) to further develop the technology and continued to market the technology on its own account. A search of the USPTO database indicates that Ausmelt holds several daughter patents and MIM holds at least one. The research team wondered whether this splitting of the intellectual property, particularly between Ausmelt and MIM, dramatically inhibited broader acceptance of the submerged-lance technology because it prevented its transfer to a third party. As it stands, Ausmelt is considered the best in the world with the technology, and it is well acknowledged that its intellectual capital lies as much in the staff's skills and tacit understandings as in the patents. Notwithstanding, if, for instance, Ausmelt wished to sell itself into a larger entity, would that larger entity hesitate to purchase the company because of the risk of a competitor buying and building on the MIM rights?

The head of the extended wear contact lens project invited the Novartis patent attorneys to attend not only the first meeting of the project, but every quarterly meeting. In addition to allowing the patent attorneys to think about their patenting strategy very early on in the process, and report on it quarterly, this experiment facilitated two fundamentally important transfers of tacit knowledge, one from the patent attorneys to the scientists, and the other from the scientists to the patent attorneys. Through their ongoing interaction, the patent attorneys – essentially inadvertently – taught the scientists how patents are used as strategic weapons, rather than as simply a record of the intellectual property that had been created. The scientists started to understand, at a much deeper level, how a patent is used. At the same time, through their participation in the meetings, the patent attorneys learned what it was that the scientists had actually created. Rather than just seeing the final product of the research, they learned why certain features were present, what approaches had been tried, what approaches had not been tried, and so forth.

These two information transfers had dramatic consequences. A traditional patent would have described the set of polymers the team had developed and tested (about 70 in this case), and would have left the door open for a competitor to develop number 71. The patent attorneys in this case started writing such a patent until the scientists stopped them. Given their enhanced understanding of the patent process, and the patent attorneys' understanding of the science, the scientists proposed a radically different – and radically stronger – patent. Rather than patenting the technological artefact which best does the job, they proposed patenting the knowledge they had created in order to create the artefact, using the artefact as an example. In so doing, they managed to patent the full breadth and depth of their work. At the time of writing, this much stronger patent had served Ciba-Vision well in litigation.

International Catamaran followed a policy of deliberately not asserting intellectual property rights over any of its inventions. Some of these inventions were significant, such as a system for stabilizing the catamarans in heavy seas. Notwithstanding, the management believed that the competitive strength of the company lay in its ability to outmanoeuvre the competition (in the market and in the water), and that patent-related battles are just a source of distraction. On the one hand, by giving competitors free access to its intellectual property, International Catamaran was able to grow the product category of high-speed catamarans much more quickly, and to create a competitive market. On the other hand, in the period 2001-2005, its only competitor, Austal Shipping, appears to have been more successful in the market. Consequently, the overall wisdom of that strategy is unclear.

At Micronisers, the patents were originally held jointly by Micronisers and Unilever, and the two companies had an agreement in place which gave Micronisers control of all product development and manufacturing, and Unilever exclusive control over marketing and distribution of Zinc Monoglycerate (but none subsequent). The agreement did not allow Micronisers to intervene in the marketing under any circumstances. When Unilever sold its specialty chemicals business to ICI, Micronisers had the right to buy back its half of the patents, but wasn't aware of that at the time, and so the deal went through without Micronisers being given the option, let alone taking it up. In the meantime, Unilever also failed to transfer the patents to ICI with the sale of the business. ICI, in turn, sold the marketing rights to its specialty chemicals to Ciba-Specialty Chemicals, while maintaining the manufacturing rights. At the time of writing, because of retirements and job movements, Micronisers was unable to find anyone in either ICI or Unilever who knew anything about its chemicals or the agreement. Given its size and the fact that it needed a partner like ICI, Unilever, or Ciba-Geigy to market its chemicals, it was unsure whether to try to assert its rights, or even go to Ciba-Geigy directly, and risk offending the large corporations. Its product had, essentially, disappeared into a bureaucratic black hole.

3.5 Leadership and culture

The differences between the companies, in terms of their strategic orientation, marketing, and strategic risk management, and to a lesser extent, in terms of the management of their intellectual property, are intimately tied to their management and organisation. In this section we consider leadership and culture, while in the next we consider organisational design.

The usual distinction which is made in this regard is between companies which companies which have a high or a low cultural predisposition towards innovation (e.g. Dougherty & Heller, 1994; Tushman et al., 1997). That is, some organisations have the cultures and systems which will support innovation, while others do not. Those which do not are forced to use 'skunkworks' or other devices to permit innovation to succeed (Tushman et al., 1997). This appears to have been the case at BHP, where Falcon was developed essentially by a skunkworks.

The other companies, in contrast, had a strong bias towards innovation, which is not surprising given their small size (Dougherty, 1996). Notwithstanding, they varied along a spectrum. At one end were companies where the founder was initially motivated to solve an interesting, commercially relevant, technical problem. Once they solved that problem well enough to create a company, they neither handed over the company to a new management team that was interested in solving the business problems of making the company survive and thrive,[4] nor did they change their orientation towards business problems and hire and hand power to people with the requisite skills. Rather, they continued to both head up the company, and maintain their principal focus and passion for the technical problems. At the other end of the

[4] As companies grow, and the competences needed to grow the organisation change, there may need to be two or more such hand-over of the top management team (insert cite).

spectrum are companies or projects that either started with a very clear commercial focus and identified technical problems which needed to be solved to meet commercial goals, or were started by multiple founders, at least of one of whom was focused on business, and who ended up heading the venture. The cases in the middle tend to be hybrids, rather than a compromise between the two extremes. That is, they seem to have embodied unresolved tensions between business and technology-oriented members of the founding team. The one possible exception to this characterisation is International Catamaran. The company solved tremendous technical problems as its boats grew in size and power. It is not clear whether the founder was more interested in selling boats or in solving these technical problems. However, because those problems did not require a separate research and development capability, and because they were always completely aligned with the company's business objectives, they were solved during the ongoing process of boat development. Consequently, while the founder may well have been driven principally by an interesting technical problem (building bigger faster boats), he had a clear understanding of the market, and that technical obsession tended to be completely congruent with business needs.

The interesting thing to note is that while some of these companies are now 30 years old, these orientations still pervade their cultures (cf. Schein, 1985). For instance, at one company with a strong technical founder, employees state openly that their affiliation to the technology is stronger than their affiliation to the company. They see the commercial success of the company purely as a vehicle to enable them to perfect the technology. At another, the founder's response to a huge commercial problem was to think about using the company's technology to develop a completely different product for a completely different market, rather than trying to solve the problem at hand.

It is possible to see a number of mechanisms which would perpetuate a technology focus. One of the research team members, who also leads a start-up company, noted how easy it is to get trapped by staffing issues. For his company, it was critical that the first product be the best, technically, in the world. Consequently, early in the life of his company, there were tremendous technical challenges, and the very good engineers had power and significant influence over the direction of the company. As the company matured, however, the strategic focus shifted to marketing, and the principal technical problems involved ensuring the reliability of the product and refining it incrementally over several generations. In comparison to the initial development, this was technically boring. Notwithstanding, the company still needed to retain these highly competent engineers, since they understood the product. For the team member, it was a major challenge to retain these engineers at a time when his organisational strategy dictated that he reduce both their power and the interest of their work. He could easily understand how the leadership of a business, even if trying to be business-focused, could be pushed back into a strong technology focus. One could easily see this playing out at International Catamaran if it decided to adopt a more pedestrian strategy.

A second mechanism lies in the absorptive capacity of the organisations (Cohen & Levinthal, 1990). Absorptive capacity refers to the organisation's ability to search for and procure innovation-relevant (or business-relevant) information from its environment. Cohen and Levinthal's core insight is that an organisation's current information-gathering capacity is predicated on its prior information-gathering capacity. An organisation with expertise in one domain (e.g. technology) will find it much easier to learn more about that domain, than to learn about a new one (e.g. business). In the context of these companies, if the founders were told, say, by their boards of directors that they needed to develop a marketing capability, they would not know how to identify a good marketer, or how to recognise good marketing work. Similarly, they would not be able to create a good environment in which a marketer could work. This is exactly what we see in the technology-oriented companies. One company only managed to attract bad marketers, didn't realise they were bad, didn't appreciate or understand the good work they did do, and drew two conclusions. First, they concluded they had been highly market-focused, since they thought they had listened to their marketers. Second, they concluded that marketers were a waste of time because listening to the marketers didn't solve their problems. Another hired someone with good marketing capability into an overseas subsidiary, and that person spent a couple of years fighting the rest of the organisation to try to get it focused on the market. Eventually, they became seriously ill and had to leave the company. They were not replaced.

A third mechanism which drove the strong technology orientation lay in the ownership structure of the companies. In two of the cases, the founder controlled the majority of the shares, and forewent the opportunity to sell the company into another company that was better positioned in the market, or better able to build the business. There were two reasons for this. First, the companies did not have on their staff people with the necessary skills to identify an appropriate purchaser and negotiate a deal. Second, the founders (and many of the staff) feared that such a move would harm the development program for the technology. Their product would become part of a portfolio, and they were concerned that this would mean that it wouldn't receive development resources in the new entity.[5] It is important to note that the founders were not the sole shareholders and they were obligated to consider the interests of the others.

A final mechanism, which will be discussed at length below, involves governance. Often, for various reasons, these companies had boards of directors who didn't understand the way an innovative business differs from a regular business. Consequently, rather than fixing these problems, they often exacerbated them.

At the other end of the spectrum were companies and projects that had a healthy business focus. In most cases, these organisations also had appropriate organisational designs for their technology development strategies. We consider some of them below.

3.6 Organisational design

The essential organisational design problem which managers must solve in organisations seeking to innovate is to channel communication and manage objectives so as to balance emergence and control (Dougherty, 1996; Lester & Piore, 2004). As noted above, emergence refers to the idea that the way to solve a problem, or possibly even the definition of the problem itself may well only become apparent during, or even after, the problem-solving process (Weick, 1995). We have a bureaucratic fantasy that we can define problems well enough in advance to define tasks clearly and allocate them to people. In as far as the problem and problem-solving method are well defined (or become well defined), traditional project management tools, which

[5] Whether or not this would actually harm technology development is unclear. On one hand, in both cases, the technology would have become secondary to the purchaser compared to other products. On the other hand, however, much higher sales and much lower marketing and distribution costs would have generated more funds for research and development, and a larger organisation would have meant that R&D engineers could have focussed on R&D, rather than being dragged into sales support the whole time.

involve extensive planning and thinking through of approaches, are likely to render a faster and more effective solution (Eisenhardt & Tabrizi, 1995). As projects become more and more innovative, this becomes increasingly ineffective as a strategy. Organisations are most effective if they attack emergent problems by moving away from structured problem-solving towards a mixture of trial-and-error learning (Eisenhardt & Tabrizi, 1995), improvisation (Weick, 1995; Weick & Roberts, 1993), and process-driven approaches (Lester & Piore, 2004). Organisations must somehow balance these two approaches.

Three of our case studies managed this particularly well, but used different approaches – approaches that were well matched to the sorts of problems they were trying to solve. In the case of Falcon, the problem was relatively clearly defined, the science was well understood, and the problem could be solved virtually in isolation from the rest of the corporation, so long as they had sufficient skills and financial resources. This was achieved with a project team of highly qualified engineers, selected from a global labour pool, and led by a manager who was powerful and well networked in the rest of the corporation.

In the case of the extended wear contact lens, there were three teams on three continents, who were looking for a fundamental scientific breakthrough. Each team contained people from all the requisite specialties (i.e. physics, chemistry, optics, etc.) In this case, they optimized the search process by oscillating between periods of convergence and focus and periods of divergence and exploration. The three national teams (and their various sub-teams) met quarterly to share results and debate next steps. The steering committee would then decide on the objectives for each sub-team for the next three months. The teams were then free to explore those objectives exhaustively, but were not allowed to stray from them. This freedom was enhanced by explicit agreements about IP ownership and trust which made it safe to make mistakes. The teams simultaneously helped each other and competed against each other. There was dense communication within and between the teams, including global telephone progress meetings every two weeks and the different teams sharing their results electronically at the end of each day.

International Catamaran had a different core problem to solve, and organised differently again as a consequence. Its production task was much more like building a jet aircraft than building a conventional ship. It had to manage very high levels of complexity. There are essentially two strategies for doing this. One is to analyse and document everything extremely carefully – as is done by companies like Boeing. The other, its strategy, is to develop extremely high levels of skill, flexibility, and a capacity for appropriate improvisation. The organisation had a very informal structure – one which involved a central individual (the founder), who was generally acknowledged as a genius, as the hub of a large wheel with a thousand supervisors, welders and engineers populating the rim. People would solve problems individually or among themselves, and improvise, within bounds and towards objectives that were well understood (but not documented) in the organisation. If ever anyone was unsure, they would consult with the boss (or sometimes one of the supervisors). While this approach worked extremely well, it relied on the genius founder at the centre of the system to resolve particularly thorny problems. This created succession issues as the company matured. The necessary changes in structure had not been completely resolved at the time the case was written.

At the other end of the spectrum were organisations with various types and levels of dysfunction. GBC Scientific operated for about ten years with minimal communication between the ICI board members and the founding partners, between the founding partners, or between the main divisions. One company insisted on doing its new product development on a shoestring, and with poor planning, and so projects which should have taken a year or two ended up taking ten or more, and costing about ten times as much as they would if managed effectively. One company which needed to be highly flexible adopted an elaborate committee structure (consistent with its academic origins) with staff members on multiple committees, and consequently ended up with a lack of direction, and a paucity of actual decisions, especially hard ones.

4 External dynamics: The operating context

If we consider the preceding text, it would seem that of the ten cases, about three and a half were successes. The only unqualified successes are the Extended Wear Contact Lens project and Computershare. International Catamaran and Falcon come in a close second as a company and a project that will probably turn out perfectly satisfactorily, but the jury is still out. The other six cases, however, all leave something to be desired. Ausmelt, Compumedics, and Proteome Systems are all trading on the stock market at deep discounts from the promises of their initial prospectuses. GBC scientific is currently doing well, but after 10 years in the doldrums, and is relatively vulnerable to low-priced competition. Vision Systems sold VESDA shortly after cessation of data collection for the case. Although the company's ownership of VESDA was phenomenally profitable (it bought VESDA for a bargain basement price and then sold it for approximately 50x what it paid for it), it did not manage to take the product out of the high security smoke detection niche. Micronisers was, at the time of the data collection, coming to the end of a ten-yeasr struggle to bring a product to market. It was selling a great product to a distributor it wasn't allowed to talk to, and who didn't understand the product.

It would be very easy to explain away the problems raised by these cases either by saying that we selected them because they were "interesting", and that there are plenty of "boring", well run, high-technology ventures in Australia. Our discussions with people with broad experience with innovation in Australia suggest that is not the case. Rather, while there are many success stories, just like Computershare, there are also a vast number of companies which have fared as badly, or worse, than the ones discussed here, for similar sorts of reasons. Consequently, there is much to learn from these cases by trying to understand why they have these problems. Similarly, to simply blame management is to ignore the possibility that the playing field for innovation managers in Australia may not be quite as level as it is for managers in other countries.

In this section, we turn to the context within which these companies operate. A venture must procure inputs (capital, staff, intellectual property, governance, etc.) and it must dispose of outputs into a market. Consequently, we examine those people who surround the venture. First, we look at those most proximate, the board of directors, then we turn to the Australian environment more generally, first as a source of finance, then as a market, and finally as a source of staff, and intellectual property.

4.1 Boards of directors

Alphatech is a small start-up, spun out of a university. The chief scientist, and founding CEO, is a luminary in his field, and holds a large portion of the equity. He obtains a modest amount of external funding, and appoints a board of directors which includes people with extensive experience as executives or directors of large successful Australian corporations, as well as representatives of his financiers. Everyone on the board likes the CEO. Everyone on the board recognises the tremendous potential of the technology. No one on the board has any experience working in or with a high-technology start-up. Rather, they have spent their careers in large cumbersome corporations and universities.

The board sees no reason why the CEO, who is clearly a very smart person, should not head the company while there are major technical challenges to solve, and he has thirty years of experience running a large research group. They see no need to look for external management in the initial period. Things appear to go well for a couple of years, but several years later, after a successful float on the stock exchange, the company is still not making money and seems to lack strategic direction. The board decides that instead of having a scientist as leader, the company needs someone who understands "business", so they replace the CEO with an accountant who has extensive experience as a senior executive in a large corporation. In addition to having virtually no credibility with the scientists and engineers in the organisation, he has never worked in a high-technology start-up before. The accountant CEO draws on his thirty years of corporate experience and imposes strict financial controls on the organisation. These are obviously missing, compared to the corporate settings he's worked in. The board sees these moves as a step forward, since the company now more closely represents the highly successful organisations they have worked in. Unfortunately, rather than solving the company's problems, the accountant CEO shuts out any possibility of emergence and innovation occurring. Several key staff members leave. Two years later, the board realises that the CEO isn't working out, so they look to replace him. They start to look outside the organisation for someone with experience running a high-technology start-up, and find that no-one who has the skills to take over the company and steer it to prosperity is interested in working for a company which has no capital, a disgruntled founding scientist, a demoralized technical staff, a market with a jaundiced view of the product, and a board which has demonstrated no understanding of the difference between an innovative business and one which is focussed on ongoing production. Rather, they find to their horror that the only time when the company would have been attractive to such a person would have been at the time they started it up.

The above description, while clearly stylized and fictitious, captures, to a first approximation, the histories of two of our cases, and the types of dysfunctions seen in the boards of directors in three others. The details obviously vary, depending on the differences in ownership, market, and history of the case. Notwithstanding, the general point holds. The board of directors has three basic roles: to provide oversight, to make decisions, and to give strategic advice (Carter & Lorsch, 2003; Roberts, McNulty, & Stiles, 2005). However, if the board does not understand how these three roles differ within a start-up from within an established firm, then it is no surprise that the managers of the company found themselves in trouble. Starting up a high-technology venture is one of the most difficult managerial tasks in a modern economy, and yet these ventures failed to attract the best managers. The managers they did have were attempting to navigate terrain they had not seen before, and their principal guides, their board of directors, was guiding them with a the wrong map.

4.2 The financing environment

The ventures were funded principally by one of three means – a corporate sponsor, venture capital, or employee equity plus retained earnings. A couple of the companies supplemented their financing with Government grants. GBC Scientific, Micronisers, Falcon, and the Extended Wear Lens Project all had significant sponsorship from a major corporation. In the cases of Falcon and the Extended Wear Lens Project, the corporation initiated the project, so that is of less interest here. In the other cases, however, the corporation held equity in the company for a long period, or provided the first orders which enabled the company to get started. Ausmelt, Compumedics, and Proteome Systems received venture capital funding, and Vesda, Computershare and International Catamaran funded themselves from retained earnings. This is summarized in table 5. Table 5 also shows that overall, the companies that have managed to fund themselves from retained earnings have done best, followed by those with corporate sponsorship, with those funded by venture capitalists coming last. The data from the cases seem to suggest that the difference in success between the venture capital funded companies and the corporate-funded companies arises from different attitudes to risk. In particular, it appears that the venture capitalists move risk onto the venture they have funded, while the corporate sponsors have tended to absorb risk from the venture. Put more concretely, in the companies that were venture capitalist funded, the venture capitalist appears to have forced an exit so they could take a profit. Often that has been to the long-term detriment of the company because it has been in the public market prematurely, or without a viable long-term strategy. In contrast, for the companies that were sponsored by a corporation, the corporation has often absorbed risk from the venture. For example, in the case of Vesda, the PMG was interested in obtaining smoke detectors for its telephone exchanges, and was quite happy to pump resources into a venture to ensure that happened, without any consideration of its return. Although it backed the wrong horse (the British Aerospace venture), its behaviour prompted IEI to design VESDA (using retained earnings from its burglar alarms business), and it then purchased a large number of detectors from the company.   Similarly, GBC Scientific benefited handsomely from ICI's decisions first to enter the market for instruments, and then to exit it. ICI paid a high entry price, transferred in its HPLC operation reasonably cheaply, and exited by writing off all its investment. This dramatically reduced the cost of capitalization of GBC. In much the same way, a senior manager at Unilever was happy to fund Micronisers, even though Unilever never aggressively sought to recoup its investment.

Company	Major source of finance	Overall Viability
Proteome systems	Venture capital	Low
Ausmelt	Venture capital	
Compumedics	Venture capital	
Micronisers	Unilever	
GBC Scientific	ICI	
Vesda	Retained earnings	
Falcon	BHP	
Computershare	Retained earnings	
International catamaran	Retained earnings	
Extended wear lens	Ciba-Geigy	High

Table 6: Sources of capital and support for the case companies, and their overall success.

Although funded from retained earnings, International Catamaran nearly failed because of the intersection of a production system which required it to start boats before finalizing their sale, the risk averseness of Australian financial institutions, and arguably the fact that its strategy and structure didn't conform to the norms for Australian business. Its bank responded to the downturn following the World Trade Centre bombings in the US in 2001 was to foreclose on the company's loans and take control of the company. The crisis was resolved eventually, but not without setting back the company many years.

4.3 Markets

In terms of an initial market, being in Australia was a mixed blessing for the companies we studied. On one hand, Australia is like a nursery for ideas. Because the market is very small and not very competitive, products can stand on their own merits, much more than in the US. In the US, a support and marketing infrastructure is critical to start up a company. In Australia and New Zealand, with a very small economy concentrated in three cities, it is possible to launch a company relatively easily. For example, Micronisers was able to become the major supplier of nano-sized Zinc Oxide (for use in sun creams and UV-protection coatings) in Australia and New Zealand without even having a marketing function. Similarly, International Catamaran made its first few sales to tour operators on the Great Barrier Reef.

As the product becomes riskier, because the rate of technological change is increasing (so you can't fuel initial expansion from retained earnings) or the technology becomes more sophisticated, however, these virtues turn into liabilities. The Australian market is only able to support a certain level of development expense, and Australian purchasers appear to be wary of highly sophisticated local products. Once the development expense or technical sophistication exceeds that threshold, the product or service must be launched into an international market from the outset. This means that the companies have to develop a sophisticated international marketing capability from the very beginning, and from a distance. This increases the start-up risk considerably. GBC Scientific and Compumedics both had significant difficulties in this respect. Furthermore, according to at least one of the case interviewees, as the technological content of a product increases, the chances of Australian customers purchasing it decreases. They do not believe that it is possible for an Australian company to produce a global-quality high-technology product or service.

4.4 Other contextual issues

In this section we discuss other aspects of the Australian environment as a source of inputs which struck us as most interesting.

The first thing we noticed was the nature of the networks these companies operated in. Networks are the primary source of finance, board members, and staff members, since people tend to be more comfortable if someone they know and trust will vouch for a venture, its staff, and the risks entailed. We noticed that these networks appeared to be both much smaller and much more closed than those in communities with a stronger innovation tradition. We attributed this principally to differences in population dynamics. In a city like Boston, there is a flow of students, scientists, and engineers from around the world, through its more than 100 universities. A portion of these move into start-ups, either as founders or employees. The networks in these cities must be able to accommodate the constant infusion of new blood. In contrast, it appears that in cities like Melbourne, the relevant networks are much tighter, more closed, and tend to be ethnically based. If the networks really are quite closed, as we suspect, then we would expect it to have a dramatic impact on the ability of would-be entrepreneurs who are not tied into a network to put together boards of directors, find patient investors, attract high-quality staff, and so forth.

The small closed nature of these networks creates an additional problem which can best be seen if viewed from the perspective of a would-be investor in a start-up, and is best illustrated by the case of Proteome Systems. An investor would like to invest only within his or her area of expertise, on one hand, but would like to diversify his or her portfolio as much as possible, on the other. Furthermore, he or she would like to be physically reasonably proximate to the company, since so much important communication is either tacit or highly contextualized. We can see that unless the pool of investors becomes quite large, this is going to mitigate against the creation of specialist ventures which are quite similar to each other, and therefore exploit network effects from each other. If a local university is capable of spinning out six companies which produce a particular class of vaccines, no local venture capitalist is likely to invest in more than one, and there are not six separate venture capitalists with the expertise to invest in one each. However, if all six firms were started, then there would be tremendous synergies which would increase the chances of each of them surviving. As noted above, this was the problem which Proteome Systems faced, and was one of the strong drivers of its exceptionally broad corporate strategy.

Given the important and beneficial role of the large corporations in our ventures, we finally consider the impact of the big technical institutions -- the Universities, the CSIRO, and (at least in the past) Telstra/Telecom/PMG. Did they help or hinder the success of the ventures? These institutions were involved in Ausmelt, Compumedics (extremely peripherally), Proteome Systems, Vesda, Micronisers, and the extended wear contact lens project. We can see that, in the cases of Vesda and the Extended Wear lens project, they were very helpful. In the case of the Extended Wear project, the CSIRO and the CRC for Vision took on the project as an interesting technical challenge and worked with an established commercial client to deliver great science. Vesda is probably more interesting because, in this case, the PMG did not try to commercialize the technology itself. Rather, it absorbed a huge amount of risk, which created an opening for the venture and enabled it to thrive. Contrast this to the CSIRO in the case of Ausmelt, and Macquarie University in the case of Proteome systems. In both cases, and in different ways, these institutions set themselves up in competition with the start-up venture. The consequence, in the case of Ausmelt, is that it had to compete with both MIM and CSIRO in addition to conventional smelters. This meant, among other things, that it did not have access to new knowledge these originating institutions created. Similarly, rather than meet the University's terms over intellectual property management, the founders of Proteome

Systems all resigned their university positions and went and invented around their own patents. This had several consequences for the risk the company was taking on, not the least of which was that the closing down of the research groups at the university made it much less likely that companies operating in a similar technical space would be spun out of the university. Given the strong pressures on CSIRO and the Universities to directly account for commercialization activity, rather than simply to support it in the community, this behaviour is not surprising, and is certainly not unique to these two cases.

5 Conclusions and further research

These ten cases are not representative of all innovation in Australia. As noted in the introduction, they have been deliberately selected to represent the high-technology end of the spectrum. This is a vanishingly small proportion of innovation in any economy. The vast majority of innovation is much more mundane. However, the innovations described in this working paper are critically important to an economy. It is products and processes like the ones described here that give a nation a toehold in new and emerging industries, and consequently provide the platform on which the other companies – the ones pursuing more mundane innovations – sit. It is difficult to say whether or not these cases are representative of high technology innovation in Australia in a statistical sense. That is, does the proportion of successes and failures match those of the broader population? Are the reasons for success and failure the same? We don't have the data to answer those questions with certainty. Notwithstanding, we are sure that these companies are far from unique. Their pathologies are representative of at least a significant sub-class of Australian organisations.

There are probably two overall conclusions to draw from the cases. The first is that it is probably much harder for these firms to be successful than it would be if they were located in another country. Second, there is no obvious single cause which, if solved would make the problems go away. Rather, it appears that the managers of these ventures are relatively poorly equipped for the task, on one hand, and that the environment they face as a source of labour, capital, and other inputs is significantly more problematic than in other countries. Furthermore, as a general rule, Australia is a more difficult domestic market for high technology products than other countries, and it is more difficult to export from Australia than from other countries. That is, these companies face a complex suite of barriers to success, and not just one or two obvious barriers which, if fixed, would make the problems all go away.

Notwithstanding, there are a number of areas where the issues appear to be particularly important, and consequently, I suggest them as areas for further systematic study.

- Innovation networks. One of the findings of this study was that the networks in which companies moved appeared to be particularly thin, and this created barriers to innovation. Consequently, I suggest a study which compares networks in Melbourne, Boston or Silicon Valley, and somewhere in Europe

- The governance of these companies appeared to be critically important. There is a need for a study of boards and their behaviour

- The way these companies managed risk emerged as a major them. Consequently, I suggest a study of risk and risk management in start-ups. This could include identification of the domains for which risk is higher or lower for Australian companies, and the sources of those risks, along with a study of the way that risk is managed.

- The major institutions (universities, CSIRO, Government agencies, Telstra etc.) appear to have a mixed impact on innovation performance. This should be studied in more detail.

- Overall, marketing and distribution by these companies appeared to be problematic. There is a place for a systematic study of marketing issues in Australian high-tech.

- There is a need for a study of financing and financier behaviour, especially that of Venture Capitalists and the superannuation funds.

- Finally, there is a clear case for further case-based qualitative research to broaden the picture.

Appendix 1: Case selection methodology

Note: This appendix was co-authored by Adam Waites.

This appendix comprises the following sections

1. Identification of potential companies
2. Assessment of company suitability
3. Contacting companies
4. Conducting the interview
5. Companies that were included
6. Companies that were excluded
7. Companies that declined
8. Companies that were not included and the reasons why

A marketing document was written to convey the objective of the project, the expectations of all parties involved. The expected input from the companies was based on the Harvard Business School document "Writing Cases and Teaching Notes".

Identification of potential companies

The initial plan was to identify companies based on broad research, including, for example, finding companies that had already been the subject of Harvard Business School cases. An IPRIA publication on the assessment of innovation and R&D in Australia provided a list of approximately 200 companies. This was supplemented by a list from Alan Jones (of the Federal Department of Industry, Trade and Resources) of another 200 or so companies on which he had written cases, some short and a few long. However, it soon became clear that assessment of the potential value of each company would require a few hours of research, which might miss out some of the interesting aspects. It was then decided to adopt a different approach.

The second approach was to ask people who had been involved in innovation and commercialisation in Australia for their opinions on which companies might be worth investigating. These people were referred to as ‘champions’ to differentiate them from the contacts within the companies. They were:

1. Ergad Gold – Principal at Momentum VC, enthusiastic about the project, and a participant in early discussions
2. Malcolm Thornton, Investment Director at Starfish Ventures, MBS alumnus, involved with MUEC
3. Ruth Drinkwater, Senior Manager, AIC
4. Bruce Godfrey, ex-CEO of CFCL, EDRC etc
5. Bruce Bayley, General Manager Ventures and Investment, MUP
6. A book by Brad Howarth ‘Innovation and Emerging Markets’ (Howarth, 2003), which contained descriptions of about 50 entrepreneurial, technology-based companies.

The champions provided varying degrees of assistance. Dr Gold, for example, provided a brief description of each company’s history, highlighting interesting aspects, and also provided suggested contacts, many of whom knew him personally. He also allowed the use of his name as an introduction. Others provided names, sometimes a call ahead to clear the way.

Using this method, about 100 companies were identified as having strong potential.

Assessment of company suitability

There were two characteristics that defined the companies’ probable suitability. Firstly, the practical aspects were important. These included access to management for the interviews, a sufficiently long history to provide depth in the case, access to information, and a willingness to participate. The second aspect related to the relevance to general innovation and commercialisation theory, as well to specific areas of theory of interest to the academics involved.

The practical aspects were fairly straight forward. The theoretical aspect was less so, since, as anyone trying to find the ‘answers’ to questions on innovation and commercialisation will soon find out, the body of literature is substantial. The framework was that proposed by Jolly (1997). The models proposed by Dodgson (2000) and Henry and Walker (1991) were also useful.

Adam Waites assessed companies based on the practical aspects, particularly length of history and stage of commercialisation. This allowed, for example, the elimination of many of the companies described in Howarth (2003). He also assessed the suitability of most of the companies by browsing their websites, and trying to identify possible areas of interest. Through this method, a few companies, particularly in the energy field were eliminated because they were not well advanced in the commercialisation process, or had not expanded beyond Australia. Essentially, the companies were selected based on a judgment which incorporated Waites’ assessment of the interest value, the time in existence, the practical aspects, and extent of the commercial development. It should be kept in mind that the use of the champions provided an additional selection ‘round’, in that the champions were often aware of the interest value of the companies. It should be noted that one consequence of selecting companies with relatively long histories is that, with the exception of Proteome Systems, all of the companies pre-date many of the current programs which governments provide to assist innovation-oriented start-ups.

Contacting Companies

In many cases the champions provided names of suggested contacts. For those companies listed in Howarth’s book, the founders were often interviewed for and quoted in the book, and hence provided a logical contact. Where this was not the case, the correct person was identified by phoning the company and asking the receptionist or by visiting the website and finding a name. The company secretary is often a good place to start, as is the corporate communications or PR person. In most cases, when the project was explained, they were able to suggest the correct people to speak to.

In some cases, in spite of many attempts, it was not possible to contact people within the company.

Conducting the interview

Interviews were scheduled for an hour. In most cases, this was preceded by preliminary research, often through browsing the company's website to obtain some idea of the technology and the company history. The interviews generally flowed more easily if the interviewee had read the marketing document and hence had a reasonable understanding of what was to be discussed. Essentially the aim of the interview was to establish the history of the company, and try to identify interesting aspects along the way. The Jolly model referred to earlier was useful in this regard, as it provides a number of activities companies should perform in the process of commercialisation, which provide areas to probe for detail. In some cases, certain steps along in the process appeared to be missing, which provided a basis for exploration.

Where possible, given the general flow of the interview, the following issues were covered in the interviews: IP protection, application of technology, channels of distribution, entry into foreign markets, capital and funding, management, market demand vs. technology push etc. In most cases, and hour was sufficient time to get an understanding of some of the key issues, and to assess the suitability of the company.

Companies that were included

The following companies were included in the summaries presented to the selection panel.

Ambri	Florigene	Mine Site Technologies
Anatomedia	Fultec	Polartechnics
ANCA	GBC	Pronto
Ausmelt	Gradipore	SAAB ITS
BHPBilliton	Iatia	SGE
CFCL	Lansa	The Preston Group
Compumedics	Managesoft	TripleP
Computershare	Medicoll	Ventracor
Datacraft	Micronisers	Vision Systems
Emagine	MINCOM	Wedgetail

Table A.1 Short list of case organisations

These were companies that had passed the previous screening rounds (i.e. had been suggested by a champion, and initial research had not eliminated them based on practical issues). Most importantly, these were companies which had been successfully contacted and agreed to participate. It should be kept in mind that the emphasis was on securing the participation of as many companies as possible for presentation to the selection panel, which would ultimately decide which companies would be chosen.

From the above list, the selection panel (Peter Cebon, Richard Speed, Ruth Drinkwater) selected twelve organisations for case development. Eight were based in Melbourne, and four in Brisbane. The cases discussed in this working paper comprise seven of the eight Melbourne cases, plus the Extended Wear contact lens case, Incat, and Proteome Systems, all of which were identified by a separate means.

References

Abernathy, W. J., & Clark, K. B. 1985. Innovation: Mapping the winds of creative destruction. ***Research Policy***, 14: 3-22.

Carter, C. B., & Lorsch, J. W. 2003. ***Back to the Drawing Board: Designing Corporate Boards for a Complex World***. Boston: Harvard Business School Press Books.

Cohen, W. M., & Levinthal, D. A. 1990. Absorptive Capacity: A New Perspective On Learning And Innovation. ***Administrative Science Quarterly***, 35(1): 128-152.

Cooper, R. G., Edgett, S. J., & Kleinschmidt, E. J. 2004. Bench Marking Best Npd Practices--III. ***Research Technology Management***, 47(Issue 6): 43.

Daft, R. L., & Weick, K. E. 1984. Toward a model of organizations as interpretation systems. ***Academy of Management Review***, 9(2): 284-295.

Dodgson, M. 2000. The management of technological innovation : an international and strategic approach. Oxford [England] ; New York: Oxford University Press.

Dougherty, D. 1996. Organizing for innovation. In S. R. Clegg, C. Hardy, & W. R. Nord (Eds.), ***Handbook of organization studies***: 424-439. Thousand Oaks CA: Sage.

Dougherty, D., & Heller, T. 1994. The illegitimacy of product innovation in established firms. ***Organization Science***, 5(2): 200-218.

Eisenhardt, K. M., & Tabrizi, B. N. 1995. Accelerated adaptive processes: Product innovation in the global computer industry. ***Administrative science quarterly***, 40(1): 84-110.

Gomory, R. E. 1989. From the `ladder of science' to the product development cycle. ***Harvard Business Review***, 67(Issue 6): 99-105.

Henry, J., & Walker, D. 1991. ***Managing innovation***. London: Sage.

Howarth, B. 2003. ***Innovation and emerging markets, where the next bulls will run***. Brisbane: Wrightbooks (an imprint of John Wiley).

Jolly, V. K. 1997. ***Commercializing new technologies : getting from mind to market***. Boston, Mass.: Harvard Business School Press.

Jones, B. O. 1982. ***Sleepers, wake! : technology and the future of work***. Melbourne ; New York: Oxford University Press.

Leonard-Barton, D. 1995. Wellsprings of knowledge: Building and sustaining the sources of innovation. Boston, MA: Harvard Business School Press.

Lester, R. K., & Piore, M. J. 2004. ***Innovation, the missing dimension***. Cambridge, Mass.: Harvard University Press.

Maidique, M. A., & Zirger, B. J. 1985. The New Product Learning Cycle. ***Research Policy; Amsterdam***, 14(6): 299-313.

Moore, G. A. 2002. Crossing the chasm : marketing and selling high-tech products to mainstream customers (Rev. ed.). New York: HarperBusiness.

Roberts, J., McNulty, T., & Stiles, P. 2005. Beyond Agency Conceptions of the Work of the Non-Executive Director: Creating Accountability in the Boardroom. ***British Journal of Management***, 16(Supplement): 5-26.

Schein, E. H. 1985. Organizational Culture and Leadership: A Dynamic View. San Francisco: Jossey-Bass.

Tushman, M. L., Anderson, P. C., & O'Reilly, C. 1997. Technology cycles, innovation streams, and ambidextrous organizations: Organizational renewal through innovation streams and strategic change. In M. L. Tushman, & P. C. Anderson (Eds.), ***Managing strategic innovation and change***: 3-23. New York: Oxford.

Weick, K. E. 1995. ***Sensemaking in organizations***. Thousand Oaks CA: Sage.

Weick, K. E., & Roberts, K. H. 1993. Collective mind in organizations: Heedful interrelating on flight decks. ***Administrative Science Quarterly***, 38: 357-381.

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