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Forming New ICT Industry Clusters in Victoria

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Forming new ICT Industry Clusters in Victoria

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Forming new ICT Industry Clusters in Victoria

1. Executive Overview

There are several ways Victorian industries, R&D organisations and universities could benefit from the formation of Information and Communications Technology (ICT) industry clusters around intelligent transport systems or project lifecycle technical data and knowledge management for collaborative engineering. This paper explains the "industry cluster" concept, reviews the current state of incipient local ICT clusters, points to some case studies where companies have benefited, and suggests practical things that local organisations may do to encourage and exploit cluster development activities for their own benefits.

Groups of companies in some geographic regions have generated great wealth via exports, compared to similar types of companies scattered elsewhere in the world. Well known and famously successful clusters in the knowledge intensive ICT industry include "Silicon Valley"[1,2], the Finnish telecommunications cluster[3,4], North Jutland's wireless communication cluster[5,6], and the Irish Software Cluster[7]. Participating companies in such clusters have benefited greatly.

Michael Porter's idea of an "industry cluster"[8] explains the sometimes remarkable export successes such groups have achieved. According to Porter, "a cluster consists of industries linked through vertical (buyer/supplier) or horizontal (common customers, technology, channels) relationships." Key features include local linkages and formal and informal interactions to share ideas and knowledge. Observing successes, many governmental organisations seek to facilitate cluster formation in their regions. Johnston[9] observes that such efforts have limited success: "Clusters cannot be 'manufactured'; however conditions can be established which facilitate the formation of clusters and their contribution to economic value." These conditions include (1) easy exchange of knowledge, information and ideas between firms – especially tacit and informal knowledge, (2) access to generic qualified labour, (3) access to markets, (4) access to new

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1 Davidson, A. 2000. Into the valley. Management Today, November 2000.

2 Kenney, M. von Berg, U. 1999. Technology, entrepreneurship and path dependence: Industrial clustering in Silicon Valley and Route 128. Industrial and Corporate Change 8:67-103.

3 Pajia, L. 2001. What is behind the Finnish "ICT miracle"? Finnish Economy and Society 3:51-54. - www.etla.fi/files/932_FES_01_3_ict_miracle.pdf

4 Ali-Yrkkö, J. 2001. The role of Nokia in the Finnish Economy. The Finnish Economy and Society 2001/1:72-80 - http://www.etla.fi/files/940_FES_01_1_nokia.pdf?PHPSESSID=5eb33d4a84d2ed092296ecec77366199

5 Pedersen, C.O.R. 2005. The development perspectives for the ICT sector in North Jutland. PhD Thesis, Department of Business Studies, Aalborg University. 329 pp. - www.business.aau.dk/~crp/CRP_PhD_Thesis.pdf

6 Dhal, M.S., Pedersen, C.O.R., Dalum, B. 2005. Entrepreneurial founder effects in the growth of regional clusters: How early success is a key determinant. Danish Research Unit for Industrial Dynamics. DRUID Working Paper No. 05-18, 21pp. - http://www.druid.dk/wp/pdf_files/05-18.pdf

7 Hot Origin. 2003. Ireland's software cluster: Winning Sales - Lessons from the Frontline. - http://www.hotorigin.com/uploads/HotOrigin-%20Ireland's%20Software%20Cluster%202003%20-%20Winning%20Sales%20-%20Lessons%20from%20the%20Frontline.pdf

8 Porter, M.E. 1990. The Competitive Advantage of Nations. Macmillan, London.

9 Johnston, R. 2003. Clusters: A Review. Mapping Australia's Science and Innovation System Taskforce. Department of Education, Science and Training. - Australian Center for Innovation Limited. - http://www.dest.gov.au/NR/rdonlyres/194EF998-BF98-40BA-8269-8210A8C410F7/1361/clusters.pdf

ideas, (5) access to specialised services or facilities and (6) access to highly skilled and specialised staff..[10]

According to Stan Beer[11], the Victorian ICT industry is stagnating. Apparent exceptions to this trend include some innovative and successfully exporting companies with products in the document authoring and engineering technical data management areas. A "stagnant" industry also has slack to support rapid growth if core ideas are found to give new directions and competitive edges.

Although Porter clusters may be hard to form by outside intervention, there are other, more easily formed industrial associations or "virtual business networks"[12] that may help crystallise successful clusters and be consciously constructed or guided to focus on tangible benefits for the parties. These offer advantages of clustering, plus developing synergism of interests and minimising direct competition. Probably the single most important cluster facilitator is the relative ease with which innovative personal knowledge can be shared amongst the participants. Unlike money that is divided when shared, knowledge is multiplied through sharing.

Case studies show that actions by one or two key organisations may be enough to crystallise the formation of an active cluster. The author is aware of two related ICT areas that seem ripe for cluster development, i.e., around engineering project management/fleet lifecycle support and intelligent transport systems. Given their prominence in Victoria, Tenix Defence[13] and/or one of the universities in Melbourne may be organisations able initiate such crystallization. Based on the author's familiarity with both organisations, the focus in this paper is on Tenix and the University of Melbourne.

Unique contractual requirements imposed on Tenix Defence by the 17 year-long ANZAC Ship Project[14] ("ASP") led to Tenix developing innovative software, procedural knowledge, collaborations and informal connections among suppliers of ICT systems relating to engineering project management and fleet maintenance management. As detailed below, Tenix innovated some applications itself (e.g., Crossbow[15], CSARS[16]), local innovators developed others (e.g., TeraText DMS[17], FMMS/AMPS[18]), and some applications from multinational organizations were locally adapted and implemented to meet Tenix integration requirements (e.g., Matrix[19], TeamCenter[20]). Tenix has also built its engineering, fleet and project management capabilities over the full ASP lifecycle, from requirements development and contracting, through in-service support and operational monitoring. ASP success and lessons learned have helped Tenix to expand its business across the full range of defence projects and into infrastructure engineering/maintenance and high technology businesses. In a similar way, Tenix

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10 van der Meer, A., van Winden, W., Woets, P. 2003. ICT clusters in European cities during the 1990s: development patterns and policy lessons. MUTEIS Macroeconomic and Urban Trends in Europe's Information Society. - http://www.culminatum.fi/content_files/ictclusters.pdf

11 Stan Beer, summarising a Centre for Innovative Industry Economic Research (CIIER) workshop on Exchange Alert - IT Wire, 2 June 2005 - http://www.itwire.com.au/content/view/1468/885/; http://www.itwire.com.au/content/view/1469/885/.

12 Thompson, K. 2005. A taxonomy of virtual business networks. The Bumble Bee - http://www.bioteams.com/2005/07/18/a_taxonomy_of.html

13 http://www.tenix.com/Main.asp?ID=27

14 http://www.tenix.com/Main.asp?ID=29

15 http://www.tenix.com/Main.asp?ID=934

16 Class System Analysis and Reporting System - jointly developed by RAN and Tenix

17 http://www.teratext.com.au/get/page/browser/browser?category=Products/TeraText%20DMS

18 http://www.eden.com.au/product/amps.shtm

19 http://www.3ds.com/products-solutions/plm-solutions/enovia-matrixone/overview/

20 http://www.ugs.com/products/teamcenter/

Solutions[21] seems to be building a network of connections around its traffic management and enforcement business.

Informal networks among the "exceptional" organisations contributing software systems to the engineering management/logistic support area already exist through Tenix activities to use and integrate their software for various projects. Also, Tenix already has existing or past associations with relevant industrial and university research centres and people in Melbourne (e.g., DSTO's[22] Maritime Platforms Division, CSIRO's Manufacturing & Infrastructure Technologies[23], CRCIMST[24], Intelligent Transport Systems - Australia (ITSA)[25], the KM Lab in Monash University's Department of Information Technology[26], and a potential KM working group at University of Melbourne crossing the faculties of Arts, Economics and Commerce, Education, Engineering, and Science[27].)

The opportunity(ies) to establish a multidisciplinary project lifecycle and engineering KM lab at University of Melbourne able to perform systems research, integration and training, and/or a KM/ICT lab in the new ITSA transport research facilities in South Melbourne could provide the kind of nuclei around which virtual enterprise networks (VENs)[12] could be formed. In either case, a small amount of seed funding could crystallise already existing mutual interests to form such organisations and attract substantial matching funds from other players, state and federal government and even overseas players[28]. For example, Tenix has already invested several million dollars to partially integrate some of the ICT cluster's systems to improve its ability to manage engineering and logistic support technical data, information and knowledge. By supporting the kind of R&D lab described above, it should be possible to achieve global project and engineering management systems applicable across engineering organisations and developing industrial and client alliances, and that would also provide demonstrators and case study research to promote the IT products involved to export markets. Other companies may find similar benefits from participating in cluster development.

2. Introduction and Background

2.1 The concept of industry clusters

According to Michael Porter in *The Competitive Advantage of Nations*[8], clusters of companies and their related supporting industries sharing factor conditions; demand conditions; strategy; structure and competitive rivalry can be highly successful competing in world markets against dispersed companies.

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21 http://www.tenix.com/Main.asp?ID=844

22 http://www.dsto.defence.gov.au/

23 http://www.cmit.csiro.au/brochures/serv/manufacturing/

24 http://web.archive.org/web/20050204073113/http://www.crcimst.com.au/ [CRCIMST has now closed]

25 http://www.its-australia.com.au/kmxserver3/

26 http://km-svr.sims.monash.edu.au/

27 Convened by Tenix Defence's Bill Hall, who is also a member of the Arts faculty via his appointment as National Fellow, in the Australian Centre of Science, Innovation and Society, and Susu Nousala, Tenix KM Intern and Research Fellow and Grants Manager in the Faculty of Economics and Commerce.

28 Susu Nousala (Tenix KM Intern) has extensive connections with European research institutes who have ready access to EU 6th and 7th Framework Program R&D funds. Initial meetings in France and Melbourne with potential European research partners has already demonstrated substantial interest in Melbourne developed ICT systems for which there are no comparable European counterparts.

Geographic proximity facilitates the formation of such clusters. Successful clusters, as demonstrated by the spectacular successes of Silicon Valley and the telecommunications cluster around Nokia in Finland, can have a major positive impact on the economy of a region or even a whole country. Consequently, many regions around the world are attempting to promote the formation of industry clusters.

2.2 Kinds and formation of industry clusters

Clusters are classified by the circumstances that bring them together. At the broadest level, Johnston[9] divides them into two classes, those driven by trading or commercial requirements, and those brought together by the benefits of sharing knowledge. Many will involve the operation of both components. Obviously, in all cases the long term sustainment and success of a cluster is measured by the economic success of its members and region.

Cluster classes based on knowledge sharing include:

- Self-creating - reliant on major self-investments in knowledge generation, and purchase of know-how in non-core technologies
- Absorptive - heavily reliant on knowledge base of their major suppliers
- Self-sufficient - companies absorb knowledge via intermediate deliveries largely created by public sector research
- Knowledge intensifying - companies make use of research and technology to increase the knowledge intensity of their goods and services

Other factors that may help cluster formation include

- research for knowledge creation
- industrial leadership
- pool of trained labour
- training and education
- networking
- venture capital
- hosting infrastructure
- entrepreneurship
- shared supporting industries
- associated services
- structurally related industries
- association with key industries
- functionally related industries
- strong customers

Most of these considerations relate to environmental factors that offer little opportunity for direct control. However, networking and industrial leadership provide the means by which other factors can be built and structured to support cluster growth. Thompson[12] gives a taxonomy of business enterprise networks that suggest how networks can be organised to support growth. He assumes that much of the networking will be virtual (i.e., involving linkages via internet technology). Of course, when organisations exist in close geographic proximity the networking can also be direct (e.g., face-to-face). Pedersen[5] observes that inter-firm brainstorming and innovation probably works best face-to-face, which is most easily achieved when firms are in close geographic proximity. Most usefully he provides additional dimensions along which different kinds of networks can be differentiated:

- Topology (e.g., one to many star dominated by a single organisation or many to many)

- Primary objective (e.g., skills dev't, lobbying, collective selling, collective product dev't)
- Level of cooperation (external info exchange, sharing best practice, collective bids)
- Longevity (long term association or purpose specific)
- Legal formality (informal association, semi-formal with NDAs, multi-lateral legal, joint enterprise)

Thompson[12] defines each of the network types in terms of these types of association and discusses the risks and benefits associated with the types along each dimension. As will be discussed in the case studies to follow, these represent various network parameters that can be tweaked to achieve particular measures of cluster success.

2.3 But, clustering is not the answer to everything

On the other hand, like many other fads, application of the cluster concept can lead to unrealistic expectations and even some potential dangers from promoting them[29].

> [C]luster policy may sponsor an exaggerated view of the extent to which firm performance is determined by local context. For instance, Porter (1998a) claims, 'The presence of clusters suggests that much of competitive advantage lies outside a given company or even outside its industry, residing instead in the locations of its business units'.... Internal and external advantages are clearly not independent, but if a company suffers from poor management, culture and practices it is hard to believe that it can rely on the competitive advantage of its location. While supporting institutions and a networked semi-public sphere may often be necessary for innovative and dynamic firm performance, such factors are unlikely to be sufficient.

Local and regional specialization may also be risky as shown by the recent downturn in Silicon Valley. There are many areas of industrial specialization that were once prosperous and dynamic but are now in decline. The reasons for such decline can be internal or due to external changes such as changing technologies, and can be exacerbated if the cluster suffers from locking in ways of thinking and doing things.

> What is striking is that in much of the literature on cluster policies, there is no real reason why place marketing and the advertising of industrial specialisms really needs to be tied to a 'cluster' label of doubtful relevance and content. There is no reason why co-ordination between different policies and groups should be handicapped with a confusing cluster framework, or why the provision of demand-led, productivity enhancing services to firms would be improved by setting up some imagined cluster boundaries

Table 1. Clusters have costs as well as benefits (from Martin & Sunley)[29]

Claimed advantages	Potential disadvantages
Higher innovation	Technological isomorphism
Higher growth	Labour cost inflation
Higher productivity	Inflation of land and housing costs
Increased profitability	Widening of income disparities
Increased competitiveness	Over-specialization
Higher new firm formation	Institutional and industrial lock-in
High job growth	Local congestion and environmental pressure

[29] Martin, R., Sunley, P. 2003. Deconstructing clusters: chaotic concept or policy panacea. Journal of Economic Geography. 3(1):5-35.

A similar message is given by Ron Johnston from an Australian perspective[9]:

- Co-location does not necessarily produce collaboration.
- Many attempts to manufacture clusters as engines of regional development fail. Probably more than half fail, and as few as 10% are significantly successful.
- Clusters can die if initiating conditions change.

Johnston lists several developmental paths that can lead to cluster failure:

- focus on real estate;
- concentrate on attracting outside investment
- use political forces to push for creation of components that don't already exist
- provide government assistance to firms where market failures exist
- allow government agencies to plan cluster development
- keep all information confidential until the proposal is finalised

However, theoretical and case studies of cluster and enterprise network associations suggest that Victorian organisations can gain a lot from providing some leadership and minor (in cost terms) stimuli and collaborating with components of the Melbourne IT industry and associated academic and research institutions towards some common interests. Essentially all the factors for sustainable cluster success seem to be present. What has been lacking is leadership to actually work together.

3. Case studies

There are a number of examples of successful ICT cluster formation that could be presented. Two cases are selected because (1) of the extent of the studies into the factors that have contributed to their formation and (2) they have taken place in small countries that lacked major natural resources relating to their success, (3) they are relatively recent instances of phenomena of interest, and (4) substantiating material is available on the Web. These are a technology led ecosystem that formed in Denmark's North Jutland area around the provincial capital of Aalborg and its university, and a collaborative supply chain formed in Finland around Nokia that both demonstrate how the kinds of factors discussed above can lead to the successful formation and survival of clusters for periods of a decade or more.

3.1 North Jutland, Denmark

One of the best documented ICT clusters formed in the North Jutland area of Denmark around the provincial capital of Aalborg.[5,6,30,31]

3.1.1 Denmark's ICT sector

Denmark, with a population of 5.4 million has some significant advantages - North Sea Oil, easy access to the world's oceans and shipping lanes and a long history of maritime activities going back to the Vikings. The maritime activities may have had some small

[30] Dahl, M.S., Dalum B. 2001. The ICT cluster in Denmark. Chapter 4, Innovative Clusters Drivers of National Innovation Systems. OECD Proceedings, pp. 65-89 - http://www.insme.it/documenti/Innovativeclusters.pdf

[31] Ministry of Science Technology and Innovation. 2002. IT research and development in Denmark - http://videnskabsministeriet.dk/site/forside/publikationer/2002/it-research-and-development-in-denmark.

role in formation of the North Jutland cluster, but as will be seen other factors not relating to natural resources have been more significant.

The ICT sector in Denmark now accounts for between 10 and 15% of the private sector economy and has four major segments: IT/electronics, telecommunications, broadcasting, information/ entertainment[30]. However, unlike Finland (dominated by Nokia) or Sweden (where Ericsson dominates ICT), no one company dominates in Denmark. In terms of education for technology work, Denmark is above the EU average but falls somewhat behind Finland and Sweden. Denmark is comparable to Norway and Sweden in the number of employees with university degrees in ICT. Aalborg and the Technical University in Copenhagen produce most engineers. Denmark has a comparatively low rate of patenting (although in the ICT cluster this is rising) - perhaps due to the absence of any major indigenous companies that have become multinational[30]. However, Denmark is a "development hub" in the process of taking innovations to market.

3.1.2 ICT in North Jutland and North Jutland's wireless telecoms cluster

Pedersen's PhD thesis[5], completed in the Department of Business Studies, Aalborg University, focuses on growth of the ICT industry in the North Jutland region around Aalborg in the 1990's, with particular focus on a subset of companies focusing on wireless communication forming the NorCOM association. NorCOM is a formal association formed by some of these businesses and Aalborg University in 1997. The cluster as a whole is defined by a joint knowledge base, relating to electronic signals transmitted by radio waves. Pedersen considered the cluster included around 35 - 50 firms, 25 of which belonged to the NorCOM association, plus the NOVI technology park and the University. The restricted definition allowed the history, formation and sustenance of the cluster to be studied in detail.

Prior to the 1980's North Jutland was characterised by traditional industries (e.g., shipbuilding) and some of the highest unemployment in Denmark. In 1990's, the region of North Jutland has seen a strong growth of industries and knowledge environments in the IT field, particularly in wireless electronic communication, software development and IT services, and components for the electronics industry. North Jutland is currently recognised for its cross-sector co-operation and numerous networks involving companies, schools, professional and industrial bodies, public authorities and, not least, Aalborg University. These networks often form the basis for establishing more formalised knowledge centres, including NDB (databases), CPK (wireless technology) and CISS (embedded software).[31] Networking has been facilitated by the local technical university and the creation of a science park/innovation centre.

Although small by comparison to all but one of Melbourne's universities[32], Aalborg University, with an enrolment of 14,000[33], is said to be one of the main contributors to

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[32] Melbourne University 33,600 effective full-time equivalent students (EFTS) in higher education in 2004 and 2005 - http://www.unimelb.edu.au/publications/docs/annual_report2005.pdf;
Monash 48,000 (exclusive of overseas campuses) in 2004 - http://www.monash.edu.au/pubs/ar/AnnualReport2004.pdf;
RMIT 28,000 in 2004 - http://mams.rmit.edu.au/c3uho323rdqvz.pdf;
Latrobe University 20,000 in 2005 - http://www.latrobe.edu.au/stats/pages/statistics.html;
Swinburne 10,000 EFTS in - http://www.swinburne.edu.au/corporate/spq/docs/statistics/summaryT1.xls;
Deakin 21,000 in 2004 - http://www.deakin.edu.au/about/stats.php#student_enrolments;
Victoria 18,000 in 2004 - http://www.vu.edu.au/library/pdf/2004ARStudents.pdf.
Total EFTS in Victoria 186,000 (many of whom will be fee-paying students from overseas). Note that EFTS discounts students only studying part time.

[33] http://en.aau.dk/. The Department of Communications Technology has a total staff of 200, including PhD students - http://vbn.aau.dk/research/afdeling_for_kommunikationsteknologi(318)|persons

this growth. The University's capabilities in mobile communications research has helped to bring R&D departments of several leading mobile companies to North Jutland.

NOVI, the regional science park and innovation environment formed in 1988 when three large companies in North Jutland closed[34], adding 2000 people to an already large pool of unemployed. NOVI has been an important catalyst for developing knowledge-based IT enterprises[35]. One hundred shareholders provided an initial capital of DKK 35 m, with additional support from the Danish Ministry of Education and the EC Regional Fund. NOVI housed a varying selection of companies as well as a number of research institutions and technological service institutes. Aalborg University was an important partner with close relations existing between the residents in NOVI and a large number of the technically based university institutes. NOVI made money available out of its own share capital for the early stages of project development (max. DKK 2.5m in equity or venture capital per project).

NorCOM's origins can be traced to the early 1960s when a consumer electronics producer, S.P. Radio, started making radio telephones for small ships. Further development of an ICT industry followed the founding of Aalborg University in 1974. A cluster grew up around these nuclei and expanded into other wireless communications technologies, and by the late 1990s accounted for the majority of the total ICT employment in North Jutland. Most of the initial cluster firms - often owned by foreign firms or multinationals - were very R&D intensive.

Aalborg University graduated its first MSc's in electronic engineering in 1979 with rapidly growing research activities, and by 1980 North Jutland industry had become visible in the context of maritime communications and printed circuit boards. The launch of the Nordic Mobile Telephony system in 1981 added impetus to growth of the embryonic cluster. Erickson, Nokia, Dancall and Storno (sold to Motorola in 1986) began growth as producers of mobile equipment, followed by Siemens and Alcatel. By the end of the 1980's North Jutland was internationally visible as a producer for the Nordic Mobile Telephony scheme. The first cohort of electrical engineering M.Sc's and the close university-industry interaction facilitated this early development. The outcome was not the result of a deliberate policy, but Pedersen claims cluster formation and growth could not have happened without the establishment of Aalborg University. For example, more than half the engineers surveyed in his studies of the NorCOM cluster were Aalborg University graduates.

The establishment of the pan-European GSM standard for all digital telephony that became operational in 1992, and the competing 2G technologies in the US and Korea started a new growth cycle that required the complete rebuilding of the Nordic Mobile Telephony system. The internationally visible knowledge and innovation structure in the region led to the formation of joint venture organisations to develop suitable technology for the new standards, which then became NOVI[5,35], established on the neutral ground of Aalborg University.

Very rapid growth took place in the latter half of the 1990's, to a certain extent based on close personal interaction between engineers with a high degree of inter-firm mobility[36,

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[34] Aalborg Shipyard closed in 1987. It is unclear whether Pedersen includes this in one of the large companies that closed in (around?) 1988.

[35] http://www.novi.dk/NOVI/Historie/?newLanguage=en

[36] Dahl, M.S. 2002. Embedded knowledge flows through labor mobility in regional clusters in Denmark. DRUID Summer Conference, Hensingoer, Copenhagen, Denmark - http://www.druid.dk/conferences/summer2002/Papers/DAHL.pdf

[37]. This led to expansion of the cluster both horizontally and vertically: horizontally by spin-off and start-up of companies and movement of skills into adjacent areas of technology, such as cordless phones; and vertically, by the entry of companies into lower or higher levels of the wireless communications supply chain, e.g., telephony operators, chip makers and telephony software developers.

University R&D and education thrived further in the late 1990s. Electronic engineers were needed all over Europe. Any region that could offer qualified engineers and an innovative research environment in the wireless field could attract multinational companies, as North Jutland did. During 1999-2000 there were 35-40 NorCOM firms, employing 4,200 people - representing half the ICT employment in the region.

In his thesis, Pedersen emphasises the importance of social networking in the formation and sustenance of NorCOM[5]. The social network forms naturally when people meet through studies, work or friends. The social contacts involve informal exchanges that tend to be relatively stable over time since the creation of contacts takes times and involves trust and frequent interaction. As the number of transactions and the level of trust increases, the value of the knowledge traded may also increase. Job changes within the industry also create bridging social networks. Although such social networks can be formed and maintained virtually, formation is facilitated by personal contact enabled by geographic proximity.

3.2 Finland

The success of Nokia and the ICT cluster that has grown up around it has enabled Finland, a country of only 5.2 million people and few natural resources except for timber, to achieve economic parity with European countries like England, France and Germany[38]. In Finland, a focus on mobile telecommunications equipment was stimulated by the formation of a trans-border Nordic Mobile Telephone network in 1981-82, followed by full deregulation that was finalised in 1994. Before the 1980's the telecommunications equipment market was dominated by foreign manufacturers such as Siemens, Ericsson and ITT.

3.2.1 Nokia

Nokia's history is outlined in a number of documents[39, 40]. In the early 1960's there were three significant producers of telecommunications equipment in Finland surviving from the 1920's that eventually coalesced to form the current Nokia. In these companies concentrating on main lines of business such as cables, rubber and consumer electronics such as radios and TVs, new radio technology was developed in back rooms by "fervent engineers who often had to endure suspicion and opposition from their more conservative colleagues". The Post and Telecommunications Organization (PTO) developed an R&D capability that was industrialised and eventually privatised. An Army need in 1963 for radiophones stimulated some R&D targeting mobile communications.

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[37] Dahl, M.S., Pedersen, C.O.R. 2003. Knowledge Flows through Informal Contacts in Industrial Clusters: Myths or Realities?. DRUID Working Papers, 03-01. - http://www.druid.dk/wp/pdf_files/03-01.pdf

[38] The World Factbook 2005. Central Intelligence Agency - http://www.cia.gov/cia/publications/factbook/geos/fi.html

[39] Paija, L. 2001. The ICT cluster: The engine of knowledge-driven growth in Finland. Chapter 2 - Innovative Clusters Drivers of National Innovation Systems. OECD Proceedings, pp. 19-46. - http://www.insme.it/documenti/Innovativeclusters.pdf

[40] Yla-Anttila, P. 2000. Nokia and Oulu - national and regional growth drivers in Finland. seminar paper, Verdiskaping, kompetanse og innovasjon, mot en ny politikk for nyskaping og næringsutvikling, Oslo May 8, 2000 - http://odin.dep.no/krd/norsk/tema/distrikts/016061-990018/dok-bn.html

Simplifying what is a complex story of mergers, in 1966, a 100-year old wood-working company, Nokia, merged with Suomen Kaapelitehdas (Finnish Cable Works), who produced telecommunications cables, and Suomen Gummitehdas (Finnish Rubber Works) to invest in telecommunications R&D as a new area of strategic investment. In the 1970's, realising that the local market was too small for both of them, the privatised PTO company merged with Nokia, and in 1979 a third player, producing consumer electronics, also merged with Nokia.

In 1982 the Nordic countries collectively introduced the Nordic Mobile Telephone network standard, and opened this to competition, which was addressed by a partly owned subsidiary of Nokia, Mobira, and 9 other manufacturers. Mobira took a global view, and by 1985 it held a leading position in several foreign markets, with sales growing at 50% a year. By 1986-87, Finnish telecommunications know-how was all centralised under the one Nokia management.

This consolidation was soon followed by a financial crisis and associated resulting from the collapse of Russian bilateral trade. Nokia survived the downturn by starting to shed all of its non-telecommunications assets. In 1983 as its Russian markets collapsed, Nokia still had 4 sectors - cable, forest, rubber and electronics, where electronics represented only 20% of company sales. By 1985-6 more than 50% of Nokia's sales were in electronics. By 1994-5 100% of company sales were electronics[39].

By 1999, Nokia accounted for 4% of Finland's GDP and 25% of its exports. By comparison, the corresponding shares of Ericsson in Sweden are: GDP 2 % export 15 %. However, as large as Nokia has become in the Finnish economy, it accounts for less than half the total ICT cluster's sales. The ICT cluster as a whole grew to more than 3000 companies (mostly small and medium sized companies, where only 300 of them are first tier suppliers to Nokia.

3.2.2 The cluster around Nokia[3,41,42]

During the 1990's, Finland came to lead the world in high-tech trade surplus among indigenous high-tech producers. Electronics and electro-technical exports almost tripled at the expense of pulp and paper and metals, to nearly 30 per cent of Finland's total manufacturing exports - and also to achieve 30 per cent of the global mobile phone market. Nokia is unquestionably the "motor" of this growth.

Much of this is due to the establishment of a production value chain (Figure 1). Nokia is a typical network company that outsources most production to concentrate on key competencies, namely product design, R&D and brand management. A key strategy is to engage actively in R&D co-operation with technology firms to induce innovation and to stay in the technological lead. It has many strategic R&D partnerships, both with small innovative enterprises and leading international ICT companies.

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41 TIEKE 2005. ICT Cluster Finland Review 2005. TIEKE Finnish Information Society Development Centre - http://www.tieke.fi/mp/db/file_library/x/IMG/13751/file/ITC-finland_050322_LR.pdf

42 Paija, L. 2000. Industrial network relationships in the Finnish ICT cluster. OECD National Innovation Systems: Workshops and Meetings of the Focus Group on Clusters (Phase III): Focus Group on Clusters. Workshop of the Focus Group on Clusters, 8-9 May 2000, Utrecht - http://www.oecd.org/dataoecd/34/57/2098542.pdf

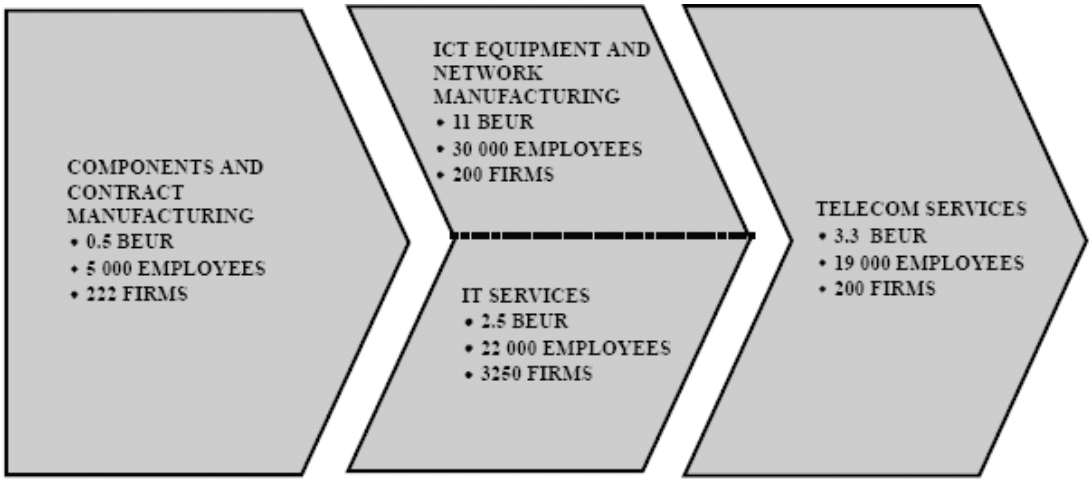

Figure 1. Production value chain in the ICT cluster – turnover, employment and number of firms in 1998 from Paija 2000[42]. Note: IT services include IT consultancy, software supply, computer hosting, data processing and equipment.

As Nokia focussed its business on telecommunications, it spun out some 15 firms, some of which have taken important subsidiary roles in the cluster. It has also acquired many recently formed companies in Finland and elsewhere operating in its strategic area, to absorb and induce future technologies. Attracted by the ferment, many multinationals (e.g., IBM, HP, Siemens, Ericksson) have established R&D units around Nokia. Finnish R&D units serve as knowledge sources or training centres from which employees fan out to other units to share the latest information on innovations, especially on wireless communication. Finland also serves as a laboratory for market testing new products and services.

The large value of the financial turnover, of course, reflects the fact that the cluster has taken a leading position in addressing a world-wide market - not just focussed on winning a share of the local Finnish or Nordic economy.

Pajia[42] surveyed companies in the Finnish ICT cluster to determine what they thought their success factors were:

- Customers are considered to be markedly important motivators for new ideas and initiatives. In turn, demanding clients can gain further benefits from outsourcing by relying on their suppliers' expertise in product design and problem solution. Efficiency in many forms can be increased by delegating some of the responsibility of the product and/or process design to the subcontractor.
- Business efficiencies have been achieved by aggregating more outsourcing to a smaller number of suppliers to increase joint productivity. This is seen as beneficial on both sides because it leads to more interdependence (i.e., security of work) and better collaboration for design and development.
- The majority of lower tier firms think their main customer's R&D is crucial to further development and improvements of their own products.
- Innovation work with the demanding key client improves their overall innovation capabilities to work with other clients.
- Providing customer service to the demanding primary client makes the SMEs better able to serve other clients, and provides the SMEs with good references to the other clients.
- Partnerships among cluster members provide incentives for/induce operational improvements (e.g., transparency of information, just in time deliveries, etc. The

timely delivery of information major client's market fluctuations is critically important to the upstream suppliers' planning.

- Networking for information among cluster members enables efficiencies in operations. "There is plenty of practical evidence [that this is taking place] in a number of firms, electronic communication systems are already the main medium of interchanging operational data between key customers and suppliers. Not only orders, but especially documents and drawings in the design phase are transferred electronically.
- Although networking may increase bidding competition, key subcontractors do not believe the integrated services they provide will be subject to simple price competition.
- A factor that suggests benefits of cluster partnership are will distributed is subcontractors' overall experiences in partnership have been positive. It is noteworthy that small firms are more often satisfied than their larger counterparts. "[T]here are positive indications that even though clients are often aware of the cost structure of the supplier (the so-called open books basis) they still allow profitable pricing to the subcontractor. Benefits from cooperation are distributed to both partners, which is the dogmatic objective of networking. *This is vital especially in the hi-tech sector where firms need to accrue financial resources to invest in R&D. Under too tight target cost pricing subcontractors easily cut down expensive R&D investments, which is fatal to technological development*." [p. 17 - my italics]

One point Pajia makes is so critical that I quote it verbatim in full.

> The key-client relationship has also improved importantly firms' ability to better understand the requirements of the market and to better serve other clients. *This relates partly to the firms ability to internationalise their operations*. As a truly global actor, Nokia has contributed, directly or indirectly, to the internationalisation of a number of Finnish suppliers. *In the foreign markets, established partnerships are a valuable asset of which customers want to take advantage. Nokia's first-tier subcontractors, in turn, try to encourage their key suppliers to follow behind. Despite many challenges small and medium sized firms are likely to encounter in global markets, internationalisation opens up new market potential that is a welcome opportunity for firms born in a small home market that Finland represents.*[p. 12 - italics mine]

Key factors influencing company success in the ICT market are rapid technological evolution and globalisation. The Finnish case also shows that firms do not have the time or resources to do everything on their own. Mutual adaptation in a cluster environment allows firms to concentrate on core competencies and also benefit from the more focussed innovation and competencies of their network partners. Clustering in a common geographic area, with common cultures and ease of personal and electronic access facilitates building and maintaining such networks. This does not prevent individual innovation. In fact, it is likely that the availability of and access to a common pool of innovative talent that is developed in a cluster actually facilitates innovation by many companies. Market access is also improved by the ability to develop and share distribution channels.

3.3 The possible role of common standards as a trigger for clustering

An interesting common factor in both the North Jutland and Nokia cases is that initial cluster growth was stimulated by the establishment of the Nordic Mobile Telephony system in 1981-82, which provided a public standard that could be addressed by all companies. This was followed in 1992 by establishment of the pan-European GSM standard for all digital telephony and later yet by global standards. Because many

companies addressed the same standard, especially where there were regional concentrations, specialised knowledge related to these standards became a valuable medium of exchange between the various firms. Companies already experienced in addressing the Nordic standard then benefited from their prior experience when more global standards were created.

As will be discussed below, there is also a strong role for emerging global standards for engineering technical documentation in facilitating the growth of a Melbourne-based cluster around the knowledge and technical data management needs of the defence and heavy engineering industries.

3.4 Australian non-ICT industry clusters

Adelaide has a very active and dynamic cluster involved with defence aerospace, land, marine and electronic systems[43]. Formation of this cluster was facilitated by the active involvement of its universities[44], DSTO Edinburgh, and Technology Park in Mawson Lakes [45] [46]. With prime contractors like Tenix Defence's Land, Electronic Systems and Aerospace divisions, Australian Submarine Corporation (ASC), General Motors Defence Australia, and a range of supporting industries including subsidiaries of international companies (as in Denmark), the Adelaide defence systems and technologies cluster will grow even stronger now that ASC has won the ~$7 billion project to build three AEGIS Class Air Warfare Destroyers.

With players like Tenix Marine's West Australian Shipyard, the ANZAC Ship Alliance[47], and Austal[48], Western Australia has developed a powerfully competitive shipbuilding and marine engineering cluster that is even able to export successfully into the US defense market[49]. However, Melbourne is the focus for this paper.

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43 http://www.defence-sa.com/

44 http://www.unisa.edu.au/about/campuses/ml.asp

45 http://www.techpark.sa.gov.au/techpark/

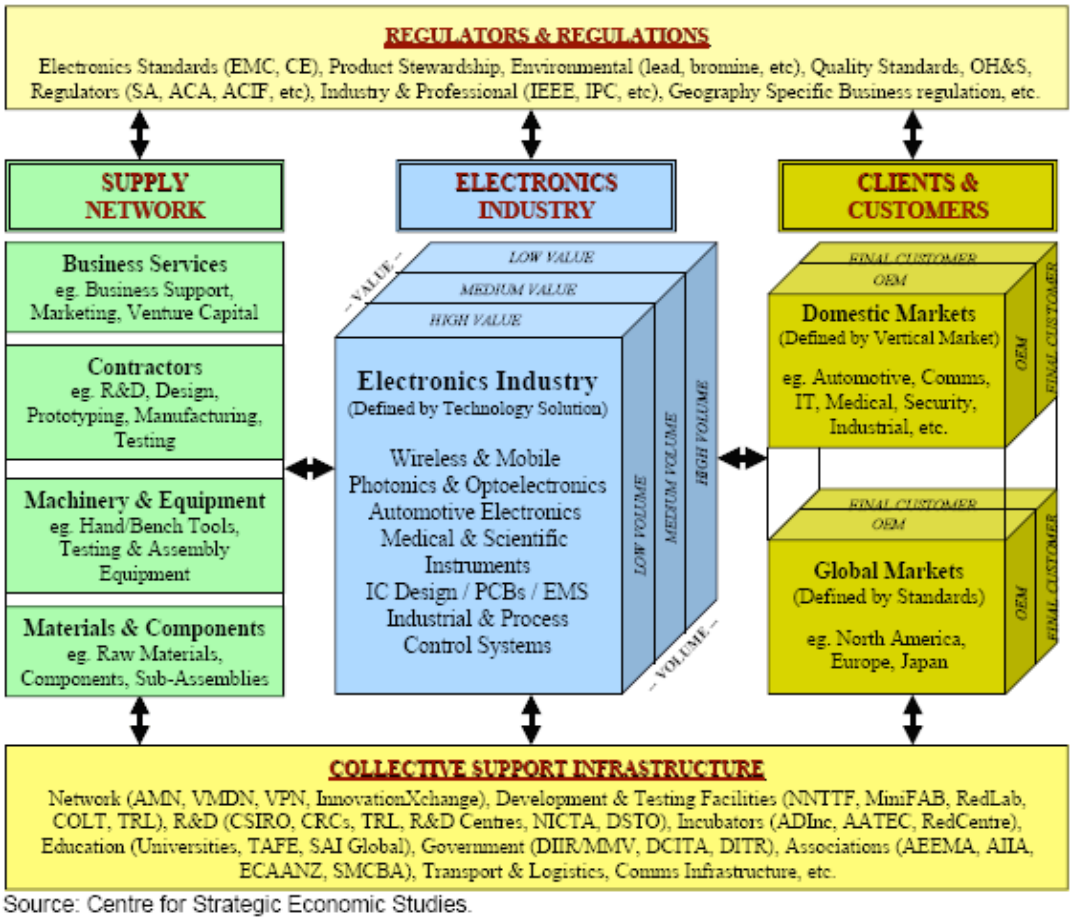
46 There is a lot of anecdotal evidence from within Tenix that this cluster has dynamics similar to that described for Nokia and North Jutland, but so far as is known to this writer, no documentation exists comparable to that available for the other two clusters.

47 http://www.tenix.com/Main.asp?ID=571;
Zhou, M., Nemes, L., Anticev, J. & Mo, J.P.T. 2005, 'The modelling and operating of a virtual engineering enterprise through project alliancing – an industrial case study', presented to International Manufacturing Leaders Forum on 'Global Competitive Manufacturing', Adelaide, South Australia, 27 February to 2 March - http://www.cmit.csiro.au/research/papers/abstract.cfm/789;
Mo, J.P.T., Zhou, M. Anticev, J., Nemes, L., Jones, M., Hall, W.P. 2006. A study on the logistics and performance of a real 'virtual enterprise'. International Journal of Business Performance Management 8(2/3): 152-169. - http://www.orgs-evolution-knowledge.net/Index/DocumentKMOrgTheoryPapers/MoEtAl2006StudyLogisticsPerformanceRealVirtualEnterprise.pdf ;
See also: http://www.icnwa.org.au/news.asp#37;
http://www.cmit.csiro.au/research/papers/abstract.cfm/789;

48 http://www.austal.com/

49 See Australian Marine Complex - http://www.techparkwa.org.au/downloads/presentations/tuesday/morning/TechPark%20-%20Steve%20Arnott.pdf;
http://www.landcorp.com.au/portal/page?_pageid=331,1&_dad=portal&_schema=PORTAL: Mazzarol, T. 2004. Industry Networks in the Australian Marine Complex: Strategic Networking within the Western Australian Maritime Engineering Sector. CEMI Report - Centre for Entrepreneurial Management and Innovation, University of Western Australia. - http://www.cemi.gsm.uwa.edu.au/__data/page/59464/AMC_Report_VF.pdf

It should be noted that other types of existing or potential clusters also already exist in the Melbourne area:



Source: Centre for Strategic Economic Studies.

Figure 2. Victorian Electronics Industry Cluster, from Houghton and Thorburn (2004)[50]

- An electronics industry "cluster"[51] as summarised in Figure 2.
- Mining and mining technologies: many head offices and mining technologies exporters are based in Melbourne, which may account for KDR Creative Software's penetration of this industry with its FMMS (Facilities Maintenance Management System) application.
- Agricultural technologies: as promoted by Vic. Dept Infrastructure, Industry and Regional Development, which may account for the fact that Fontera (a New Zealand-based milk products cooperative accounting for 8% of New Zealand's total GDP has established a research lab in Melbourne).

3.5 Some conclusions about industry clusters

The examples illustrate the formation and growth of two kinds of cluster forming networks[9,12] - Finland's collaborative supply chain centred around Nokia as a single major, market creating entity. North Jutland's collaborative product development network

[50] Houghton, J., Thorburn, L. 2004. The Victorian electronics industry cluster. Centre for Strategic Economic Studies (Victoria University), August 2004 - http://www.cfses.com/documents/CSES_Victorian_Electronics_Cluster_Study.pdf .

[51] The report actually describes what I would call an industry "sector". This sector may actually contain several Porter clusters, although the data has not been organised to highlight these in the way that was done for the Nokia and Danish clusters.

also has aspects of a technology led ecosystem. Both studies emphasise the importance of networking in the early stages of development.

Pedersen[5], following Enright[52] describes the development stages of a cluster as follows:

- *Wishful thinking*. Not an actual stage in development, but mainly a policy or idea. It could lead cluster development, but does not yet have the kinds of elements it needs to work or sustain itself. Presumably in this stage, the wishful thinkers are primarily governmental bodies, who would like to see their regional economy grow. It is unlikely that potential member organisations would have in mind the potential to form a cluster or anything like that.
- *Potential*. A group of existing organisations that has the potential to become a working cluster. Has some elements, but lacks size, breadth, depth and local interactions. A regional industry is beginning to develop, but still only involves a few organisations with no conscious intent to build closer relations.
- *Latent*. Has a critical mass of organisations, but needs to establish interactions and networks to start a self-augmenting process. A few organisations may see benefits from closer interactions, but no dynamic attractor has yet emerged to crystallise relationships.
- *Working*. The cluster has a critical mass of organisations, labour, knowledge, etc. that has reached a dynamic stage of self-sustainability. Interactions are taking place between the organisations that are seen to be individually beneficial to the organisations.[53]

Once the dynamics of a "working" cluster are established and as long as they are maintained, growth may occur. A large factor in the success and cohesion of a cluster is determined by founding of new entrants and the extent to which they can build on domain knowledge already existing in the cluster. Pedersen (Table 2) lists several kinds of entrants that may join a cluster.

Table 2. Types of new firm entrants
(Pedersen[5] after Helfat and Lieberman (2002) and Klepper (2001)

Entrant type	Relation to established firm	Parent company ownership
(1) Diversifying entrant	Same firm	Full
(2) Parent-company activity	New firm as a separate entity	
- Joint venture	- Founded by multiple established firms	Partial
- Parent spin-off	- Founded by established firm	Partial
(3) De novo entrant	New firm as a separate entity	
- Entrepreneurial spin-off	- Founder(s) from industry	None
- Inexperienced start-up	- Founders lack experience or contacts in industry	None

[52] Enright, M.J. 2000. The globalisation of competition and localization of competitive advantage. in The Globalisation of Multinational Enterprise Activity and Economic Development. N. Hood and S. Young, eds. Baskingstoke, Macmillan.

[53] Hertog, P.d., Bergman, E.M., Charles, D. 2001. Creating and sustaining innovative clusters: Towards a synthesis. Chapter 22. Innovative Clusters Drivers of National Innovation Systems. OECD Proceedings, pp. 405-419 - http://www.insme.it/documenti/Innovativeclusters.pdf

4. Victorian ICT Clusters

4.1 What global needs might provide a market for a new Victorian ICT cluster?

As the world becomes a more complex and competitive place to live and do business in, to prosper, firms and organisations need to become more and more knowledge[54] intensive. Large organisations and firms increasingly need to implement infrastructure systems and software applications able to help automate collecting, assembling, transforming, authoring, managing, retrieving, and distributing knowledge in explicit forms. Collectively these can be called "content" or "knowledge management systems". The increasing complexity of business is causing this market to grow continuously - with a need for increasingly integrated and user-friendly systems.

Two focal areas in this broad market are of interest locally - both because Victorian industries such as Tenix need and use products from the areas and because potential cluster members market their own products and services into them. These are markets for:

- *Engineering/project technical data and knowledge management tools* - including configuration and product data management (also known as product/program lifecycle management - "PLM") tools, data aggregation engines, word processing and structured authoring tools, document and content management systems, logistic support analysis tools, computerised maintenance management systems, document conversion and publishing systems, content searching and retrieval, web portals and repositories, data security tools, etc.
- *Intelligent transport applications* - including tolling and billing systems, speed cameras, infringement processing and management, records management and tracking, possible container and rail-transport tracking and management, computerised fleet / maintenance management systems, support engineering (ILS) analysis tools, etc. A clustering process has already started in association with the Intelligent Transport Systems (Australia) and the Victorian state government.[55]. However, this focuses primarily on the electronic systems and information management side. The cluster focus of the present document is on transport/engineering knowledge management issues.

The necessary publications to document potential market sizes and growth of these broad areas are not available to the writer. However, authoritative values for the PLM market are provided by CIMdata[56]. In 2004 the market for product lifecycle management (PLM) alone was worth $US 16.9 billion and $18.1 billion in 2005 for a compound annual growth rate of approximately 7.7%. The conclusion is that the market is large enough to support growth of a cluster offering competitively superior products into the world market, where two incumbents are each achieving more than USD one billion in direct annual sales (exclusive of additional partner revenues), and two others are achieving more than 400 million per year.

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[54] Knowledge can be defined in many ways that are subject to intense debates in the knowledge management community. For the purposes of the current document, knowledge is defined as proposed or tested solutions to problems of existence (after Karl Popper. 1972. Objective Knowledge, Oxford University Press, London).

[55] http://www.dpc.vic.gov.au/domino/Web_Notes/newmedia.nsf/798c8b072d117a01ca256c8c0019bb01/ 908eb81a80e51ba1ca256fab0002816a?OpenDocument; http://www.mmv.vic.gov.au/IntelligentTransportSystems.

[56] http://www.cimdata.com/press/PR05-0413.htm; http://www.cimdata.com/press/PR06-0405.htm

4.2 Current state of the Victorian ICT industry

Victoria has a reasonably well developed ICT sector. However, despite active state support, it currently seems to be languishing. Stan Beer summarises work by the Centre for Innovative Industry Economic Research (CIIER) on the current condition of the Victorian ICT industry[11]:

- a predominance of contract workers in the industry (one estimate suggested that 80% of ICT placements are contract);
- fragmented employment—to such an extent that a very substantial majority of ICT businesses have fewer than 20 people working for them;
- very low participation by women in the ICT industry. This is seen to be to the detriment of the industry given the different contributions that can be made by men and women in ICT;
- an unwillingness by the ICT industry to employ those over 45 years of age even though these people are qualified and have abundant experience;
- competition from overseas ICT industries — a challenge that the Victorian industry is yet to properly address;
- the lack of an Australian or Victorian niche in global ICT; a contribution that it can strongly and sustainably make both for its own benefit and for that of the rest of the world;
- an apparent anomaly is that at times there are too many people with ICT skills who are unemployed and at other times, a deficit of ICT skills in the ICT industry. *This was seen by the participants of the workshop to be more a mismatch of skills rather than a skills gap*;
- *a growing sense of confusion regarding ICT training*, with evidence of:
  - a major decline in numbers of students studying ICT in universities,
  - a drop in internal ICT training budgets by employers,
  - a strong, vibrant and diverse VET sector, and
  - employers apparently seeking people for their skills and competencies rather than qualifications or accreditation.

As will be established below, this paper provides some answers for all of these issues.

With some exceptions, where a few organisations are currently building dynamic export markets, this lack of direction probably also applies to the Australian ICT sector in general—not just Victoria. "Stagnation" also describes an industry that currently offers substantial slack to support rapid growth if core ideas can be found to provide a direction to give the industry a competitive edge.

Some exceptional ICT organisations in Victoria (including Tenix subsidiaries) have developed software applications targeting specific information and knowledge management needs in the contracting, technical authoring, engineering, defence and transport environments. Although there is as yet no articulated focus among them to address common needs and markets, companies in this group have potentially synergistic capabilities to form a strongly competitive export oriented industry cluster around the concept of fleet/facility project lifecycle knowledge management. Tenix has also formed its own entrants into the ICT/Intelligent Transport areas as a diversifying entrant (Tenix Connections[57]) and as a joint venture (Tenix Solutions[21]) - where Tenix has then bought out the partner.

[57] http://www.tenix.com/Main.asp?ID=961 - marketing Crossbow

This paper describes how such clusters may be formed and given focus, and how involvement of leading companies in building the cluster may generate an economic return through reduced costs and increased sales of related products and services.

Summarising to this point:

In the Melbourne area there is a group of software development and implementation companies, including Tenix's recently established ICT units and potential diversification activities, addressing engineering project/fleet lifecycle data/information/knowledge management requirements that could readily expand into worldwide markets for "intelligent transport" solutions and for all kinds of engineering technical data and knowledge management disciplines. The implementation of new technical data and documentation methodologies based on the international S1000D standard[58] will flow down through and transform all applications concerned with engineering technical data and documentation. The importance of Melbourne in this market is attested by the fact that the International S1000D User Forum, involving Nordic, NATO, and North American national standards groups will be held here in May, 2007[59]. In another dimension, the transport sector is under substantial pressure to become more "intelligent" and "sustainable"[60], which will create new and growing markets for transport fleet and infrastructure management, maintenance and automation that can potentially be addressed by members of the Melbourne ICT community introduced above.

- Cluster development is a phenomenon depending largely on external factors such as a new/growing market able to be tapped by existing firms in the local economic ecology. If the favourable economic circumstances don't exist, clustering will not take place.
- Cluster initiation and development is facilitated by
  - the establishment of "market attractors" (e.g., large organisations with significant supply chain requirements and/or world marketing capabilities)
  - the availability of appropriate human resources to allow industrial expansion to take place (e.g., a population of appropriately trained and educated technicians and engineers as may be provided by local educational institutions, or readily drawn from adjacent industries)
  - a culture that supports change and innovation

From the point of view of cluster dynamics, the group of ICT organisations in the Melbourne metropolitan area described below is somewhere between a "potential" and "latent" cluster. It does not yet function as an active cluster because the intent to do so

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58 http://www.S1000D.org; http://www.defdoc.com/downloads/DefDoc06Program.pdf

59 http://www.s1000d.com/content/events/index.html

60 For example, the EU budgeted more than EU 2 billion in its Sixth Framework Program for Sustainable Development, Global Change and Ecosystems area. - http://www.cordis.lu/sustdev/; of which EU 670 million was earmarked for Sustainable Surface Transport - defined as follows - http://www.cordis.lu/fp6/sustdev.htm:

- Environmentally friendly and competitive transport systems and means of transport
- New technologies and concepts for all surface transport modes (road, rail, waterborne)
- Advanced design and production techniques
- Safer, more effective and competitive rail and maritime transport
- Rebalancing and integrating different transport modes
- Increasing road, rail and waterborne safety and avoiding traffic congestion

and a high level of networking do not yet exist[61]. Given that market conditions appear to be appropriate, relatively minor interventions to facilitate the network interactions should be enough to precipitate progression to the formation of an actively self-sustaining cluster.

4.3 Involvement of Victorian industry and Melbourne universities in activities towards forming a new Victorian ICT industry cluster

This section reviews the kinds of industry/university collaborations that can work towards facilitating the formation of an ICT industry cluster. Tenix is considered here as one possible example with which the author is particularly familiar. Tenix is a particularly strong player in Melbourne, with head or major offices for Tenix Defence Marine Division, Tenix Defence Aerospace Division, Tenix Solutions, Tenix Connections, and Tenix Alliance. The Melbourne educational and research establishment's capabilities to provide training and R&D support for cluster development will also be reviewed, again focusing on Melbourne, Monash and RMIT Universities because of the author's familiarity with these institutions. The potential roles for the educational and research establishment should especially be considered in the light of the comparative statistics and observations given in Appendix 1.

Historically, the fixed price prime contract for the $7 billion ANZAC Ship Project, won by Tenix in 1989, required that 80% of the contract value be sourced from Australian and New Zealand industry under the Australia New Zealand Industry Participation (ANZIP) scheme. The engineering and support management requirements for the ANZAC project technical data and documentation provided a market attractor for establishing a semiformal "collaborative supply chain" network in the ICT industry sector that still persists. Most members of this supply chain are either based in or have substantial resources in Melbourne. Melbourne's many world-class educational and R&D institutions and supportive government policies are potentially available to help this group develop strong cluster dynamics.

This collaborative supply chain began to form in 1992/3 when the ANZAC Ship Project Authority decided to implement the FMMS computerised maintenance management system developed in Victoria by KDR Creative Software[62]. The Navy hired Sydney-based Eden Technology to add inventory and costing components to FMMS - to form the AMPS product marketed by Eden[63]. The ANZAC Ship Project contract also required Tenix to author maintenance procedural documentation for electronic delivery into AMPS and to meet Test, Evaluation and Validation requirements of the contract to prove that support engineering deliverables satisfied contract requirements. Tenix had no choice but to develop methods and procure/integrate systems able to both deliver technical data

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61 As this paper is being written, the author is working to facilitate the emergence of a "nascent" cluster structure. One meeting has already been held of the potential members and at least some of the potential customers for cluster products - where a high degree of networking was observed. Whether this networking activity will be self-sustaining remains to be established.

62 Around 1992, the ANZAC Ship Project Authority selected the Facilities Maintenance Management System (FMMS) developed in Port Melbourne by KDR Creative Software (http://www.kdr.com.au/) as the basis for the computerised maintenance management system for the ANZAC Ships. KDR has developed a significant export market for the software in rail, facilities, oil and gas, and building maintenance - with the capability to manage "continuous assets" such as tracks and pipelines as well as components in hierarchically structured systems.

63 Eden Technology (http://www.eden.com.au), based in North Sydney, was contracted to integrate FMMS with stores management and procurement systems to produce the ANZAC Ship Maintenance + Planning System (AMPS), now marketed as Asset Management & Planning System. Eden Technology has developed its own export market for the AMPS integration in naval systems support (e.g., Royal Malaysian Navy, RNZN), as well as piggy backing on FMMS's export success.

and documentation into AMPS and to extract details of operations and maintenance out of AMPS. Data extraction and analysis requirements were met by the OARRS[64] system Tenix developed in-house. OARRS is now used in the RAN as the Class System Analysis and Reporting System (CSARS)[65]. After an exhaustive search of the world market, Tenix's increasingly intractable issues with delivering document content and data electronically into AMPS[66] were addressed most effectively in 1999/2000 by the SIM applications developed in Melbourne by RMIT University's MultiMedia Database Systems (now marketed as TeraText[67] and wholly acquired by SAIC[68]). Similar

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[64] The Operational Availability Recording and Reporting System (OARRS) was developed internally within Tenix in 1993-4 for the ANZAC Ship Project Authority to help meet requirements under the Test, Evaluation and Validation (TE&V) clauses of the Contract for Tenix to prove that the fixed-price logistic support deliverables (spares, technical data, procedural documentation) were sufficient to enable the ANZAC Ships to meet operational availability thresholds 90% for the Combat System as a whole, and 80% for a number of individual Critical Systems on their own. This was to be measured over the first 10 ship-years of operation in service (4 years for Ship 01, 3 for Ship 02, 2 for Ship 03, and 1 for Ship 04). The solution required certain operational information to be captured in AMPS (e.g., down times for particular system components). OARRS extracted and analysed individual component failures as recorded within AMPS to determine whether they caused the system to fail, determined the resulting downtimes, and reported what components were responsible for the system downtimes.

[65] CSARS - On completion of the TE&V OARRS was taken over and extended by Tenix and CSC for the RAN for use as a logistic support analysis tool now known as the Class Systems Analysis and Reporting System (CSARS) to assist with optimising lifecycle management for all surface ships. Around 2002 Eden Technology sought to procure or license Tenix's IP in the OARRS and CSARS for integration into AMPS for the export market (Defence has free use of it for Australian assets) - Hall, W.P. Beer, J., & McFie, K. 2002. Managing Maintenance to Reduce Life-cycle Costs for a Multi-national Fleet of Warships. Proceedings. International Maintenance Management Conference, 29-30 August, 2002, Gold Coast, Queensland - http://www.orgs-evolution-knowledge.net/Index/DocumentKMOrgTheoryPapers/HallBeer2002ManageMaintLifeCycleCostsFleet.pdf

[66] The difficulty was that approximately 2000 separate maintenance routines were required per ship, and it was impossible to maintain frequently changing data fields required to match in the AMPS environment using manual methods in a word processing environment. A year long R&D project conducted in 1998 reviewed a range of technological options, and decided that the only practical solution was to implement an SGML content management environment able to maintain data validation links with the ILS Database to ensure data coherence was maintained at all times. Hall, W.P. 2001. Writing and Managing Maintenance Procedures for a Class of Warships: A Case for Structured Authoring and Content Management. May 2001 issue of Technical Communication, the professional journal of the Society for Technical Communication. - http://www.tenix.com/PDFLibrary/91.pdf .

[67] Multimedia Database Systems (MDS) was an RMIT R&D centre founded by Prof. Ron Sacks-Davis, previously Prof. Information Sciences. This spun off as InQuirion Pty Ltd in 2002 and has recently been wholly acquired by the US-based Science Applications International Corporation (SAIC - http://web.archive.org/web/19991006231808/http://www.mds.rmit.edu.au/; http://www.teratext.com). Although MDS's corporate structure has changed, there have been virtually no changes to key staff. In the early 1990's MDS developed from first principles a non-relational database technology called SIM (Structured Information Manager) for managing large volumes of hierarchically structured documents using SGML standards (the ancestor to XML and HTML now used pervasively by the Web). In 1998, after doing a world-wide survey of content management applications, Tenix selected the locally developed SIM, which was implemented in 1999-2000 for Tenix by Aspect Computing who were then Australian distributors for SIM - Hall, W.P. 2001 - cited above. (Aspect was acquired by KAZ in 2002 and now forms part of KAZ Technology Services. KAZ was wholly acquired by Telstra in 2004 but retains the KAZ name).

Around 2001, Tenix collaborated with Aspect Computing, MDS and Imag Australia (http://www.imag.com.au - providing local vendor support for MatrixOne product data management systems - see Note 70 below) to prototype an integration of Matrix and SIM/TeraText as part of the workup for a joint bid to implement the Logistics Management Information System (LOGMIS) for the ASLAV AuStralian Light Armoured Vehicle). The bid was not won. However, an update of the solution as proposed for ASLAV was implemented by the Aspect, Imag, and the MDS team with considerable success by TD Land for the M113 project - Hall, W.P. and Brouwers, P. 2004. PDM experiences in an

requirements to coherently deliver other engineering and logistics technical data into AMPS from some 15 disparate and unconnected systems and data repositories led TD Marine to develop the Crossbow system that we are now marketing internationally via the Tenix Connections business unit[69]. Similar data and documentation management requirements in other Tenix Defence divisions led them to work closely with a number of other local and locally supported international suppliers of technical authoring and engineering/logistic data management systems (e.g., Imag, supplier of Enovia MatrixOne[70], Product Lifecycle Management (Australasia) - supplier of TeamCenter[71]) and other support systems (e.g., Exari[72] and TurnKey Systems[73]) to mention a few.

Australian Prime Contractor. SPIDER - STEP in Defence Engineering - Workshop Series Two. Melbourne, Adelaide, Sydney, Australia 10-12 August 2004. - http://www.ausdec.com.au/WS2_07_SPIDER Workshops_Tenix_PDM_rev.pdf;

[68] SAIC (http://www.saic.com), a Fortune 500 company, is the second largest supplier of computer services to the US Department of Defence. It was responsible for supporting SIM for security intelligence users in the USA that was first implemented there around 1997 (Kaihla, P. 2003. In the company of spies. Business 2.0 May 1 2003 - http://www.corpwatch.org/article.php?id=7892). Around 2000, SAIC replaced a non-performing US agent as SIM's US distributor, renamed the product to TeraText and established a full SAIC division, TeraText Solutions (http://www.teratext.com) to distribute and support the system in the US and North America.

[69] Implementing SIM/TeraText provided a completely satisfactory solution for Client's data quality issues with maintenance routines (and saved Tenix substantial labour over the continuing project). However, similar problems remained with engineering technical data. The engineering environment for the ANZAC Ship Project was assembled in the early 1990's with the consequence that engineering data was developed across some 15 separate engineering applications (including the ILS DB). The result was that the same physical item might be identified differently in different data repositories - causing great difficulties when the Client tried to assemble these into a single database giving a coherent view of the product.

A Tenix team, designed an XML compatible "data warehousing" solution on the Microsoft dot Net platform called Crossbow. This consists of data aggregation, validation and viewing engines able to accept data from a variety of different sources, detect any mismatches and automatically notify database "owners" what corrections need to be made on the source platform to bring that body of data into coherence with other data streams. Normalised data is then delivered from Crossbow to the Client. Tenix patented the Crossbow technology and spun off a company, Tenix Connections (http://www.tenix.com/Main.asp?ID=961) to market Crossbow world-wide. Sykes, M. Hall, W. P. 2003. Generating Fleet Support Knowledge from Data and Information. Australian Conference for Knowledge Management & Intelligent Decision Support ACKMIDS 2003 Melbourne, Australia, 11 and 12 December 2003 - http://www.hotkey.net.au/~bill.hall/DataAndInformationInFleetKM(submitted1).pdf; Microsoft Asia Pacific Case Studies. Tenix Defence Australia's Largest Defense Contractor Saves A$11 Million on Major Shipbuilding Project - http://www.microsoft.com/asia/case/casedetail.asp?casestudyid=15736.

[70] MatrixOne's Matrix product (http://www.matrixone.com/matrixonesolutions/index.html) implemented by TD Land for the M113 project is distributed, supported and implemented in Australia by Imag Australia (http://www.imag.com.au/). Matrix was the world's fifth largest selling product/project lifecycle management system (CIMdata Press Release, 13 April 2005, CIMdata Reports Continuing Strong PLM Market Growth - http://www.cimdata.com/press/PR05-0413.htm). On 11 May 2006, Dassault Systemes, already the top selling developer of product lifecycle management products completed its acquisition of MatrixOne to provide the core collaboration tool for its top of the range Enovia products. Imag Australia continues to support the Enovia Matrix range (http://www.3ds.com/news-events/announcement/matrixone/). The same team from Aspect Computing that implemented TeraText for Tenix's ANZAC Ship Project also managed the implementation of Matrix and integration with TeraText and other engineering applications in Adelaide, where they worked closely with Imag and TeraText. Although KAZ and Telstra dispersed the SIM/TeraText knowledge Aspect had built up over the years, key members of that implementation team are still available in the Melbourne area.

[71] UGS's TeamCenter (http://www.ugs.com/products/teamcenter/), the world's second largest selling product lifecycle management system (see CIMdata Press Release, 13 April 2005 cited above) has been

Not only are Tenix Defence's support engineering groups expert in the overall problem space of fleet lifecycle documentation and technical data authoring, management, delivery and maintenance but we have also managed the internal implementation and integration of a wide range of products in this space. Because the core IP development or Australian support for most of these products is based in Melbourne, a collaborative supply chain network already exists as a nascent industry cluster. Essentially all of the organisations, including Tenix, involved in this collaborative supply chain have individually established export markets for their products. However, to date, there has been no effort to expand export markets by building on the synergisms already proven in Tenix's various bespoke integrations of their products.

Although the author of the present paper is not closely involved with Tenix Solutions, it appears that similar types of networks are being developed around Solutions in the area of infringement processing and possibly other intelligent transport systems.

As will be elaborated below, through Tenix's R&D activities, Tenix has also formed associations with R&D labs such as DSTO[74], CSIRO[75], the newly established Transport

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selected by the RAN as its primary configuration management tool for its surface combatants. It is supported in Australia by Project Lifecycle Management (Australasia) (http://www.plma.com.au/). An internal TD Marine team has implemented TeamCenter for the ANZAC Ship Alliance and is extending its configuration management and engineering change control capabilities to other TD Marine projects such as Protector and Delos and will have the capabilities to manage integration activities in-house. TD Marine is currently considering whether to implement the kind of single-user-interface engineering knowledge management framework that TD Land developed on the Matrix platform.

[72] Exari (http://www.exari.com) is the new name for the SpeedLegal company and the SmartPrecedent product suite. The product suite includes XML-based applications using precedents to automate the routine aspects of producing standardised documents such as contracts (technical and maintenance documents also potentially fit this model). Components include a questionnaire/precedents-driven document authoring tool, a repository for precedents and reusable text, and a smart editor for creating XML documents as well as its own precedents. A Tenix R&D project assessed the applicability of the tool to Tenix controlled contracts and agreements, and recently the company has begun to explore use of the Exari product for authoring electronic technical documents conforming to the new international S1000D standard (http://www.S1000D.org) increasingly being adopted by defence and heavy engineering industries around the world.

[73] TurnKey Systems (http://www.turnkey.com.au/) has developed and is successfully exporting a very capable engine called TopLeaf for formatting the managed versions of structured (i.e., in SGML or XML) electronic documents. Output can go to a printing facility, HTML or PDF. Tenix is particularly interested in the system because it includes a "loose-leaf" publishing tool that totally automates the exacting, time consuming and fallible tasks of printing insert pages for loose-leaf technical manuals and the like. For even simple changes to the text, changed pages need to be distributed to everyone holding the manual along with instructions as to what pages are to be removed and inserted to bring the manual up to date.

[74] e.g., Box, P. 2002. DSTO Maritime Platforms Division: External Interactions, DSTO-GD-0345 - http://www.dsto.defence.gov.au/publications/2503/

[75] Tenix maintains connections with several relevant CSIRO divisions and has worked particularly closely with the Manufacturing Infrastructure Technology Group - http://www.cmit.csiro.au/home/about/; http://www.cmit.csiro.au/home/contacts/resume.cfm?id=420; http://www.cmit.csiro.au/home/contacts/resume.cfm?id=695; Mo, J.P.T., Zhou, M. Anticev, J., Nemes, L., Jones, M., Hall, W.P. 2006. A study on the logistics and performance of a real 'virtual enterprise' International Journal of Business Performance Management 8(2/3): 152-169; Hall, W.P., Jones, M., Zhou, M., Anticev, J., Zheng, J., Mo, J. & Nemes L. 2002. Document-based Knowledge Management in Global Engineering and Manufacturing Projects. Proceedings of the Globemen Plenary Meeting No. 6. 8-13 December 2002, Helsinki, Finland. - http://cic.vtt.fi/projects/globemen/book/21_hall.pdf.

Research Lab of Intelligent Transport Systems - Australia[76], together with knowledge management interests in several major universities that have research and teaching programs directly relevant to both cluster areas[77].

Many of the factors for forming a strong enterprise cluster focussed on exporting technology and services relating to project and fleet lifecycle management already exist even though nothing has been done to coordinate or focus their individual efforts towards any kind of common goal in the ICT area being considered here.

Also, the Nokia and North Jutland studies both emphasise the importance of educational and R&D institutions in cluster initiation and growth. Appendix 1 presents some facts that were surprising even to the author of this paper about the Melbourne educational and research establishment's abilities to support cluster formation once a crystallising factor is added. As shown in the Appendix, *three Australian regions where Tenix has a strong presence rank substantially better than any other metropolitan region in the world in an objective evaluation of the per capita quality of the local educational institutions*.

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[76] ITS - Australia (ITSA) opens its National ITS Centre, which will include a transport research lab in Port Melbourne on 27 February 2006 (http://www.its-australia.com.au/kmxserver3/). Tenix Solutions is represented on ITSA's governing board.

[77] From 2002 through mid 2005, Tenix's Dr Hall was an Honorary Fellow associated with the KM Lab in Monash University's Faculty of Information Technology (http://km-svr.sims.monash.edu.au/) and is currently a National Fellow (honorary) associated with Melbourne University's Australian Centre for Science, Innovation and Society, an interdisciplinary centre recently established by the Faculty of Engineering and the History and Philosophy of Sciences department in the Arts Faculty (http://www.hps.unimelb.edu.au/research_centres/acsis.html; http://www.acsis.unimelb.edu.au/).

Monash University claims to have the largest and most prestigious information technology faculty in the Southern Hemisphere. According to The Times Higher Education Supplement world rankings (released Nov 2005), Monash University is ranked 24th in the world in technology and 33rd in the world overall - http://www.infotech.monash.edu.au/about/about-faculty.html.

Melbourne University currently offers a number of other KM interests, e.g., an interdisciplinary Masters Degree in Knowledge Management jointly between the Faculties of Education, Economics and Commerce and Science (http://www.edfac.unimelb.edu.au/courses/postgraduate/Courses/knowlegdemanagement.shtml), a Masters Degrees in Engineering Management (http://www.eng.unimelb.edu.au/courses/pgrad/courses/grad_mem.html) and Engineering Project Management (http://www.eng.unimelb.edu.au/courses/pgrad/courses/grad_mepm.html).
The Engineering Faculty also includes an active transport research group - http://www.civag.unimelb.edu.au/research/groups/transport.html. The University also participates in a variety of relevant centres, e.g.,
- Australian National ICT Australia Limited (NICTA) - http://www.nicta.com.au/
- CRC for Smart Internet Technology - http://www.smartinternet.com.au/
- Advanced Centre for Automotive Research & Testing (ACART) - http://www.mame.mu.oz.au/research/groups/acart.html

Monash University also has similar connections.

In addition to Melbourne and Monash, there are five more universities in the Melbourne Metropolitan area with research and postgraduate education programs able to contribute skills and people to a growing cluster:
- RMIT - http://www.rmit.edu.au,
- Swinburne University of Technology - http://www.swinburne.edu.au,
- Latrobe - http://www.latrobe.edu.au/,
- Deakin - http://www.deakin.edu.au/ and
- Victoria University - http://www.vu.edu.au/.

5. Proposed plan of action

What is presented here represents an intellectual leap to a more-or-less complete plan of action. This is based on information and contacts available to the author through his close connections with the knowledge management and academic communities in Melbourne. Other suggestions should of course be explored. A series of comparatively minor interventions and investments are suggested that should help to crystallise the clustering process. It should also be emphasised at the outset that neither Tenix nor any of the other named organisations have made any formal commitment to possible cluster roles as discussed in this section.

5.1 Establish ICT engineering systems integration and knowledge exchange workshops

As illustrated by Tenix Defence's divisions, project engineering organisations abound the world have common data and documentation management issues that are addressed by the cluster of ICT products discussed above. TD Land has progressed farthest to build an integrated engineering environment through its integration of Matrix and TeraText with its engineering drawing and production management tools[78]. Marine has implemented the Teamcenter PLM application[20] for managing ANZAC Ship technical data, and is currently working to determine how best to incorporate structured document management into the system. Aerospace are currently running InSync[79] configuration management software from Integrated Support Systems (ISS) and are seeking to move to a more integrated PLM-style application for engineering change control.

In this regard, the world of engineering technical documentation is seeing the promulgation and spread of a new standard for electronic technical documents under the name S1000D[80]. This was originally developed by the European aerospace industry and has subsequently been adopted as the preferred or mandated standard by defence departments throughout NATO (specifically including the USA and Canada), the Nordic countries, and Australia. Australian companies have been leading in developing tools and in implementing systems around the standard, e.g., Absolute Data Group (ADG - also a potential cluster partner, based in Queensland) is exporting their applications into the US and European markets.[81]

In 2005 Tenix sponsored two workshops involving potential cluster members that brought several of the interests together. This was in association with Tenix R&D to evaluate the feasibility to integrate TeamCenter and TeraText. Feasibility was demonstrated but no activities followed on to sustain the human network connections made in the workshops. To now the latent cluster has not been mature enough to form such workshops without continuing focal activity to attract participants. However, current events in the PLM systems market and new activities may help to establish such a focus.

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78 Hall, W.P. and Brouwers, P. 2004. The CMIS solution for Tenix's M113 program. MatrixOne Innovation Summit. Shangri-La's Rasa Sentosa Resort, Singapore, 12 - 14 August, 2004. - http://www.orgs-evolution-knowledge.net/Index/DocumentKMOrgTheoryPapers/HallBrouwers2004TenixMatrixInovSummitCMIS(present).pdf; Hall, W.P., Richards, G., Sarelius, C. 2005. Implementing defence documentation standards in fully controlled engineering management environments. OpenPublish 2005. 5th Annual Conference for Standards in Publishing, Sydney - July 27-29, 2005 - http://www.orgs-evolution-knowledge.net/Index/DocumentKMOrgTheoryPapers/HallEtAl2005ImplementDefenceDocStdsControlledEngMgtEnvirons.pdf

79 http://www.isscorp.com/html/insync_overview.html

80 See http://www.s1000d.org.

81 http://www.absolutedata.com/section/news.html#General; http://www.absolutedata.com/section/news.html#Pennant

- Based on solicitations to the international body from ADG, Boeing Australia and Australian Defence, it has been decided that the International S1000D Users Forum meeting will be held in Melbourne, Australia 1-3 May, 2007.[82] This will bring several hundred key decision makers to Melbourne from defence and defence supplier organizations around the world. As such, it will provide an ideal opportunity for Melbourne ICT players to present S1000D applications and integrations relating to the technical documentation and data management area.
- Tenix Defence has established an internal Support Engineering Community of Practice (that most recently met 17 May and 9 June) across its four divisions (Marine, Land, Aerospace and Electronic Systems) and has agreed, possibly subject to other priorities, to establish R&D funding to carry out a project to demonstrate the 'end-to-end' ability to manage S1000D data and documentation - possibly using both the Matrix and Teamcenter PLM applications.
- Many of the potential participants listed above, plus representatives of Tenix Defence divisions and managers from DSTO's Land Operations Division, Defence Materiel Organization's Land Engineering Agency, and Army Technical Regulation Policy met on 24 August to discuss possible collaborative demonstrations to present at the S1000D Users Forum.

In addition to this external opportunity, there is a list of things major engineering project management companies such as Tenix could do working towards a global way of doing business across its divisions and business units that can be tested and validated in R&D projects to develop specifications and prototypes.

To date, such work within Tenix has usually involved one-on-one contractual arrangements with technology suppliers or implementers that have been fully funded by Tenix itself. By taking advantage of R&D needs in the general area of engineering/ILS data and knowledge management, clustering can be consciously facilitated. Industry R&D expenditure could be applied via already established university connections in a way (1) that will encourage the continuing involvement of potential cluster members, (2) that will attract matching grants potentially able to multiply Tenix "seed funding" several times over, (3) that will provide training in research projects for engineering and IT students who will then be available for employment by industry in a time of genuine skills shortages[83], and (4) should be able to attract international interest and collaboration to showcase Tenix's ICT products (e.g,. via collaboration with EU Seventh Framework projects allied to what we are trying to do here).

One possible way to approach this is via another intellectual leap, as elaborated in the next section.

5.2 Establishment of an Engineering KM Lab at Melbourne University

The statistics presented in Appendix 1 about Melbourne's educational establishment demonstrates that on a per capita basis Melbourne has an educational and research infrastructure and quality equal if not superior to that available anywhere else in the world to fuel the growth of high technology industry clusters. This is very substantially better than that available to the Danish and Finnish clusters reviewed above. What needs

[82] http://www.s1000d.com/content/events/user_forum/melbourne_07/F1030_Advert_UF07.pdf. Despite ADG and Boeing both being located in Queensland, the Defence support engineering activities and related defence industry is so strongly centred in Melbourne that the Queensland organisations had no practical option but to hold the forum meeting in Melbourne.

[83] The skills shortage is already bad and is due to become much worse due to competition between a number of multi billion dollar Defence projects and the booming resources industry for a still shrinking workforce: http://www.dsi.org.au/Portal/Portals/15/P06I36%20Defence%20Skill_DTC.pdf; http://www.navy.gov.au/publications/engineering/march2006/lateralentrytechnicians.html;

to be done is to orient Melbourne's extensive educational and R&D resources to enhance local cluster formation and sustenance activities. In the same way that Aalborg University provided a focus for the Danish NorCOM cluster, University of Melbourne, the top ranked Australian university by all measures, can provide a similar focus for Melbourne ICT communities.

5.2.1 Suitable circumstances

In 2002, University of Melbourne had the next largest R&D expenditure in Australia after CSIRO, and generally ranks highest of all Australian universities in the BRW 1000 list of Australia's richest organizations. In the past, the University was probably too conservative to have much interest in the ideas developed here. However, beginning in 2006, Melbourne University has started down a path to reinvent itself in ways that relate better to today's issues and the future. The University is currently reviewing and revising all of its curricula as outlined in Growing Esteem Strategy[84] to move from undergraduate professional degrees towards the "Bologna" (a reasonably typical US) model, where professional degrees- i.e., law, medicine, engineering, etc. will require a general education bachelors degree qualification as a pre-requisite. The University's goals are expressed as a "triple helix"[85] involving research, learning and teaching, and knowledge transfer.

There is also a goal within the university to develop and strengthen interdisciplinary professional degrees. Existing programs of direct interest to the defence, project management and engineering industries Master of Knowledge Management[86], offered jointly by the faculties of Economic and Commerce, Education, and Science (Department of Information Systems); and the Master of Engineering Management[87] and Master of Engineering Project Management[88] offered within the Faculty of Engineering. These could be enhanced and expanded.

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84 http://www.unimelb.edu.au/vc/consultation/strategy.html etc.

85 In reaffirming the intention to be among the finest, the University will address some deficits in achievement to date – a strong but still uneven research record, pressures of size, span and coherence in undergraduate teaching, and public outreach not always well-linked to teaching and research.

Setting three equal priorities for the University of Melbourne – research, teaching and knowledge transfer – adds a new dimension to the teaching-research nexus. Melbourne's academic programs should form a tightly-wrapped spiral of distinct but related activities that together define the institution's character.

Research is the first strand, embracing the systematic generation of new knowledge, development of new ideas and experiment with new techniques. These activities inform student learning and provide an intellectual platform for engaging in knowledge transfer.

The second strand is **learning and teaching**. It explicates a body of ideas, is informed by available research, and instils habits of inquiry that reflect the provisional nature of knowledge.

The final strand is **knowledge transfer**. It encompasses many dimensions of interaction between academia and wider society – from the way public intellectuals use media platforms to participate in debate, to policy work for government, industry and communities, to contract research and education services, and to the complex and risky work of creating business ventures to distribute new technology. A sharper focus on knowledge transfer will ensure the institution is more widely connected to non-academic partners and able to receive, develop, co-produce and share new concepts and their applications. To be effective, knowledge transfer activities should both shape and shadow the University's research and teaching priorities, and be informed by active social and economic engagement. As a public-spirited university Melbourne will serve local and international communities best by selective engagement, when it has distinctive contributions to make and when the benefits are compelling. - http://www.unimelb.edu.au/vc/consultation/triplehelix.html

86 http://www.edfac.unimelb.edu.au/courses/postgraduate/programs/knowlman/index.shtml

87 http://www.eng.unimelb.edu.au/courses/pgrad/courses/grad_mem.html

88 http://www.eng.unimelb.edu.au/courses/pgrad/courses/grad_mepm.html

A cross faculty workshop meeting was held on 1 February to explore opportunities for collaboration in the knowledge management area[89]. This was facilitated by Bill Hall (appointed National Fellow, Australian Centre for Science, Innovation and Society in December 2005; Documentation and KM Systems Analyst, Tenix Defence Head Office) and Dr Susu Nousala (TD Knowledge Management Intern, a past University of Melbourne Research Fellow who has just completed her PhD in 'soft systems engineering' at RMIT). The Minutes of the 1 February 2006 meeting stated that there may be considerable support available from within the university to establish interdisciplinary degree and associated research programs. The workshop agreed to consider establishing/extending an interdisciplinary and industry focussed knowledge management program; and that it would be useful to establish a research, training and consulting lab in association with such a course. Not only would the lab provide training for students on systems used in industry, but it would support R&D, integration and consulting programs. Seed funding may be available within the University to help kick start such programs where a business case can be made that the program will become self-sustaining by enrolments and industry support.

There are at least three things industry can do to crystallise and facilitate the formation of a KM Lab/System Test Bed and research program addressing the University's "triple helix" of research, teaching and industry involvement, and focussed on issues of interest. Because this is the kind of thing that universities are good at, this could be done for a considerably smaller investment from industry than would be required for industrial organisations to establish their own programs in-house and in isolation from the surrounding supply chain for applications.

5.2.2 How would the lab work to crystallise a cluster?

An initial informal canvass[90] of relevant ICT players (including a couple from other areas of Australia) showed that most, and possibly all, would be happy to provide license-free installations of their software applications to help establish a lab with major and crucial software for engineering and project knowledge management. This may include both Dassault Systemes (Catia, Enovia MatrixOne, etc) and UGS (Solid Edge, Teamcenter, etc.). Both parent organisations have strong programs to place their software in educational institutions at all levels.[91] As suggested in the present document, most also recognised the potential marketing advantages that could be gained to have their products integrated and highlighted in various kinds of demonstration projects and case studies that could be carried out by a university lab of the type envisaged here. This would provide a continuing activity to maintain close networking and the collaborative development of marketing concepts. The university lab environment would also provide the opportunity to focus on the people and process issues surrounding the introduction of new ways of working into the engineering environment. Historically, internal IT implementations in project engineering companies such as Tenix often do not meet expectations because neither the implementers nor the engineering organisations understand the people and process issues associated with the implementations.

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[89] Bill Hall (2006). First Interfaculthy Workshop on Collaborative Research and Teaching on Organizational Knowledge Management (KM) - Minutes and Notes 1 February 2006. The Workshop includes representatives from the Faculties of Arts, Economics and Commerce, Education, Engineering, Science.

[90] Conducted by Bill Hall and Susu Nousala in October - December 2005 that involved personal meetings with key people in all of the organisations.

[91] For Dassault Systemes see, e,g., http://www.rea.org.au/initiatives/index.htm; http://www.3ds.com/news-events/press-room/release/981/1/ etc. For UGS see http://www.plma.com.au/index_general2.asp?menuid=050.160

Much of the evaluation and integration work in the lab could be done as unpaid student research projects, so the main recurring costs would be for project management and review - most of which could be funded by the University or via grants.

Application skills gained by students would then be available to hire by cluster members or would diffuse into the broader community of innovators and potential and actual users of the applications - thus feeding growth both of cluster members themselves, and the markets for cluster products.

5.2.3 Seed funding

Industry organisations (such as possibly Tenix) could establish a "challenge fund" to be paid towards the initial establishment costs of the KM Lab facility on condition that the funds be matched by some multiple from other sources, such as internal University, government granting agencies, DSTO, other industry, etc. In the US, these kinds of challenge grants are often used by corporate and private benefactors to universities to fund endowment, buildings or other project expenditures. Many universities actively seek such benefactors. The resulting labs or buildings are often named after their benefactors. This would require some discussion between Melbourne University management and potential benefactors to establish the ground rules, but it should be the kind of approach that would be understood and respected by the University.

Other than the direct payoff from stimulating research directly targeting industry needs, there should be an opportunity for donors and contributors to gain publicity about good corporate citizenship and forward thinking.

5.2.4 Availability of and release time for industry experts to engage in teaching

Establishment of collaborative relationships with industry should facilitate the involvement of industry experts to participate in graduate teaching. Not only should such involvement inject "real world" experience into academic environments that are often very theoretical, but it should provide the opportunity for industry to help train and educate university students in just those high-level project and system management skills most needed within the industry. Many people within Tenix would also see the opportunity to participate in university activities as an honour and reward for their capable involvement with the company.

This will also bring industry people into contact with other cluster members to guide their innovative activities in ways that will be mutually beneficial.

One way to ensure the KM Lab reflects industry requirements, and to provide genuine "in kind" contributions that would require matching support from other sources, would be to second a suitably qualified industry staff to serve as a lab director or manager, at least for the initial start-up period of 2-3 years.

5.2.5 Internships

A third area where industry organisations can offer important influence for little or no cost is by embedding university postgraduate students in their businesses as "interns". As demonstrated by recent discussions in internet KM forums, many non-academic organisations have little respect for academic qualifications - for the good reason that most academic programs provide little contact with real problems in real organisations. Many graduates face a large gap between knowing theory and actually being able to apply it. At least where their knowledge management programs are concerned, University

of Melbourne faculties are aware of this problem and are already seeking industrial involvements for their students[92].

If the student already happens to be employed in the industry of interest, university credit can be gained for work-related projects. However, the university is always seeking internship possibilities for students who lack current industry involvements. In recognition that providing access to an intern is to some degree disruptive and uses resources of the host organisation for supervision, there is no expectation that the intern will be paid for the period of participation, as this is considered to be genuine course or research work towards a degree. However, given that most industrial organisations can't be "bothered" to help either the university or its students, substantial kudos would go to an organisation like Tenix that actually establishes itself as a regular internship partner to the university.

As an example, Tenix has already had significant experience taking interns: TD's Systems Division Graduate Programme has supported one or more from the University of Adelaide[93]. Tenix Defence Head Office has accommodated three interns for periods ranging from a few days to one student who was fully embedded for over a year. All of these relationships have proved successful for the students. Two (one from RMIT Engineering and one from UTS Information Technology) have completed their PhDs based in part on their case study research at Tenix and have provided useful input and insight into Tenix's self-understanding via their case studies. Both were also invited to present papers on their case studies in the July 2006 Tenix Engineering Conference. Several Tenix staff have also used their Tenix experience as practical input towards their degrees.

To date, most of these engagements have been organised individually. Establishing a process to manage internships should allow both the university and industry to gain more benefits from such associations.

5.3 Joint Marketing activities

Given that virtually all of the commercial players already have established overseas markets and some with well developed "channels", there should be opportunities for piggy back marketing of new, integrated products to users of existing products. For example, the PDM vendors UGS and Dassault have well established "partner" marketing channels for integrated products, and TeraText, wholly owned by SAIC should offer good access for integrated products into SAIC's US markets.

There may also be opportunities for joint presentations at conferences and exhibitions, etc. as discussed above for the International S1000D User Forum.

6. Conclusions

The following conclusions can be drawn:

- ICT organisations can draw many benefits from being associated in industry clusters.
- An initial basis exists to form an ICT industry cluster centred in Melbourne to focus on the development of products managing various aspects of technical data, information and knowledge of relevant to engineering, project and fleet

[92] http://www.edfac.unimelb.edu.au/futurestudents/courses/postgraduate/Subjects/SUBJ482866.html.
[93] Ref Dr Martin Jones

management plus adjacent fields. Basically this would be a consortium of organisations developing technologies for the management of complex systems (TMCS).

- This potential TMCS cluster has the possibility to access the growing global market for product lifecycle data and knowledge management applications.
- Depending on the type(s) of engagement(s) sought, there are a variety of ways local industry members can gain advantages from involving themselves in or leading the cluster dynamics.
- Reviews of the ICT clusters formed around Nokia in Finland and in the North Jutland area of Denmark demonstrate many of the factors apparently contributing to the successes of these clusters.
- Other than the obvious advantages of geographic proximity and supply chain collaboration, connections with local education, research and development organisations appear to be very helpful or even critical in the dynamics of cluster formation and sustenance.
- On a per capita basis, Melbourne, Adelaide and Perth offer a concentration of research oriented universities and industrial research organizations that is not exceeded by any other region in the world.
- Steps are given that industry members can take to involve this educational and research establishment, at least in Melbourne, for comparatively small investment costs to help crystallise and support growth of an ICT cluster they can participate in.
- The fact that the University of Melbourne is reinventing itself offers special circumstances that should allow industry to generate substantial leverage through targeted investments in money and in-kind support targeting the "triple helix" of research, education and knowledge transfer as outlined in University's well publicised "Growing Esteem Strategy".
- Recommended strategies for industry's involvement with a university such as the University of Melbourne include:
  - Establishing a "challenge grant" to support an engineering knowledge management lab.
  - Releasing or seconding domain experts to participate in University teaching and research.
  - Establishing an "internship" program providing University postgraduate students with access into Tenix for case study research and practical work experience.

Appendix 1. Ranking the Australian Educational Establishment

The Nokia and North Jutland studies both emphasised the importance of educational and R&D institutions in cluster initiation and growth.

Finland and Denmark have closely comparable populations to Victoria's. Finland has a total university student population of 150,000 in universities offering postgraduate degrees[94]. Denmark has 112,000[95]. Victoria alone has 186,000 effective full time students (EFTS) in such universities[32]. By comparison to Finland and Denmark, the Victorian student population is inflated by the large number of overseas students. On the other hand, EFTS numbers discount the large number of students studying part-time by comparison the simple head counts given by the Finnish and Danish statistics. Also to be considered in evaluating the numbers is that with an industry cluster trying to expand and facing Australia's well publicised skills shortages, locally trained foreign students could represent an additional pool from which new talent could be recruited. Students with overseas connections will also provide potential marketing contacts into their different countries of origin.

The London Times Education Supplement's (THES) well regarded International Comparisons tables[96] also show the high calibre of Victoria's university system by comparison to Finland and Denmark.

Four of Melbourne's universities are in THES's top 200: Melbourne ranks 19th in the world; Monash 33; RMIT 55; Latrobe 98. Denmark has three top ranking universities - Copenhagen 66, Aarhus 138, and Technical University of Denmark 154. Finland has only 2 in the top 200: Helsinki 62; Helsinki University of Technology 194.

From other THES ranking tables: three of Melbourne's universities are in the top 100 technology universities - Melbourne ranks 18; Monash 24 and RMIT 90. Finland's Helsinki is 52 and Denmark's Technical University is 60. Two of Melbourne's universities are in the top 100 science universities: Melbourne 32 and Monash 39. Neither Finland nor Denmark has a ranked science university. A final comparison of note is from the THES rankings of the top 10 non-university institutions, where CSIRO ranks 4th in the world based on the number of citations per publication. Finland and Denmark have no ranked institutions in this table.

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94 http://www.edu.fi/english/SubPage.asp?path=500,4699

95 http://www.ciriusonline.dk/Default.asp?ID=3764; http://web.archive.org/web/*/http://www.rks.dk/sider/publikationer/english/uni-edu-den.pdf; http://www.rks.dk/sider/publikationer/english/DU-UK.pdf

96 http://www.thes.co.uk/statistics/international_comparisons/2005/top_unis.aspx?window_type=popup Note: the university rankings are based on a mix of peer-review rankings and objective measures: Peer review score (40%) Recruiter review (10%) Int'l faculty score (5%) Int'l students score (5%) Faculty/student score (20%) Citations/faculty score (20%).

Victoria's high ranking doesn't just apply by comparison to the Nordic countries. Australia's and Melbourne's higher education establishments rank among the very best of the world's metropolitan regions.

Comparing Australia's 17 universities in the top 200 against the number of top 200 universities per million population in USA and larger EU countries ranks the countries as follows[97] :

Country	No of THES ranked uni's	Top two rankings	population in millions	ranked uni's per million population
Australia	17	18, 23	20	**0.85**
Netherlands	10	53, 57	16.4	**0.61**
Great Britain	24	3, 4	60	**0.40**
USA	54	1, 2	296	**0.18**
France	9	10, 24	61	**0.15**
Germany	9	45, 55	82	**0.11**

Focusing on the top metropolitan regions roughly defined by daily commuters,

Region	No of THES ranked uni's	Top two rankings	population in millions	ranked uni's per million population
Greater Adelaide	2	80=, 154	1.3	**1.55**
Perth	2	80=, 101	1.5	**1.33**
Greater Melbourne	4	19, 33	3.5	**1.14**
Switzerland/Geneva	7	21, 34	7.5	**0.93**
Greater Boston	5	1, 2	5.8	**0.86**
Greater Sydney	4	38, 40	5	**0.80**
Greater London	9	3, 4	14	**0.64**
Greater Paris	7	10, 24	11	**0.64**
Hong Kong	4	41, 43	6.9	**0.58**
SF Bay Area	3	5, 6	7	**0.43**

To qualify these numbers, it should be noted that Boston has the two top ranked universities in the world (THES raw scores of 100 and 86.9), and London has the third and fourth ranks (85.8 and 83.9) with two more universities (59.1 and 59) outranking University of Melbourne's (54.5). Monash, Greater Melbourne's second rank at 33 scores 46.5, RMIT is 82 (30.3) and La Trobe is 98 (28.6). (The lowest score, for the for the 200th rank is 20.8). The San Francisco Bay Area (including Silicon Valley) with a population around 7 million has three of the world's top 20 universities (Stanford 5, UC

[97] Statistics as drawn from THES International Comparisons and 2004-2005 population estimates extracted via Google. Rankings can only be approximate given the difficulties of defining properly comparable geographic regions. However, comparing Greater Melbourne against Greater Boston, Greater London and Greater Paris is considered to be an objectively conservative approach.

Berkeley 6, and UC San Francisco 17) but none of the several other universities in the area are ranked in THES's top 200. This gives the Bay Area a score of only **0.429**. However, the crucial roles these three universities played in the microelectronics revolution are too well known to need documentation.