Edward J. Blakely, Brian H. Roberts, and
Philip Manidis

Inducing High Tech: Principles of Designing Support Systems For the Formation and Attraction Of Advanced Technology Firms

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Inducing high tech: Principles of designing support systems for the formation and attraction of advanced technology firms

Introduction de la haute technologie: bases d'une ébauche de systèmes auxiliaires pour la fondation et la participation de firmes dans la domaine de la haute technologie

Einführung der Hochtechnologie: Grundlagen des Entwurfs von Hilfssystemen für die Gründung und Heranziehung von Firmen auf dem Bereich der Hochtechnologie

先端技術の誘致 — ハイテク企業の育成・誘致計画支援システム

Prof. Edward J. Blakely
Professor and Chair of City and Regional Planning, University of California, Berkeley, USA

Brian H. Roberts and Philip Manidis
Consultants with Cameron McNamara, Brisbane, Australia

Abstract: Almost all Western nations are involved in some form of regional technology development. These strategies are very similar in execution and orientation. The literature on attracting and retaining high-technology firms fails to provide any clear guidance on the factors that in fact affect the locational behaviour of this type of firm. This article is based on the premise that high-technology firms are not attracted by the usual incentives used with industrial firms, but are induced by 'soft infrastructure' factors such as government support for research, local amenities, and networks of communications. The paper shows how a community can analyse its strengths and weaknesses with respect to developing the right infrastructure to induce economic development.

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Biographical notes: Professor Edward J. Blakely is Chair of the Department of City and Regional Planning at the University of California, Berkeley. Professor Blakely is an international authority on local economic development and technology. His most recent work

is *Taking Local Development Initiatives* published by the Australian Institute of Urban Studies.

Brian Roberts is a senior consultant with Camerion McNamara in their headquarters offices in Brisbane, Australia. He has worked with the World Bank on development projects in Turkey and Africa, as well as consulting throughout Australia.

Philip Manidis is a senior consultant with Cameron McNamara in the Sydney office. He specializes in economic and technology development. He has had experience in this field in Europe and Africa before joining Cameron McNamara.

Résumé: Presque toutes les nations occidentales sont engagées d'une manière ou d'une autre dans le développement technologique régional. Ces stratégies se ressemblent de par leur orientation et leur exécution. La littérature dont on dispose déjà portant sur l'établissement et l'implantation d'entreprises de haute technologie dans certaines régions géographiques n'offre aucune directive ni aucun soutient dans la recherche des facteurs qui influencent la localisation de ce genre de firms. Cet exposé est basé sur la supposition que les entreprises de haute technologie ne sont pas influencées dans le choix de l'emplacement par les impulsions coutumières attirant en général les firms mais plutôt par les facteurs 'souples' d'infrastructure comme par exemple l'aide du gouvernement, les avantages locaux, les réseaux de communications. Cet exposé montre comment une communauté peut analyser sa force et sa faiblesse pour arriver à développer une bonne infrastructure et par conséquent le développement économique.

Mots-clés: Développement technologique, développement économique local, infrastructure technologique, évaluation du développement économique.

Zusammenfassung: Fast alle westlichen Nationen sind in irgendeiner Art und Weise mit der regionalen Technologieentwicklung beschäftigt. Diese Strategien sind in bezug auf ihre Orientierung und Ausführung sehr ähnlich. Die bereits existierende Literatur über Ansiedelung und Festigung von Hochtechnologiefirmen in bestimmten geographischen Lagen bietet keine Führung oder Stütze bei der Auffindung der das Lageverhalten dieser Arten von Firma beeinflussenden Faktoren. Dieser Beitrag basiert auf der Voraussetzung, daß die Hochtechnologiefirmen nicht von den üblichen Anregungen und Anreizen, welche Firmen gegenüber gegeben werden, in ihrer Standortwahl beeinflußt werden, sondern von 'weichen Infrastruktur-Faktoren' wie z.B. Forschungsunterstützung durch die Regierung, lokale Annehmlichkeiten und Kommunikationsnetze abhängig werden. Dieser Beitrag zeigt, wie eine Gemeinschaft ihre Stärken und Schwächen in bezug auf die Entwicklung der für eine ökonomische Entwicklung richtigen Infrastruktur analysieren kann.

Sachwörter: Technologieentwicklung, lokale Wirtschaftsentwicklung, technologische Infrastruktur, Bewertung der Technologieentwicklung.

要約。西側諸国のほとんどがなんらかの形での地域的技術振興計画に携わっている。その背後にある考え方や実際のやり方は似通っている。ハイテク企業誘致に関するこれまでの研究論文は，これら企業の工場立地選択に実際に影響する要因を看過してきた。本稿によれば，他の企業と異なり，ハイテク企業の場合はソフト・インフラストラクチャーが決定的な誘因となる。ソフト・インフラストラクチャーとは，たとえば，研究開発に対する政府援助，環境要因，通信網その他である。ここでは，地方自治体にとって，経済的発展を図るためのインフラストラクチャーとはどのようなものであるか，またそれをどのように構築していくかを分析する。

キーワード。技術開発，地域経済開発，技術のためのインフラストラクチャー，技術開発アセスメント。

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1 Introduction

The literature on attracting and retaining advanced or high-technology firms as an economic development strategy is very mixed. The precise methods, as well as the factors that lead high-technology firms to select one community over another, remain an issue of considerable debate [1,2,3]. Many analysts argue persuasively that for most communities the policy choices are either new high-tech jobs or no jobs at all [4]. Irrespective of the arguments for or against high-technology options as job generators, public officials at every level are enthusiastically supporting efforts to attract, retain or grow new advanced/high-technology firms. In fact, nearly every urban region in the western world has a high-tech strategy or programme of some type that emphasizes the use of university resources and public facilities as the central component aimed at innovative firms in specialized technologies with global markets.

In many instances, regions in the United States like North Carolina, Pennsylvania and California have formulated specific technology strategies. In a similar manner, France, Sweden, Germany, Italy and Japan have embarked on ambitious regional technology development programmes that even pinpoint specific technologies for specific regions. In essence, regions and localities are embarking on industrial policies even when at the national level there remains considerable debate as to whether such policy initiatives are feasible [5].

While regional industrial policy has more adherents than national policy, it has no less risks, particularly in the area of selecting the correct sectors for technology investments. Obviously, trying to select or target any advanced or high-technology programme is even more dicey than relying on traditional sectors of the economy. Nevertheless, anxious government officials are proposing specific technology approaches and promoting such things as science parks and university incubators as the magnets to attract or the 'seed corn' to grow new firms. All of this activity seems to ignore, or not to fully recognize, the overwhelming literature and empirical evidence that suggests that high-technology development is nearly impossible to *produce* or purchase by traditional industrial incentives such as free land or low taxes. Rather, the evidence indicates that advanced technology firms are *induced* by the character of the environment in the region. That is, the setting itself and not the amount of money spent or other blandishments will stimulate the creation of new firms or the attraction of existing technology-oriented enterprises. In a sense, some places have it and others don't. The question then is: can a community that does not have the correct environment now create or stimulate it? In this article we cannot answer that question categorically, but we can suggest the capacity requirements that communities need at the various stages of technology development, as well as present an analytical method that we have used with considerable success in assisting regions examine their 'technology development capacity' as attractors for new high-tech firms.

2 The technology development process

There are no instant formulae for advanced technology development success. What is applicable or successful in one region may not, if duplicated, be successful in another area. Each region must find its own place or niche in the technology environment. It may even be that high tech is not the best strategy to adopt for a particular region since it lacks the factors that can or will induce 'knowledge-intensive' firms.

The range of support systems needed to encourage and foster advanced technology development are many and complex. Only a broad list of essential support structures are addressed in this paper. The basic orientation we take is that the 'soft infrastructure' leads the hard (money and physical) infrastructure, and not the reverse. In order to plan for advanced technology, it is important to understand how the technology process works. There are four stages in the process, and the failure to provide the necessary supports at any one stage may ultimately inhibit the development of new products and industries. The traditional linear model of technological development assumes a four-step process, beginning with the development of a new idea or discovery and following through to the commercial applications. Figure 1 illustrates a simplified model of the process of technology development.

The technology process is cyclical and interactive, as Figure 2 depicts. Each stage in the process may revert back or interact with a previous stage. For example, product

Figure 1 Linear model of technology development

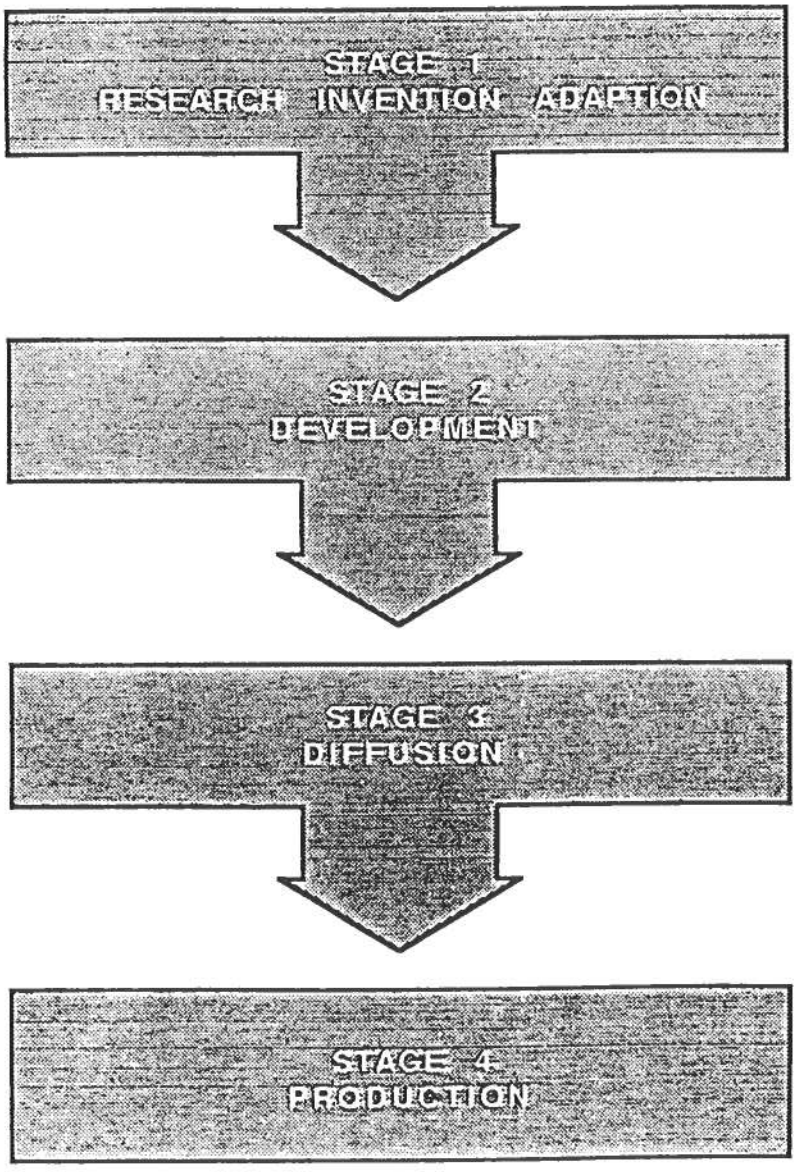
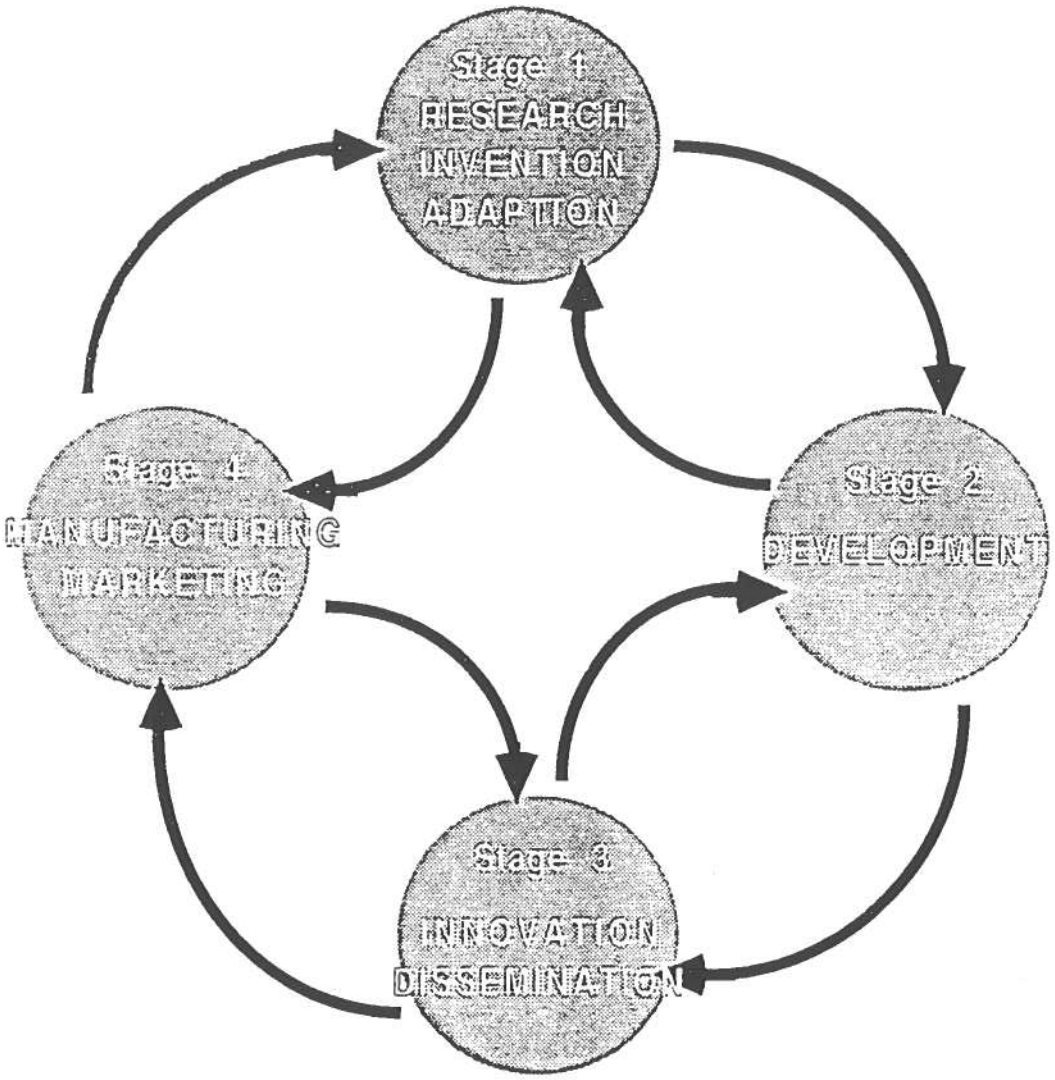


Figure 2 Cyclical/interactive process of technology development



failure spurns new research or a new phase of innovation. The process has its own support system requirements. In too many instances, the regional policy or programme fails to recognize these distinct stages and consequently fails to create the right environment at the right time. The basic components can be described as follows.

2.1 Research

Research identifies the basic scientific principles on which new technology industries or products are based. Research may be applied (that is, be designed to solve specific problems or have an application for a field of technology) or generic (which is non-specific research in areas of continuing pertinence for a business enterprise). Targeted research may be market-driven, that is guided by the knowledge of market requirements; or technology-driven, that is guided by perceived capabilities of specific technology [6]. Each field of research will also have its own peculiar support system. Most generic research

is performed at national universities or laboratories, with funding coming primarily from government. Most applied research is performed at large industrial labs.

2.1.1 Invention

Inventions are products which may or may not arise directly from research. Often inventions result from ideas which help to improve the efficiency of an operation. In many cases, gadgets, devices or programmes are the result of invention. These are eventually developed and refined as new technology products.

2.1.2 Adaptations

Adaptations are modifications or improvements to existing technology which improve the efficiency of operations, for example a modification to software. Adaptations may result from research or invention.

2.2 Development

The second stage in the process of technological development is product development. At this stage, ideas, research principles, inventions and adaptations are translated into a practical product. During this stage, prototype tests or models will be built to evaluate the performance, application and feasibility of developing the product to a commercial level. More detailed feasibility studies and some market research will be undertaken. Much prototype development work on new products and technologies is undertaken by small companies. These are often more productive and efficient than large corporations, as most of their resources are devoted to research and development. They must also survive on what they produce.

2.3 Innovation and dissemination

The third stage in the process involves the commercialization of a new product or process. A decision will be made by the company which developed the product to manufacture or sell it. If a company decides to manufacture, it may enter into joint venture or other production arrangements. Marketing, venture capital finance and entrepreneurs will be important in the innovation and dissemination stage [6].

2.4 Production

The first three stages in the technology process all represent investment costs. It is through the manufacture or sale of new technology that a company produces a return and recoups the cost of the product's creation. Production is the final stage of the process. Larger companies which have purchased or developed a high-tech product will manufacture and distribute it. Other companies will disseminate the production of components to subsidiaries to produce, i.e. chips, circuits, etc. Constant marketing and monitoring of the product is essential during the production stage. Regular feedback to research and development and marketing is essential in order to continue to improve a product or terminate the production before it reaches the end of the technology life cycle.

3 Support systems and advanced technology development

During each stage of the technological process, a complex range of support systems are required to ensure that the application of research or ideas are carried through to the production stage. The support systems required for advanced technology development are numerous, and the extent to which they are needed within the process of technological development varies. But unless the right supports are available at every stage of the process, that process breaks down and the prospect for promoting advanced technology industrial development is considerably weakened. It is important, therefore, to understand how the process operates so that the right support systems can be put in place for the different stages of technological development [7].

Advanced technology development requires timely and totally integrated support systems to grow and develop. High-technology firms have a complex and interrelated set of special requirements based on their stage of development, including their size, technology base and global market position.

Table 1 shows some important support systems which are required at the different stages of the technology process. These will be discussed in more detail below. The list is based on a compilation of the latest literature on high technology and location, as well as field observations of the authors in implementing technology development strategies in Australia, Europe and the United States [8].

3.1 The soft infrastructure

The need for information systems, education and research, and business and environmental supports are the soft infrastructure for development, as these are important in getting the research stage of the technology process started.

3.1.1 Information, communication and strategic relationships

The essential link between each stage of the technology process is information: it is what drives technology. Without this it would be impossible to proceed to the next stage, since information provides the clues about the direction in which to move. Without facts from research, no matter how simple, a product is unlikely to be developed; without marketing information, new products run a high risk of failure; without social interaction, the flow of information about research and new ideas between scientists slows, and so does the rate of change in technology [9].

The information required at each stage in the technology process is different. At the research stage, buying or acquiring information is important. At the production phase, selling information will be essential to commercial success. Information is transferred on a formal and informal basis, and special attention needs to be given to the latter. Much of this information is not technical but commercial, production and marketing information.

Conference centres – some associated with hotels, others with university and research institutes – play an important part in the information transfer support system for advanced technology. Information exchange is also fostered by greater access to information networks, through libraries, information exchange bureaux, media and publications. The ability to tap into networks is very important, and will require even greater investment by the communications industry in the future to provide the necessary infrastructure to help establish new and improved information networks [7].

Table 1 Support systems required for advanced technology development

	Stages of the Development Cycle			
Support system	*Research*	*Development*	*Diffusion*	*Production*
Information Communications Strategic relationships	Social inter-actions library and database	Conference facilities	Innovation centres	Publications Media support Commercial Marketing
Human resources	Research scientists Inventors	Skilled technicians	Entrepreneur venture capitalists	Top management skilled and flexible
Education and research facilities	University or Research Institute	Research labs	Conference facilities	Community/ Vocational/ Technical College
Environmental quality	High quality houses and recreation areas	High quality recreation and cultural areas	High quality living and working envir.	High quality work facilities and equipment
Business and community institutions	Contracts from large firms	Venture capitalists for start-up firms	Entrepreneurs and local social network	High-tech specialists
Government	Government contracts available	Joint-venture technology companies	Information services	Offset policies
Finance	Research grants	Private investment	Investor consortia	Institutional finance
Physical infrastructure	Specialized infrastructure in support of technology	Research facilities accessible to local investors	Fibre optics or related trans-mission services	International airports Toxic and scientific waste systems
Enterprise facilities	Research Institutes, Universities	Incubator buildings	Innovation centres	Technology and/or business and science parks
Community facilities and support	Good community facilities	Regional recreational, cultural and social facilities (e.g. golf, symphony, sports, etc,)		Specialized commercial and professional services
Technology image	Technology Publications Name Status	Environmental quality reputation	Designation/or reputation for specific technology	Top quality high-tech firms
Planning and development regulations	Controls related to industrial requirements	Provision of research and testing areas	Designated mixed use areas	Regional technology strategy

Creating an environment which maximizes the exchange of information, communication and the formation of strategic relationships is the key to successful advanced technology development. It is the nucleus around which the other physical, social, economic and environmental systems needed to support advanced technology industrial development will depend.

3.1.2 Human resources

Human resources, in terms of skills, know-how and entrepreneurship, is an important support system for advanced technology development. During the research phase of development, a highly skilled workforce is required. Most people involved in research will have Masters or higher degrees, and some will have multidisciplinary skills.

Social skills related to communication, language, and interests which develop between scientific personnel also need to be developed. These skills develop as the result of peer group association and interaction as scientists and researchers meet in different forums of scientific and social interest. One of the successes of Silicon Valley is the high level of social interaction which develops between scientists in one locality. Scientists in social vacuums are deprived of innovative thought that results from social interaction. They rely on publications which are limited in what they can convey. Once a research discovery or invention proceeds to the development stage, there is a need for a pool of technicians to undertake the rigorous testing and quality control on new products. The skills required of these personnel are not highly specialized, but involve a careful eye for detail on what can often be repetitive work [10].

During the development and dissemination phase, special resources are required – particularly entrepreneurs. Entrepreneur venture capitalists are an essential link between product development and product production. Trained entrepreneur venture capitalists are an essential human resource support system required to promote and develop advanced technology industries. In the final stage of the technology process when a product is manufactured, special marketing, finance and management skills are required.

Employment mobility is an important feature of advanced technology areas. This is partly due to the rapidly changing nature and high failure rates of technology enterprises. In addition, many individuals do not want to be bound to companies and prefer contractual or project-based employment. Most businesses look upon this favourably as it reduces problems with staff retrenchments in economic downturns or at the end of technology life cycles. This mobility also encourages considerable interchanges of staff, and hence ideas, within companies and research centres – a convenient means of providing refresher courses. In most of Europe, mobility is generally not encouraged, partly because of the lack of transferable superannuation and other benefits as well as other structural rigidities in the labour market system [11].

3.1.3 Education and research facilities

Another important support system for advanced technology development is the presence of a university or technical institute of international standing orientated towards science and research. A university provides a catalyst for future scientists and researchers to develop their ideas and thinking in a wide field of science. Evidence from studies carried out in the United States and elsewhere suggests that while universities do play a direct role in supporting high-tech research, they have a more vital role in providing a pool of fresh minds and ideas which high-tech industries require to develop.

Perhaps the most important support system for advanced technology development is the establishment of research institutes. These are specialized institutes which place a greater emphasis on applied research. Stanford Research Institute, for example, was one of the important ingredients in propelling the high-tech development in Silicon Valley, California. Such institutes might be privately or publicly funded and may consist of one or more centres [12].

Equally as important as the research institutes are research laboratories and incubator establishments, some of which are tied to major companies. Bell Laboratories and the Wang Research Institute are good examples. There is a tendency for major companies to form, or parcel out work to, subsidiary companies whose activites specifically involve research and development. Government research centres are also important in the technology process. Many are involved with generic or pure research [13].

During the development stage of technology product development, there is a need for a pool of technical staff whose training, while not to a university level, must be at a level to carry out skilled work. Research or technical institutes are often responsible for training skilled technical staff. Colleges with specialized courses related to science may also be needed to provide lower-level support staff for research institutes or research laboratories. Technically-orientated colleges form an important role in training staff for mid- and low-tech industries [14].

While universities, research institutes and laboratories perform an important educational function in the process of technology development, strong support is also required at the secondary education level. Students of science at high schools must be computer literate and have some knowledge and training in research methods to gain employment in technology-based enterprises. This support goes as far as providing computer facilities in public libraries for pupils of families who cannot afford home computers to develop their knowledge of programming and skills with computers.

3.1.4 Environmental quality

The quality of the environment in which people live and work (life style) can have a significant effect on whether an individual chooses to live in one locality or another. Experience throughout the world indicates that personnel involved in research and development choose to live in high quality residential environments with good amenities, and cultural, commercial and education facilities. Rural areas and small town areas, not too distant from major cities, are specially good locations.

High salaries are unlikely to attract such personnel to areas where the quality of the environment is perceived to be poor. Most scientists value the association they have with friends and colleagues in an environment which has quality settings, and cultural and intellectual stimulus. Similarly, executives and managers require good living environments as part of their work environment: the total environment, including recreational areas, homes and social gathering places are important parts of the work environment in a knowledge-sharing business.

3.1.5 Business and institutions

While universities and research institutes play a significant role in promoting new advanced technology-based enterprises, the literature and our observations indicates that the establishment of major corporations and institutions which have research and development sections attached to their operation form a major stimulus to the growth and clustering of technology industries. Many large companies in the United States have defence contracts

which have been the principal stimulus behind numerous high-technology developments. Other companies in the pharmaceutical, biotechnology, medical and chemical fields offer significant spin-offs for advanced technology enterprises.

A major mistake that many government and municipal authorities make in trying to promote advanced technology development is to attract a branch of an overseas subsidiary of a major company to their area. Experience has shown that the spin-offs from these subsidiary or branch companies are small. It is essential if a major company is to be attracted to a region that it moves there of its own accord because the environment and the support systems in that locality are conducive to its needs. If a company moves its headquarters of sub-headquarters and product lines, it brings with it its own internal support systems which in turn require external servicing. On the other hand, a community that embarks on a strategy for growing its own technology enterprises can create an agglomeration of technology industries within the region or locality. The multiplier effect of technology development when this occurs is significant as small R & D businesses pick up contracts from these larger companies. Small high-tech businesses are dependent on large businesses to fund applied research and develop high-tech products. Evidence shows there is a very strong vertical relationship between small high-tech businesses and major companies. Many small start-up firms supply components to larger companies. These small companies develop a 'niche' which remains as long as the parent manufacturing company continues to use its products. Failures in small-scale high-tech enterprises are due to major companies terminating their contract with servicing companies when the primary product is no longer marketable. Small companies are part of the technology life cycle of product development. Many never survive to grow into large firms but become part of larger operations. There is a trend in recent years to establish innovation centres to encourage the development of small-scale businesses involved in high tech. Many of these have failed partly because they were too far removed from the major businesses they serve. Innovation centres are more likely to succeed when located close to major users or developers of high-technology products and research institutions [15].

The importance of institutions as catalysts to advanced technology development has often been overlooked in the belief that the greatest spin-offs come from corporations. Medicine is one of the sciences where research is expanding rapidly and hospitals are a base for much of that research. With hospitals becoming more specialized, there is a greater need for more precise instruments, drugs, vaccines and equipment. There are considerable opportunities for advanced technology enterprises to take advantage of these institutions' needs.

Other government institutions which can act as catalysts for high tech are telecommunications, government science laboratories, agriculture and marine research centres, and administrative services. The latter are becoming increasingly dependent on substantial data storage and retrieval systems and processing. The obvious benefits of defence institutions are well documented, but the opportunities to develop advanced technology industries from the special requirements of other government institutions are numerous.

3.1.6 Government support

The primary role of government in promoting advanced technology development should be supportive – not directive. Experience in several nations has shown that direct government involvement at best results in mediocrity but more often results in a disappointing performance. There is a tendency for government to dictate the path of research rather

than let market forces determine what path research and advanced technology development should take of its own volition and in response to market demand [16].

However, government has a very important role in supporting the research stage of the development process. Direct funding of applied and generic research is essential but overseas there has been an emphasis on governments contracting research work. In the United States, much government laboratory and applied research work is sub-contracted to research institutes to ensure that it is directed towards a market with commercial application. Government institutes are notoriously poor at marketing their own developments.

Government support is also required for small-scale private research and development. Tax incentives, dispensations and tariff protection may be necessary. The provision of major infrastructure such as airports, which only governments can build, are needed to support advanced technology industries at the production stage.

Governments have a very important role in ensuring that off-setting occurs when foreign investment is involved. Off-setting is a process whereby major overseas companies investing or selling advanced technology goods in a country are required to have some components for their operations serviced by local companies. Off-setting can have tremendous benefit in promoting local small-scale high-tech enterprises. Off-setting also exposes local industry to advanced technology from overseas and often leads to new industries being developed as the result of technology transfer. In many countries, however, off-setting has been assigned to servicing only and as a result there have been few spin-offs or benefits to local manufacturers and research and development establishments. Governments should ensure that for large contracts involving overseas companies, off-sets are used to develop R & D and new technology industries [15].

Municipalities have an important role to play in promoting and, in some cases, developing facilities for advanced technology industries. Municipal government support is also needed in giving planning concessions and local taxation relief. Many countries have successfully promoted advanced technology industrial development through local economic development programmes or industrial development organizations. These entrepreneurial organizations have representation from local government, business, finance, research, education and trade union interests. They help co-ordinate development and pool resources to market the region. Such organizations are very common in Japan, Sweden and the United States. They have been one of the principal reasons for the success of the Japanese Technopolises [17].

It is essential that total political support be given at all levels of government to help encourage advanced technology development. Such support is needed to maintain and build the image of a technology region, and to avoid the parochial competition that often arises between municipalities within a region. Advanced technology is a global business and a co-ordinated regional development effort is required for success.

3.1.7 Finance

Venture capital is an essential prerequisite of advanced technology development. Venture capital enterprises using funds from private investment are responsible for promoting most products in small-scale business enterprises. Larger companies draw on their own capital reserves to fund research projects and to develop their own products. The literature on technology development suggests that venture capital financing should be left to the private sector, as government-sponsored or created venture capital organizations appear to have a very poor understanding of sound investment in the technology market [18].

Current research suggests that government should not become involved in direct financing of commercial products as they can stifle the entrepreneurial role of venture capitalists and marketers promoting a better or more competitive product. Government financial assistance is required at university and research institute level; however, experience in the United States suggests that some programmes of research should not be funded entirely by government. Partnership arrangements or joint venturing between government and the private sector is an emerging practice [19].

3.2 The hard infrastructure

3.2.1 Services and facilities

Most modern industrial areas are properly serviced; however, for advanced technology industries, infrastructure requirements are more specialized. These may include:

- High quality water supply. In this respect, some chemical industries require a water supply that is neither too acid nor alkaline, and chemical properties which will not react with materials used in the production of technology-based products.
- Fail-safe electricity supply. For advanced technology industries associated with computing or information transfer, current surge, loss of power or low voltage can significantly jeopardize the operations of the company. Back-up electrical support systems are an essential part of advanced technology industries associated with computer or information transfer systems.
- Fibre optic cables. For many new advanced technology industries – particularly those handling a significant amount of data – a need for fibre optic cables is paramount. The cabling system may be linked to service centres and finance houses within the region, to the national network, and increasingly to satellite networks.
- Toxic waste disposal facilities. There is a tendency to think that high-tech industries are all clean. Many are, but some of the by-products of process-orientated high-tech enterprises are the most toxic and explosive wastes known to man. Careful planning of toxic waste disposal is required for some process-orientated technology industries.
- Transport system. Most advanced technology enterprises are located in areas close to or along main highways, particularly those leading to ports and airports. In Japan, public transport within and to advanced technology industrial areas is an important support system.
- Airports. Because a large number of advanced technology enterprises are export-orientated businesses, there is a growing tendency for such businesses to be located close to international airports – particularly cargo airports. In recent years there has been a marked growth in the number of 'freight-line industries' assembling high-technology products close to international airports. Freight-line industries may be associated with the computer, printing, dispatch, biotechnology, and precision biomedical parts.

The significance of government services is well documented in a variety of surveys. Table 2 documents the services high-tech firms generally want from government.

3.2.2 Technology image

To successfully promote advanced technology development, it is essential to set out to create a regional technology image. To do this, it is paramount that the universities, research

Table 2 Expert survey scoring of urban-level physical location factors for high-technology industries in Australia

Factor rank	*Description*
1	Major highway access
2	Land cost
3	Co-operative local government
4	Quality public utilities
5	Professional and technical workforce residential areas
6	High quality industrial sites
7	Proximity to airport
8	Topography
9	Proximity to other technology firms
10	Proximity to cultural amenities

Source: The authors based their research on interviews with high-tech firms in Australia. (Very similar lists are available for USA and Europe [see 23, 24].)

institutes, companies and back-up facilities are world class. Both businesses and research personnel are attracted to world class facilities, and they in turn strengthen the image of the region and attract other industries and scientists to it. Those regions with well-established advanced technology enterprises have world-recognized universities, well-known company names and lists of Nobel prize winners. Creating this image is a long-term task but a first step is the naming of facilities such as education and research institutes. These names, for example Massachusetts Institute of Technology, convey a technology image. The second step is ensuring that future development is of the highest standards and environmental quality.

3.2.3 Planning and development regulations

Urban planning and development regulations can have a significant impact on the decision by businesses to locate in one region or another. There are no rigid guidelines that can be laid down to determine the percentage of a business which can be used for one land use activity or another. Advanced technology industries are in a constant state of change, as is the land or floor space they use. The development control system adopted in advanced technology industries should be very flexible. Planning guidelines should stress performance standards and the need for high environmental quality through landscaping, urban design, architecture and supporting social and recreation facilities. Planning policies should give incentives to industry, and not act as a total controlling mechanism. There are always other regions which will bend rules to entice industry.

3.2.4 Enterprise facilities

'Enterprise facilities' is a term used to describe the buildings, areas or estates necessary to carry out business associated with high-technology. Some of these would be developed as part of other support systems, for example universities, research institutes, research laboratories, and innovation and conference centres.

Depending on the type of facilities required, directors of advanced technology companies will select a locality for either the corporate headquarters, satellite or branch offices, research and development facilities, subsidiary manufacturing centre of field offices. Some

companies may combine all of the above in one location. For some enterprises a rural location will be selected; for others an urban, commercial or industrial area will better suit their needs.

In a study [20] which compared the location of high-tech industries in the USA and Britain, high-tech industries were shown to fall into two locations: those industries centred in older well-established industrial regions, and those in more open spacious rural settings. Most new businesses, however, will follow the trend of becoming established in one of four specialized development areas. These are research and science parks, high-tech parks, business parks and high quality industrial estates. These are defined by Joseph [21] as follows:

Research park A high quality, low density physical development in a park-like setting, where there is significant interaction between academics, researchers involved in research and product development, and commercial organizations and entrepreneurs.

Science park A science park contains research and development enterprises with an innovation centre, but can also include light industrial production relating to scientific research and appropriate ancillary services.

Technology park A collection of advanced technology industries concerned with both research and manufacturing, located in attractive, well-landscaped surroundings and situated within a reasonable catchment area of a scientific university or major institute.

Business park A prestigious environment, suitable for a wide range of activities, including manufacturing, assembly, sales and other office-based activities. There is no requirement for these parks to be close to academic institutions.

High quality industrial estate These estates have attractive features for certain forms of contemporary light industries.

There are many benefits to be gained by new industries being located in specialized, well-marked facilities, namely good services, shared facilities, high quality environment and flexible planning conditions. These facilities are now becoming firmly established with the image of high-technology and are therefore an important support system.

3.2.5 Community facilities and support

Few scientists will choose to live in areas which have a poor range of community facilities and services. Good shopping facilities, entertainment, restaurant dining, recreation and medical services are important to their way of living. Such facilities are also important in developing associations between people involved in research and development and high-tech industries. These associations allow ideas to be expressed on an informal basis and knowledge to circulate.

As many people involved in the fields of science, research, and development are generally highly paid, most of them expect higher levels of service and are prepared to pay for it. There is an exclusiveness about high-tech personnel and where they live, recreate and do business. The quality and range of services expected by them is therefore very important to their life style.

Total community support for advanced technology is also important. Most people in

the community are totally unaware of what advanced technology industries are or what they make – apart from computers. The great success of the Japanese Technopolises has been the interest and total community support given to help promote and attract new industries to the different regions. This enthusiasm has been brought about by education programmes within and outside the work place.

Trade union participation has been a very successful means of generating total community support in countries like Sweden where unions are promoting new technology development. The role of unions in selling the needs of new technology to members has often proved more successful than management-enforced change. The role of unions in promoting advanced technology development is a very important support system.

3.2.6 Marketing

Marketing requires special mention as a requirement for advanced technology development. It has a role in all the stages of the technology development process. It should direct research and is most important in the development, diffusion, and production stages of technology development. The marketing of advanced technology products is a very complex process requiring an understanding of the international market place and the use of key participants in the development process. Word of mouth from a reputable firm, and endorsement by this firm and other key participants such as key journalists, is very important.

3.2.7 Location of high-technology industries

Most high-tech enterprises are not dependent on localized materials, transport, a large labour pool, and local or national markets to survive. They are, however, dependent on global markets, information, and special technical and social skills. The reason there is a concentration of silicon semiconductor industries in California is that the necessary social and technical skills are there. People with those skills generate information about that industry which the high-tech companies, in turn, need to develop new products. This agglomeration of industries and social skills creates an image of high-tech which provides a magnet for new industry [15].

Building social and technical skills and developing the information network is, therefore, the prime objective for high-technology industrial development. Creating the environment to attract people, investment, and business is the means by which that objective can be met. The more support systems there are in a region, the greater will be the chance of new industries being attracted to it [7].

Ultimately, it is the business which decides where to locate. That decision will be made by weighing a basket of factors. For some companies, it may be an almost insignificant factor such as the closeness of the business to the managing director's home that would tip the scales. However, for larger enterprises, which provide the catalyst for spin-offs, it will be the strengths of the major supports perceived to be of the greatest benefit to that industry which will affect the decisions on location [22].

4 Framework for evaluating deficiencies of support systems in Western Sydney, Australia: A case study

Australia is moving away from natural resources, agriculture and manufacturing as the nation's economic base. As a companion to this national economic thrust, several large regions are developing technology management strategies on their own.

Western Sydney is one of Australia's largest manufacturing regions with a high-tech economic strategy. This area has been designated as one of the areas that has potential for advanced technology development and attraction. As a result, a major assessment of the area was undertaken by the authors in 1976 [17]. Australia, in order to succeed in developing advanced technology, needs to build on its existing industrial and natural resources and to use these as a basis for moving towards high-tech development. Western Sydney, with an established industrial base and other resources, is one such region where the opportunity for providing advanced technology development would appear favourable.

The above discussion identifies some of the support systems necessary to encourage technology-based industrial development. However, many supports cannot be provided by either municipal or state governments. R & D tax and export incentives, for example, are the jurisdiction of the Federal government in Australia. This poses significant problems in promoting regional development of advanced technology. It does, however, force regions to develop their own resources and to prepare appropriate strategies to encourage new-technology industries.

Table 3 outlines the basis of the framework used to evaluate the strengths and weaknesses of advanced technology support systems in western Sydney. The left-hand column of the table shows broad support system categories. Using this framework, each support system was broken down into individual support items. For example, education and research contains listed supports such as research, university and state laboratories. In this way, it was possible to list those supports which need to be developed as part of an overall strategy for technology development in that region.

Table 3 Support system deficiency analysis

Support system	*(Strengths)* R D I P	*(Weaknesses)* R D I P
Information system		
Human resources		
Edication & research		
Environment quality		
Business and institutions		
Government		
Finance		
Infrastructure		
Enterprise facilities		
Community facilities		
Technology image		
Town planning		
Marketing		

R = Research D = Development I = Innovation P = Production

It is acknowledged that much of the analysis used in this framework was expert judgment. These judgments were formed through a process of interviews and four 'think tanks' comprising representatives from government with technology interests, entrepreneurs, venture capitalists, trade unions, research and education personnel that were used to evaluate the strengths or weaknesses of support systems in the region. These have been summarized in the matrix in Table 4.

Table 4 Matrix of strengths and weaknesses of advanced technology support systems

Support system	*Existing*		*Short-term*	
	Strengths	*Weaknesses*	*Strengths*	*Weaknesses*
Information exchange and communications		OO		OO
Human resources				
– Entreprenuers		OO	X	
– Scientists		OO	X	
– Skilled Labour	XX		XX	
– Semi-skilled Labour	XX		XX	
– Unskilled Labour	XX		XX	
Education and research facilities				
– University		OO	XX	
– Research labs/incubators		O	XX	
– Government research facilities	XX		XX	
Environmental quality				
– Residential amenity		OO		OO
– Rural residential	XX		XX	
Government support				
– National	X		X	
– State		OO	XX	
– Regional organization	X		XX	
– Local government		O	XX	
Community support		O	XX	
Union support		O	XX	
High-tech firms		OO		
Developers		O	X	
Finance		OO	X	
Marketing		OO	X	
Technology image		OO	X	
Enterprise facilities		O	X	
Infrastructure				
– Roads		OO		OO
– Telecommunications		OO	XX	
– Toxic waste disposal		OO		

O minor weakness
OO major weakness
X minor strength
XX major strength

Source: The Authors

This matrix provides a ledger which identifies those support systems most lacking in western Sydney. The area is severely handicapped by a lack of a university or research institute, has a poorly developed information exchange and communications network, has a perceived low quality living environment, and poor financial support systems and infrastructure. The region, however, has a concentration of medical and electronic establishments, a major hospital – Westmead (which is working in the forefront of medicine related to life support systems), a government-based research centre, a large pool of semi-

skilled labour and opportunities for a rural residential life style with direct access to good outdoor recreation areas such as the Blue Mountains.

The biomedical/electronic-based strengths of the region provide definite opportunities to promote advanced technology industries in the medical instrument, pacemaker, pharmaceutical and drug-related fields. These industries will require new support systems – especially the establishment of a medical/science-related university and the building of information and strategic networks. This will be done through the establihsment of a regional technology organization made up of private and public sector interests. Its role will be to market, co-ordinate and direct regional resources to support new technology development in the West.

5 Conclusions and observations

High- or advanced-technology strategies are important to almost all regions of industrialized nations. A strategy that is based on using particular tools rather than in-depth assessment of the scientific and human resource potential of an area will fail. Therefore, it is important for policy makers and strategists to develop a sound framework for technology development that creates the conditions for the technology rather than forcing the technology firm(s) into the environment. Inducements rather than incentives represent the key concepts developed in this paper. That is, creating the right conditions using private and public sector resources will be far more rewarding and realistic than any other approach to high-tech development in any region of the world.

This paper has sought to identify those support systems which are necessary to encourage the establishment of new advanced technology industries, taking as an example a case study of western Sydney. Some supports are more important than others, and those regions which have the best supports for particular industries are more likely to achieve success than those which lure industries that eventually turn out to be a total mismatch with regional resources. High-tech is a high risk business. There are no instant successes and far too many failures. Those regions which succeed are those with resources and support systems which meet the requirements of every stage in the technology process.

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