BC STATS
Province of British Columbia
Ministry of Government Services

DEFINING THE BRITISH COLUMBIA HIGH TECHNOLOGY / KNOWLEDGE SECTOR IN BRITISH COLUMBIA

A joint project of BC STATS and the Science and Technology Division
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This paper was prepared by

Jill Lawrance, Ecometrics Research
and
Steve Miller, BCSTATS

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Shawna Meade, Science and Technology Division
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Gurmit Sandhu, Sandhu and Associates

INTRODUCTION

As planners look increasingly to the high technology industry as a source of future growth, the need for a consistent monitoring mechanism is apparent. The lack of a widely accepted industry definition makes it difficult to assess the high technology industry's performance. The resulting uncertainties, in turn, hamper policy makers' efforts to develop effective policies and programs to assist the industry's growth and development.

This paper is the first step in a project to define British Columbia's high technology industry and measure its employment and economic characteristics on an on-going basis. The project starts by defining the industry using the standard industrial classification (SIC). At this stage, we are interested in developing a widely accepted selection of SICs for inclusion in the high technology definition. However, as our understanding of the industry grows and more detailed information becomes available, a more precise measure of the industry, based on company- rather than industry-level data, will be adopted.

The goal of this paper is to identify the set of standard industries in British Columbia that will be included in the high technology definition. This is done by reviewing and comparing the industries identified by nine different studies of the high technology industry. Together, these studies consider many criteria commonly associated with high technology activity, such as research and development, employment of scientists, and production and use of advanced technology commodities. They agree almost unanimously on the inclusion of some industries and the exclusion of others. However, there are some gray areas, where only a few of the studies identify an industry as possessing high technology characteristics. We plan to consult with technology experts who are familiar with the industry in BC before making a final determination in these instances.

2.0 A MODEST APPROACH

The use of SICs to define the high technology industry is modest because data are readily available for standard industries and, thus, relatively inexpensive. However, there are several drawbacks to using SICs. To begin, the standard industrial classification does not recognize industries of the 'new economy', including the high technology and knowledge-based sectors, nor is it likely to do so in the near future. This is because Statistics Canada ensures consistency of historical data series and international comparability by holding its classification constant over many years and subjecting changes to agreement from NAFTA and the EU partners. Without an SIC code that applies specifically to high technology companies, their information is published along with data from other companies producing similar products or using similar inputs.

SIC-based definitions are unable to capture the breadth of high technology or knowledge intensive activity in the economy. Industry Canada (1994: 7) argues that "the innovation economy covers all industries, not just those known as high-tech industries." The survival of BC's resource industries, in the face of competition from developing countries, is a testament to the creativity of some resource companies, who have applied technology and knowledge to the production and marketing of their

products. A study of the high technology industry based on SICs, however, will inevitably exclude some of these companies because they are classified to industries that, in aggregate, do not show high-tech characteristics. At the same time, the definition will include companies in high-tech SICs whose operations lag behind the industry norm. We propose to compensate for these inaccuracies by applying high-tech percentages to SIC totals wherever possible, and by updating these percentages as improved or new information becomes available.

Other drawbacks to SIC-based definitions stem from their reliance on secondary data sources. These sources may not be sufficiently timely to track the activities of an industry, which, by definition, is changing rapidly. The high technology industry consists of companies that are on the 'leading-edge' in terms of their processes, products and services, and who invest extensively in research and development. As such, the industry is always in a state of flux; its product mix, production processes and the companies comprising it change constantly. Only the most timely data will accurately capture this industry, and they too will become dated quickly.

Finally, the high technology industry benefits from the clustering of similar economic activities geographically. As such, BC's high-tech industry is comprised of different economic activities than, say, Ontario's or California's. Subsea research and product development, for instance, is an area of specialization for British Columbia. To accurately reflect the distinct make-up of BC's high technology industry would require a methodology that focuses specifically on BC.

These drawbacks of SIC-based definitions and their corresponding reliance on secondary data could be overcome by adopting a company-level methodology, such as direct surveys. However, a list of companies possessing a set of defined high technology characteristics, which could serve as a survey frame, has not yet been developed for British Columbia.[1] Thus, this project will begin with a macro-approach that selects a set of SICs that show the strongest tendency toward high technology activities. We recognize at the outset that these SICs will inevitably include some low-tech activities and exclude some high-tech. We also recognize that the data available may reflect the industry as it existed two, three or even four years ago. However, this is a procedure that will produce stable figures for monitoring the industry over a long period of time.

3.0 NINE SIC-BASED DEFINITIONS

The nine SIC-based definitions may be divided into four groups based on their methodologies: commodity list, research activity, expert allocation and company list. These methodologies are similar in that they use the existing statistical framework to create a high-tech industry as a composite of standard industries displaying high-tech characteristics. They are all macro-level approaches that make inferences about the activities of companies by studying the industries to which they are classified.

[1] While no such list currently exists, the Centre for Policy Research on Science and Technology (CPROST) has started the process by consolidating contact lists and directories from public sector agencies who deal with high-tech companies. CPROST intends to contact each company and administer two screening questions regarding their research orientation. A list such as this may provide the basis for a future micro-level examination of the industry.

They differ with respect to the indicators used to identify industries for inclusion in the high technology group. Some look at the use or production of high technology commodities, while others measure research and development performance or the employment of highly educated workers. We also review definitions that rely on expert opinion or the opinions of companies themselves to define the industry. After rating industries on one of these measures, most definitions select the top performers as the high technology industry. However, recognizing the potential for high technology companies to be found throughout the economy, other methods split SICs according to their performance on a given high technology measure and define the industry as a composite of parts of many SICs.

The methodologies and studies are reviewed below.

3.1 Commodity List Definitions

The commodity list approach examines industry inputs and outputs to separate the high-tech from the low-tech. This method starts by identifying a set of commodities which embody the results of extensive research and development and stand clearly on the forefront of progress in their field. Industries which use or produce these commodities relatively intensively are then identified through input/output (I/O) analysis or other methods that link commodities and industries. While commodity list definitions do not consider directly an industry's investment in research and development or its employment of highly educated workers, they do so indirectly through the selection of commodities for inclusion on the list.

3.1.1 Critique of Commodity List Definitions

Key to the accuracy of commodity list definitions is the quality of the commodity list and the method used to link the list to industries. There are several lists of high technology commodities that have been compiled by experts. Trade analysts at the US Bureau of the Census, for instance, designated 550 out of 20,000 traded products as high-tech based on their knowledge of recent developments in recognized advanced technology fields, such as aerospace and biotechnology (McGuckin *et al*., 1989). Their determinations were then reviewed by trade experts external to the Census Bureau, and some were changed accordingly.

This method of list development has the obvious drawback of subjectivity. Commodity lists are generally developed without adherence to any formal methodology; there are no set criteria to guide experts as they allocate commodities to the high-tech group. It is, therefore, unlikely that another group of analysts, working independently, would replicate the commodity list. On the other hand, it is difficult to arrive at a better methodology for the creation of such lists. High-tech commodities have no tangible distinguishing characteristics; they share only an intensive knowledge investment and a position on the leading edge of development.

Several other characteristics of the commodity list influence the usefulness of this method. High-tech products and services are produced throughout the economy, by manufacturers and service providers alike. The high-tech commodity list should, therefore, cover the entire economy, but, in practice, this is hampered by the absence of a widely accepted classification system for services. The list must also be updated regularly to reflect current conditions in an industry characterized by short business

cycles and extensive innovation. Similarly, lists borrowed from other countries or regions may have to be modified to reflect the distinct set of high-tech commodities flowing into and out of the study region.

Once a commodity list is selected, a method that links commodities with industries is needed. This usually involves I/O tables or related sources, which show commodity flows by industry. Generally, some combination of the high-tech input ratio (value of high-tech inputs/all inputs) and high-tech output ratio (value of high-tech outputs/all outputs) is used to identify high-tech industries. The accuracy of these ratios depends on the timeliness of the I/O data. An up-to-date commodity list is only useful if the I/O table reflects flows of the same commodities. This is an issue for the BC analysis, since the most recent tables available reflect commodity flows of 1990. Also, the I/O matrices showing commodity inputs provide insufficient detail to track high-tech flows with precision.

3.1.2 Examples of Commodity List Definitions

Table 1 summarizes the key features of 4 applications of commodity list definitions. Taken together, these studies indicate: which industries use high-tech inputs (Wong and I/O-90), employ advanced process technologies (Baldwin) and produce high-tech outputs (Miller). The studies differ in many ways: they use different lists; some are national in scope, while others focus on BC; they use different linking methodologies, etc. A brief description of each is provided below.

Table 1: Summary of Commodity List Definitions

	Wong	I/O-90	Baldwin	Miller
List source	Economic Council of Canada	Own list of high technology commodities	Statistics Canada's list of advanced mfg technologies	US Bureau of the Census, ATP list
Study region	Canada	British Columbia	Canada	British Columbia
Linking methodology	Input/Output	Input/Output	Adoption survey	Export HS/SIC concordance
Industry detail	Two-digit	Four-digit	Two-digit	Four-digit
Coverage	Business sector	Business Sector	Manufacturing	Manufacturing
High-tech industry indicator	High-tech input ratio	High-tech input ratio	% of plants using >10 APTs[1]	High-tech export ratio

1: Advanced process technologies

- High-Tech Input Methods

  Wong (1990) used the Economic Council of Canada's (ECC) high-tech commodity list to identify industries that use advanced technology commodities to produce their goods and services. This list is almost identical to the commodity list used by the United States and the Organization for Economic Co-operation and Development (OECD). The input/output framework was used to calculate the ratio of high-tech inputs to all inputs for each of Canada's forty business sector SICs (two-digit). Wong argues that the input ratio reflects both the proportion of high-tech inputs imbedded in the final products and used in the production process. The industries were divided into quartiles based on their high-tech input rank, and the top quarter was designated as the high-tech industry (Table2).

  In I/O-90, we employed a similar methodology to identify high technology industries (four-digit) in BC. Using the US Advanced Technology Product (ATP) list as a guide, a list of 25 commodities from a possible 627 were selected from the input/output framework (Appendix 1). The new list differs from the ATP list in its inclusion of services, such as computer, architectural, engineering and scientific services. After ranking 221 business sector industries (three- and four-digit SIC) according to the ratio of high-tech to total inputs, we selected the nine industries with ratios of 15 percent or greater (Table2). In addition to identifying industries that use high-tech inputs intensively, this analysis showed that the penetration of high-tech products is very widespread; in fact, all SICs use some high-tech inputs. We also found that the knowledge intensive services, included in the I/O-90 list, account for the greatest percentage of all high-tech inputs by value.

  The results of Statistics Canada's 1993 Advanced Technology Adoption Survey provide another view of the high technology industry in Canada (Baldwin and Sabourin, 1995). Manufacturers were asked whether they use or plan to use any technologies from a comprehensive set of 22 computer-based process technologies. We designated the five manufacturing industries with the highest rates of adoption of 10 or more technologies as high-tech (Table2). The results of this survey are not entirely applicable to the BC context. There is substantial variation by region in the use of advanced technologies. Ontario is the clear leader with 4.7% of establishments using more than 9 advanced technologies, while BC lags with only 0.5 % of establishments using more than 9 technologies. Given these regional differences, a breakdown of the detailed industry results by province would make this study more useful to the current analysis.

- High-Tech Output Methods[2]

  Miller identified high technology SICs based on their production of commodities on the ATP list developed by the US Bureau of the Census. The list was produced in 1988 and used the ten-digit level of the Harmonized System of product classification (HS). The ten-digit list was truncated at the six-digit level to allow comparability with

[2] By identifying the producers of high-tech commodities, output definitions are useful to policy makers. Production of high-tech commodities tends to be concentrated in a few industries, while the use of high-tech products is more widespread. Producers of advanced commodities are sometimes considered *enabling industries* because of the spin-off high technology activity they create in other sectors. These enabling industries, or high technology producers, are a logical target for policies and programs designed to assist the industry's development.

Canadian coding, and as such cited 229 product categories as high tech. The products were allocated to SICs based on a concordance developed by Statistics Canada. Industries were then identified by the proportion of high-tech commodities, by value, in the total export commodity stream for each SIC (Table2).

Miller's approach shows that high-tech products comprise a portion of the output of many industries. With the exception of a few Electronics Industries and the Aircraft and Aircraft Parts Industry, none are so dominated by the production of high-tech products to warrant considering 100 percent of their activities as high-tech related. For this reason, Miller suggests using the high-tech output percentages as weights when estimating high-tech GDP and employment in BC. In the absence of further information, this approach must assume that the high-tech component of standard industries has the same employment and production characteristics as the rest of the industry. If, in reality, the high-tech portion of an industry is less labour intensive than the low-tech component, then high-tech employment will be over-estimated by the unadjusted output ratio. This raises the question of whether it is preferable to include 100 percent of industries that show relatively strong high-tech characteristics in the high-tech group, or a portion of all industries showing some high-tech characteristics.

3.1.3 Commodity List Results

Table1 shows that while these four definitions share the use of commodity lists to define the high-tech industry, they also differ in many important ways. As a result, we would not expect them to select exactly the same industries to the high-tech group. Indeed, there are a few cases where industries were selected by only one of the commodity list definitions. For instance, Wong identified Metal Mines and Rubber and Plastic Products with no support from Baldwin, I/O-90 or Miller, and Baldwin was alone in identifying Primary Metals.

Despite these differences, three out of four methods agree that there is high-tech activity in the Transportation and Equipment Industry, the Electrical and Electronic Products Industry, the Chemical and Chemical Products Industry and Other Manufacturing Industries. Both Wong and Baldwin identified industries at the two-digit level of industrial detail, making it difficult to determine which of the four-digit industries are responsible for the industry's high-tech appearance. I/O-90 and Miller help in this regard by using a finer level of industrial detail. For instance, these studies show that it is likely the Aircraft and Aircraft Parts Industry that is responsible for the Transportation and Equipment Industry's strong performance. Similarly, a few of the four-digit Electrical and Electronics Industries have very strong high-tech input and output characteristics (see Table2).

3.2 Research Activity Definitions

The constraints of data availability have led many researchers to designate industries as high-tech based solely on their research activity: expenditure on R&D and/or employment of highly skilled labour. This approach identifies industries that are making the investment necessary to maintain or acquire a position on the leading edge of development.

There are several drawbacks to the use of research and development as an indicator of high technology. First, while R&D measures identify industries working toward the

development of new technological knowledge, they say nothing about the current stock of technological knowledge in an industry. Thus, industries benefiting from past R&D efforts are not recognized as high-tech. Second, R&D is often performed outside of the company itself, by contractors or the public sector, making it difficult to assign to any particular industry or region. A special case of this issue is illustrated by foreign-owned companies, which tend to conduct R&D at their head office located in the home country. In this case, the subsidiary in Canada may produce advanced products with state-of-the art production equipment, but the industry would be excluded from the high-tech group on the basis of low domestic R&D. Given the extent of foreign ownership in Canada, a reliance on R&D indicators alone could misrepresent the industry.

Knowledge input indicators, such as education levels and occupational structure provide useful information about the human side of the input equation. There may be a lag before extensive research and innovation are reflected in the production of advanced products or services and, thus, the material flows of the I/O tables used by commodity list definitions. However, researchers, engineers, computer scientists, etc, are likely to be hired early in the product development process, making them good leading indicators of high technology activity. These measures may, however, exclude those manufacturing industries whose use of advanced manufacturing technologies may allow them to employ a relatively low-skill workforce.

R&D and human input measures are better than commodity list definitions at identifying high technology activity in the service sector or knowledge industries. Services requiring substantial knowledge input are often missing from high technology commodity lists, making it impossible to identify them as part of the high technology industry. Given that service industries account for more direct employment and GDP in British Columbia than manufacturing industries, the results of a methodology that recognizes their contribution should be considered seriously.

3.2.1 Examples of Research Activity Definitions

Table 2 includes the results of two studies employing research activity definitions. The first, undertaken by Industry Canada (Lee and Has, 1995), was designed to identify Canada's "high knowledge" industries. The authors used three R&D and three human capital measures to identify sixteen industries as high knowledge. One of the measures dealt with expenditure on R&D, while the remaining five were concerned either with R&D personnel relative to total personnel or the number of high-knowledge workers relative to all workers (see Table3). Data were tabulated for a mix of SICs covering the business sector and ranging in detail from the two-digit to the four-digit level.

The OECD offers a research activity definition based on the ratio of R&D expenditures to the value of production. Their study considers thirteen countries together and calculates the R&D intensity for each of 22 industries. The top 7 industries are taken to represent the high- and medium-high technology industries (Table2). The OECD mentions that a more comprehensive indicator of high-tech activity would be preferable, but the constraints of data availability for thirteen countries dictated the use of a single indicator.

Table 2: SIC-Based Definitions of High-Tech Industries

			Commodity List				Research Activity			Expert Allocation	Company List	
	SIC	Industry Description	Wong Input Ratio	I/O-90 Input Ratio	Baldwin Adoption rate	Miller Export Ratio	Industry R&D[1]	 Know[2]	OECD R&D	E&I	CPROST hi-tech% of industry	Techwest Industry response rate
	0610	Metal mines	27%									
	0710	Crude petroleum and natural gas									10%	
	1052	Prepared flour mixes and prepared cereal foods industry									10%	
	1131	Brewery products industry									10%	
	15	**Rubber products**	37%[3]									
	16	**Plastic products**	37%[4]									
	1611	Foamed and expanded plastic products								✓		
	1621	Plastic pipe and pipe fittings								✓		
	1631	Plastic film and sheeting industry								✓		
	1690	Other plastic products industries								✓		
	2541	Prefabricated wooden buildings industry									18%	
	29	**Primary metals**			65%							
	30	**Fabricated metals**										
	3011	Power boiler and heat exchangers				0						
	3022	Plate work industry									8%	
	3032	Prefabricated portable metal buildings									10%	
	3069	Other hardware and cutlery				13%						
	3099	Other metal fabricating N.E.C.				1%					8%	
	31	**Machinery industries**	23%				1%	22%				
☑	3111	Agricultural implement industry									9%	
☑	3121	Commercial refrigeration and air conditioning equipment										25%
☑	3192	Construction & mining machinery & materials handling				13%						32%
☑	3194	Turbine & mechanical power transmission equipment				42%						43%
	3199	Other machinery and equipment industries N.E.C.				19%						
	32	**Transportation and equipment industry**	56%		51%				4%			
☑	3211	Aircraft & aircraft parts		25%		94%	11%	26%	20%	✓		28%
☑	3242	Commercial trailer industry									10%	
☑	3256	Motor vehicle plastic parts industry								✓		
☑	3259	Other motor vehicle accessories, parts and assemblies									9%	
☑	3271	Shipbuilding and repair industry									10%	
	33	**Electrical and electronic products industry**	36%		62%				11%			
☑	3311	Small electrical appliance industry				40%						
☑	3321	Major appliance industry				46%						
☑	3331	Lighting fixture industry									8%	
☑	3341	Record player, radio & television receiver industry				83%						
☑	3351	Telecommunication equipment industry		16%		91%				✓		50%
☑	3352	Electronic parts and components		24%		93%				✓		37%
☑	3359	Other communication & electronic equipment		23%		94%	19%	39%		✓		32%

			Commodity List				Research Activity			Expert Allocation	Company List	
	SIC	Industry Description	Wong Input Ratio	I/O-90 Input Ratio	Baldwin Adoption rate	Miller Export Ratio	Industry R&D[1]	Know[2]	OECD R&D	E&I	CPROST hi-tech% of industry	Techwest Industry response rate
☑	3361	Electronic computing & peripheral equipment		28%		100%			13%	✓		28%
☑	3362	Electronic office store and business machines				62%	9%	45%		✓		
☑	3369	Other office store and business machines								✓	9%	
☑	3372	Electrical switchgear and protective equipment				60%				✓		56%
☑	3379	Other electrical industrial equipment industries				4%				✓		28%
☑	3381	Communications & energy wire & cable industry				59%				✓		
☑	3399	Other electrical products industries N.E.C.										25%
	36	**Refined petroleum and coal**					.9%	34%				
	37	**Chemicals and chemical products industry**	23%		38%				3%			
☑	3711	Industrial inorganic chemical industries N.E.C.				7%						29%
☑	3712	Industrial organic chemical industries N.E.C.				0%						
☑	3731	Plastic and synthetic resin industry										29%
☑	3741	Pharmaceutical & medicine		18%		45%	4%	35%	10%	✓		
☑	3761	Soap and cleaning compounds industry									11%	
☑	3799	Other chemical products N.E.C.				1%	1%	28%				
	39	**Other manufacturing industries N.E.C.**			46%							
	391	Scientific & professional equipment					2%	31%				
☑	3911	Indicating, recording & controlling instruments		29%		62%			5%	✓	9%	32%
	3912	Other instruments & related products				78%				✓		28%
	3994	Musical instrument and sound recording		28%		60%						
	3999	Other manufactured products industries N.E.C.				12%						
	46	**Pipeline transportation industries**					-	36%				
	48	**Communication industries**	38%									
	4911	Electric power systems industry					1%	30%				
	70	**Deposit accepting intermediary industries**	30%									
	77	**Business service industries**	25%									
	777	Management consulting services					0.5%	62%				
☑	775	Engineering & scientific services					9%	75%		✓		
☑	7721	Computer & related services					10%	62%		✓		
	7722	Computer equipment, maintenance and repair								✓		
	779	Other business services					-	38%				
	85	**Educational service industries**					-	70%				
	86	**Health and social services**	32%				-	62%				

☑ Indicates either a manufacturing industry chosen by at least 4 of a possible nine definitions or a service industry chosen by at least three of a possible six definitions

1. R&D intensity: R&D expenditure/gross output
2. Percentage of knowledge workers/total workers in industry

3,4. Wong used the 1970 Standard Industrial Classification, which considers the Plastics and Rubber Industries as one industry. We show each two industries in this table with the same input ratio.

Table 3: Summary of Research Activity, Expert Allocation and Company List Approaches

	Research Activity		Expert Allocation	Company List	
	Industry Canada	*OECD*	*E&I*	*Techwest*	*CPROST*
Study region	Canada	13 countries	British Columbia	British Columbia	British Columbia
Industry detail	Range from two-digit to four-digit	Two-digit	Four-digit	Four-digit	Four-digit
Coverage	Business sector	Manufacturing	Manufacturing	Business sector	Business sector
High-tech industry indicator	%R&D personnel %R&D personnel with university degree %R&D expenditures/ gross output % workers with post-secondary ed. %engineers & scientists %knowledge workers[1]	%R&D expenditures/ gross output	None	Self-identified as high-tech	Identified through response to self-administered survey

1: Knowledge workers include workers with trade-vocational education, post-secondary non-university education and university education.

3.2.2 Research Activity Results

Both research activity definitions selected the Aircraft and Aircraft Parts Industry, the Pharmaceutical and Medicine Industry and segments of the Electrical and Electronics Industry as high-tech. Disagreement between the definitions likely reflects their use of different study regions. In general, where only one research activity definition selected an industry, it was chosen by at least one of the commodity list approaches as well. Exceptions to this are the Scientific and Professional Equipment Industry and the Pipeline Transportation Industry, which were chosen only by Industry Canada.

The Industry Canada study shows clearly the concentration of knowledge workers in service industries, such as engineering, management consulting, computer and related services education and health. The proportion of knowledge workers is greater in these industries than in any of the manufacturing industries. Computer services and engineering and scientific service industries also devote about 10% of their gross output to research and development.

3.3 Expert Allocation Methods

In some cases, researchers have relied on their knowledge of the high-tech industry in forming a definition for analysis. BC's Ministry of Economic Development, Small Business and Trade (E&I, 1991) used this approach to select 23 four-digit manufacturing SICs to represent the high-tech industry in BC. As much as possible,

these researchers selected standard industries, for which Statistics Canada data are available, to make-up the high-tech group (Table2). However, they also included industries that are not reflected in the current standard industrial classification system, such as biotechnology, medical devices, subsea and the environmental industry. Data for these industries were attained from various sources

3.3.1 Expert Allocation Results

With the exception of several plastic products industries, the expert's selection of SICs is supported by other definitions. Perhaps the Ministry had some information regarding high-tech activity peculiar to BC's plastic industry. However, Miller and I/O-90, working with BC data, did not identify any of the plastics industries as having strong high-tech ratios. Also, Industry Canada identifies the plastics industries with the medium-knowledge rather than the high-knowledge industry group.

3.4 Company List Approaches

A final SIC-based approach works by linking a list of high-tech companies to Statistics Canada's Business Register (BR) to determine the SIC to which they have been classified. Once the company list is SIC coded, each industry's representation is compared to the total industry size, in terms of the number of establishments represented on the BR. For example, if 40 of a possible 100 BC shoe companies were on a high-tech company list, the shoe company industry would score 40. Those industries with the greatest percentage of their total establishments represented on a high technology list are considered to be high-tech.

The advantage of this approach is that it starts at a micro level, identifying the actual establishments involved in high-tech activity. It, therefore, has the potential to provide results that reflect the distinct mix of high-tech activities in a particular region. However, to yield useful results, this approach requires an accurate, up-to-date company list that operationalizes an acceptable definition of the industry. In theory, the list should include every establishment with a specific set of high-tech characteristics in the study region. Since the match rate of the list to the BR is never 100%, some companies will not be included in the SIC profile. We assume, however, that the match process is random and that the BR is free of systematic bias (i.e., all SICs are equally well represented).

3.4.1 Examples of Company List Definitions

We created two company list definitions of BC's high technology industry. The first is based on a company list derived from a survey conducted by the Centre for Policy Research on Science and Technology (CPROST). The survey was administered to a sample of companies who appeared on various contact lists and directories of public agencies dealing with the high technology and knowledge based industry. CPROST screened the responses and created a subset of those that indicated performing at least one of four non-routine technical activities to be used in this analysis.[3] Out of a

[3]Companies indicating that they either: a) develop or improve products or services, b) develop or improve manufacturing or production processes, c) combine or use technologies in new ways or d) conduct early stage research and development, were included in this analysis. Those indicating that they solely provide or deliver products or services that are routine in nature were excluded from the study list.

total of 447 companies meeting these criteria, we found 304 matches on the BR, for a match rate of 68%.

The second list definition is based on Techwest's list of companies. The list consists of companies that responded to a magazine's request for businesses involved in the high-tech field to identify themselves. It does not, therefore, operationalize a particular or comprehensive high technology definition. There are likely many high-tech companies that were not aware of the database or who chose not to respond. Also, since there were no criteria on which companies were to base their decision, the list may contain some low-tech operations as well. In fact, some companies likely enumerated themselves more for the prestige of being considered part of this population than because of their business activities. However, by identifying the industries in which firms consider themselves as high-tech, the list provides useful insight into the process of high-tech definition. A match on company name yielded SIC codes for 1,445 of a possible 2,740 companies on the Techwest list, for a match rate of 53%.

Having SIC coded the lists, each industry's representation was compared to the total industry size, in terms of the number of establishments on the BR. Industries with high rates of representation were interpreted as being more high-tech oriented than those with lower rates of representation (Table2).

3.4.1 Company List Results

Both of these studies suggest that innovation and high technology activity exist throughout the economy. The 304 companies on the CPROST list represented 134 SICs. Techwest's 1,445 companies came from 271 different four-digit SICs, ranging from computer services to motels. These studies suggest that innovative companies are found in every corner of the economy. To some extent, however, the apparent dispersion of innovation throughout the economy reflects the relatively broad definition of high technology employed by both studies.

Techwest, for instance, allowed companies to decide for themselves whether they were 'high-tech'. CPROST, on the other hand, gathered information on specific technical activities, but it relied on general questions that were not accompanied by definitions and examples. The information would have been more useful as a definition tool if it had been based on objective measures of committment to high-tech, such as expenditures or number of scientists working on a set of defined activities that constitute R&D. As it stands, the CPROST survey tells us that just over half of the companies see themselves as performers of early stage R&D, but we do not know what activities the respondents considered or the level of their commitment.

After sorting industries by the percent of their establishments represented on the lists, we found that the two lists point to different industries as being high-tech. Of the top 15 industries on Techwest, 13 had been identified by other definitions. By contrast, only 4 of CPROST's top 15 industries were identified by the other definitions. The industries added to Table2 by CPROST-- Prefabricated Wooden Buildings, Soap and Cleaning Compounds, Crude Petroleum and Natural Gas, Prepared Flour Mixes etc. -- are not industries that one traditionally associates with high-tech. This may reflect CPROST's relatively low sample size; most industries had only one or two establishments

represented. On the other hand, it may indicate that innovation is everywhere and not just where we tend to think it is.

Table 4: The High-Tech Industries and the Gray Area: Number of definitions citing each of 40 industries

		Definition Method				
SIC	**Industry**	Commodity List out of 4:	Research Activity out of 2:	Expert Allocation out of 1:	Company List out of 2:	Total Score out of 9:
3211	Aircraft & aircraft parts	4	2	1	1	8
3359	Other communication & electronic equipment	4	2	1	1	8
3911	Indicating, recording & controlling instruments	3	2	1	2	8
3351	Telecommunication equipment industry	4	1	1	1	7
3352	Electronic parts and components	4	1	1	1	7
3361	Electronic computing & peripheral equipment	4	1	1	1	7
3741	Pharmaceutical & medicine	4	2	1	0	7
3362	Electronic office store and business machines	3	2	1	0	6
3372	Electrical switchgear and protective equipment	3	1	1	1	6
3379	Other electrical industrial equipment industries	3	1	1	1	6
3369	Other office store and business machines	2	1	1	1	5
3381	Communications & energy wire & cable industry	3	1	1	0	5
3711	Industrial inorganic chemical industries N.E.C.	3	1	0	1	5
3731	Plastic and synthetic resin industry	2	1	1	1	5
3799	Other chemical products N.E.C.	3	2	0	0	5
3912	Other instruments and related products	2	1	1	1	5
3192	Construction & mining machinery & materials handling	2	1	0	1	4
3194	Turbine & mechanical power transmission equipment	2	1	0	1	4
3242	Commercial trailer industry	2	1	0	1	4
3256	Motor vehicle plastic parts industry	2	1	1	0	4
3259	Other motor vehicle accessories, parts and assemblies	2	1	0	1	4
3271	Shipbuilding and repair industry	2	1	0	1	4
3311	Small electrical appliance industry	3	1	0	0	4
3321	Major appliance industry	3	1	0	0	4
3331	Lighting fixture industry	2	1	0	1	4
3341	Record player, radio & television receiver industry	3	1	0	0	4
3399	Other electrical products industries N.E.C.	2	1	0	1	4
3712	Industrial organic chemical industries N.E.C.	3	1	0	0	4
3761	Soap and cleaning compounds industry	2	1	0	1	4
775	Engineering & scientific services	1	1	1	0	3
7721	Computer & related services	1	1	1	0	3
3111	Agricultural implement industry	1	1	0	1	3
3121	Commercial refrigeration and air conditioning equipment	1	1	0	1	3
3199	Other machinery and equipment industries N.E.C.	2	1	0	0	3
3994	Musical instrument and sound recording	3	0	0	0	3
86	Health and social services	1	1	0	0	2
777	Management consulting services	1	1	0	0	2
779	Other business services	1	1	0	0	2
3999	Other manufactured products industries N.E.C.	2	0	0	0	2
7722	Computer equipment, maintenance and repair	1	0	1	0	2

A few industries that showed strong support from other definitions were not well represented on either of the lists. For instance, the Pharmaceutical Industry was chosen by all of the other definitions, yet only 7% of its establishments were on CPROST and 5% on Techwest. Management Consulting, Architects and Other Business Services also tended to be low on the lists, with less than 1% of their establishments on each list. These anomalies suggest that all sectors were not given an equal opportunity to be on the lists. The readership of the Techwest magazine may

have been concentrated in certain sectors, and the frame from which the CPROST sample was drawn may not have contained sufficient representation from certain industries. It may also indicate that certain industries do not view themselves as high-tech, suggesting that survey research should be based on objective measures of high-tech activity that allow the researcher, rather than the respondent, to allocate responses to the high technology group.

3.5 Summary

There is consensus amongst the studies included in this paper in their selection of 31 four-digit SICs as high-tech. The unshaded portion of Table 4 lists all manufacturing SICs chosen by at least four of a possible nine definitions and all service SICs chosen by at least three of a possible six definitions. These industries exhibit strong high-tech characteristics and their inclusion in the high technology definition is relatively certain.

The definitions also point with less certainty to a smaller group of industries: the gray area of Table 4. These industries were selected by only two or three of a possible nine definitions. More information about the nature of the activities carried out by these industries is required to make a decision regarding their inclusion in the high technology group.

There may also be industries, not identified by any of these methods, that possess significant high technology characteristics. This is especially the case for service sector industries. The poor representation of these industries in Table 4 reflects several factors. First, three of the nine studies focused solely on manufacturing and did not consider the service sector. Second, commodity list methods tend to be better suited to the study of manufactured goods than services. Third, our interest in the service sector stems largely from its substantial knowledge content. There is really only one indicator that captures this: education of the workforce. Thus, a study such as this that compares industry performance on several variables, is likely to under-represent the knowledge industry. Finally, service sector businesses may not perceive themselves as members of the high-tech industry and may, therefore, be less likely to identify themselves as such.

4.0 EXPERT INPUT

The opinions of a panel of high technology experts were sought in order to make a final determination on the preliminary list of SICs in Table 4 (Appendix 2). In general, the experts agreed with the chosen industries; their recommendations are summarized below.

1. **Divide the high-tech industries into two groups: those that are relatively homogeneous with respect to high technology characteristics, and industries comprised of a greater mix of high- and low-tech establishments.**

   The analysis should consider 100% of each industry in the first group, and weight industries in the second group, so that only a portion of each is included in the analysis.

2. **Include the following SICs from the "gray area" of Table 4 in the weighted portion of the definition:**

   3199 Other Machinery and Equipment Industries N.E.C.
   3994 Musical Instrument and Sound Recording
   3999 Other Manufactured Products N.E.C.
   7722 Computer Equipment, Maintenance and Repair[4]

3. **Exclude SIC 7771, Management Consulting Services, because the knowledge content of this industry reflects the social rather than the pure sciences.**

4. **Exclude the following SICs from the high technology definition unless it can be shown that a substantial portion of the companies comprising these SICs are high-tech.**

   3111 Agricultural Implement Industry
   3121 Commercial Refrigeration and Air Conditioning Equipment
   3242 Commercial Trailer Industry
   7790 Other Business Services

5. **Examine SIC 8600 in more detail to determine which, if any, of its three- or four-digit SICs are high-tech.**

6. **Exclude any short-listed industries in the weighted category, if the calculated weight for that industry, based on either the export, input or output ratio, is extremely low.**

4.1 Finalizing the High-tech Industry List

In order to finalize the industry list, recommendations 4, 5 and 6 need to be addressed. The following describes changes made to the short-list of high technology industries as a result of these three recommendations.

The fourth recommendation applies to four SICs in the "gray area" of Table 4, which the experts could neither include nor exclude without more information about the actual establishments involved. We, therefore, examined the list of 54 BC establishments from the Business Register (BR) that are coded to these four industries. Only one establishment name was recognized, and only a portion of its operations are known to be high-tech. Our conclusion, therefore, was to exclude SICs 3111, 3121, 3242 and 7790 from the definition.

The fifth recommendation was to identify the three- or four-digit SICs within the Health and Social Services industry that are high-tech. We did this by SIC-coding four additional lists of BC high technology companies: one each from the Science Council of British Columbia, Western Economic Diversification, the Capital Regional District and

[4] Statistics Canada combines the data for SICs 7722 and 7721 because the services they produce are very similar. As such, in the final analysis, we also combine these two 4-digit SICs and present information at the 3-digit level, SIC 772, in the unweighted portion of the definition.

the Ministry of Employment and Investment. Most of these were mailing lists for surveys, conducted by these organizations, on either the BC high-tech industry or portions of it, such as subsea or marine technology.

Matches were found on the BR for 203 of the listed high technology establishments. Of these, 6 establishments were coded to Medical and Other Health Laboratories (SIC 8680)[5]. This three digit SIC includes: medical; radiological; public; blood bank and other health laboratories. According to the industry designation assigned by the list providers, the 6 high technology establishments coded to these SICs are either involved in bio- or marine-technology pursuits. Since these are areas of high technology activity that are not recognized by the current SIC classification system, we decided to include SIC 8680 in the 100% portion of the definition.

Finally, the experts agreed that, if the weights calculated for industries in the weighted portion of the definition were extremely low, the industries should be excluded from the definition. In other words, it was agreed that evidence, in the form of the use or production of high technology commodities or services, was needed to secure a position in the weighted portion of the definition. Three methods were used to determine weights for these industries: high-tech input and output ratios were calculated from input/output data, and a high-tech export ratio for each industry was calculated from the ATP list of commodities and manufacturing export data. Industries that did not achieve a score of greater than 2% on any one of these measures were excluded from the definition (Table 6)[6].

Table 6 Industries Excluded from Definition Due to Insufficient Weights

SIC	Industry	Input %	Output %	Export %
3256	Motor vehicle plastic parts industry	0.81	0.00	0.00
3259	Other motor vehicle accessories and parts N.E.C.	1.45	0.04	0.00
3331	Electric lighting industries	1.25	0.03	0.00
3399	Miscellaneous electrical product industries	1.66	0.00	0.00
3712	Industrial organic chemicals N.E.C.	1.47	0.00	0.00
3731	Plastic & synthetic resin industry	0.96	0.00	0.00
3761	Soap and cleaning compounds industry	1.13	0.00	0.00
3799	Other chemical products industries	1.45	0.01	1.00

4.2 Verifying the High Technology List

Table 7 shows the final list of high technology industries, after accounting for the experts' recommendations. This section examines how well this list of industries reflects the high technology establishments found on the four high technology establishment lists. We would expect that the majority of high technology establishments would be found in the 100% category of the definition and that a smaller proportion would be coded to industries in the weighted portion. Given that some high technology establishments are coded to SICs that do not, in aggregate,

[5] Other than SIC 7790, which had one establishment on the lists, note that the SICs excluded under recommendation four, 3111, 3121, 3242, were not represented on any of the lists.
[6] Note that, with the exception of SIC 3799, which had one establishment represented on the lists, none of the SICs excluded under recommendation six had establishments on the 4 lists.

display high technology characteristics, we would also expect that some establishments will not belong to any of the short listed industries.

Table 7: The High Technology/Knowledge Sector in British Columbia

SIC	Industry Description	# of est. on 4 lists	# of est. in BC 1994
	100% Portion		
3211	Aircraft and aircraft parts	4	49
3351	Telecommunication equipment industry	5	19
3352	Electronic parts and components	7	50
3359	Other communication and electronic equipment	17	74
3361	Electronic computing and peripheral equipment	11	58
3362	Electronic office, store and business machines	0	4
3369	Other office, store and business machines	0	11
3372	Electrical switchgear and protective equipment	1	15
3379	Other electrical industrial equipment industries	3	34
3741	Pharmaceutical and medicine	6	30
3911	Indicating, recording and controlling instruments	4	34
3912	Other instruments and related products	2	50
772	Computer and related services	43	1,273
7752	Offices of engineers	12	1,376
7759	Other scientific and technical services	23	736
7759	Other scientific and technical services	5	143
	TOTAL 100%	**143**	**3,956**
Weighted Portion			
3192	Construction, mining machinery and materials handling	1	110
3194	Turbine and mechanical power transmission equipment	1	22
3199	Other machinery and equipment industries N.E.C.	4	153
3271	Shipbuilding and repair industry	0	21
3311	Small electrical appliance industry	1	11
3381	Communications and energy wire and cable industry	1	8
3711	Industrial inorganic chemical industries N.E.C.	1	28
3994	Musical instrument and sound recording	0	20
3999	Other manufactured products industries N.E.C.	1	388
	TOTAL WEIGHTED	**15**	**904**
All Industries			
		148	**4,574**

The industries listed in Table 7 account for just 3% of BC establishments, yet 75% of the establishments on the four high technology lists are coded to these industries. This means that high technology establishments are concentrated in the industries selected as high-tech. In addition, the distribution of these establishments within the definition accords with our expectations; 90% of the establishments are found in the unweighted portion of definition, while the remaining 10% are coded to the weighted industries.

The 25% of listed establishments that were not coded to any of the short-listed industries, are spread across many industries. In fact, these 50 establishments represent 25 different industries. Because they are not clustered in any particular industry, or even industry group, they will not result in the addition of any SICs to the short list.

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[7]We are still tracking down this reference -- sorry for the inconvenience.

Appendix 1
List of high technology commodities used in I/O-90

1. Machine tools
2. Firearms and military hardware
3. Computers, video units, printers etc.
4. Aircraft engines
5. Aircraft parts and equipment
6. Aircraft service and repairs
7. Radio, tv, stereo, vcr and unrec. tape
8. Broadcasting and radio comm. equip.
9. Radar and radio navigation equip.
10. Semi-conductors
11. Printed circuits
12. Integrated circuits
13. Other electronic equipment comp.
14. Pharmaceuticals
15. Radioactive chemicals
16. Aircraft and naut., navig, instr., excl radio
17. Lab and scientific instruments
18. Measuring and control instruments
19. Medical and dental equipment and supplies
20. Personal and medical goods
21. Optical and photo equipment
22. Photocopy and microfilm equipment
23. Architect, engineering, scientific services
24. Computer services
25. Laboratory equipment and supplies

Appendix 2
List of High Technology Experts

Max Cairns, Science Council of British Columbia
Robert Grace, Ministry of Employment and Investment
Adam Holbrook, Industry Canada
Alex Klopfer, Private Consultant
Morley Lipsett, Simon Fraser University
Shawna Meade, Ministry of Employment and Investment
Steve Miller, BC Statistics
Calvin Shantz, Ministry of Employment and Investment

Table 5: High-Tech Industry Short-list

SIC	Industry Description
100% Portion	
3211	Aircraft and aircraft parts
3351	Telecommunication equipment industry
3352	Electronic parts and components
3359	Other communication and electronic equipment
3361	Electronic computing and peripheral equipment
3362	Electronic office, store and business machines
3369	Other office, store and business machines
3372	Electrical switchgear and protective equipment
3379	Other electrical industrial equipment industries
3741	Pharmaceutical and medicine
3911	Indicating, recording and controlling instruments
3912	Other instruments and related products
7721	Computer and related services
7752	Offices of engineers
7759	Other scientific and technical services
Weighted Portion	
3192	Construction, mining machinery and materials handling
3194	Turbine and mechanical power transmission equipment
3199	Other machinery and equipment industries N.E.C.
3256	Motor vehicle plastic parts industry
3259	Other motor vehicle accessories, parts and assemblies
3271	Shipbuilding and repair industry
3311	Small electrical appliance industry
3331	Lighting fixture industry
3381	Communications and energy wire and cable industry
3399	Other electrical products industries N.E.C.
3711	Industrial inorganic chemical industries N.E.C.
3712	Industrial organic chemical industries N.E.C
3731	Plastic and synthetic resin industry
3761	Soap and cleaning compounds industry
3799	Other chemical products N.E.C.
3994	Musical instrument and sound recording
3999	Other manufactured products industries N.E.C.
7722	Computer equipment, maintenance and repair
Check	
3111	Agricultural implement industry
3121	Commercial refrigeration and air conditioning equipment
3242	Commercial trailer industry
3321	Major appliance industry
7790	Other business services
8600	Health and social services
Remove	
777	Management consulting services

Export and Knowledge Ratios for the High Technology Industry

SIC	Industry Description	weight	educ%[1]
	100% Portion		
3211	Aircraft and aircraft parts	100	14
3351	Telecommunication equipment industry	100	7
3352	Electronic parts and components	100	7
3359	Other communication and electronic equipment	100	21
3361	Electronic computing and peripheral equipment	100	27
3362	Electronic office, store and business machines	100	27
3369	Other office, store and business machines	100	27
3372	Electrical switchgear and protective equipment	100	10
3379	Other electrical industrial equipment industries	100	10
3741	Pharmaceutical and medicine	100	32
3911	Indicating, recording and controlling instruments	100	16
3912	Other instruments and related products	100	16
772	Computer and related services	100	36
7752	Offices of engineers	100	43
7759	Other scientific and technical services	100	43
Weighted Portion			
3192	Construction, mining machinery and materials handling	13	9
3194	Turbine and mechanical power transmission equipment	42	9
3199	Other machinery and equipment industries N.E.C.	19	9
3271	Shipbuilding and repair industry	11	5
3311	Small electrical appliance industry	40	7
3381	Communications and energy wire and cable industry	59	14
3711	Industrial inorganic chemical industries N.E.C.	7	18
3994	Musical instrument and sound recording	60	9
3999	Other manufactured products industries N.E.C.	12	9
8680	Medical and other health laboratories		24

1. Knowledge ratio = percentage of total industry employment with a graduate or undergraduate university degree. These data are available at the three-digit level for all of Canada. As such, ratios are repeated for four-digit industries in the same three-digit industry group.

The export ratio was chosen as the final weight to be used in the weighted portion of the definition for the following reasons. First, the export ratio is based on the the US Bureau of the Census' ATP list, which is generally accepted as a comprehensive list of high technology commodities. Second, the export data are compiled at a much finer level of detail than are the commodity classes of the input/output tables. Finally, although the I/O framework has the benefit of including service industries, only manufacturing industries needed to be weighted; the service industries are all in the 100%, unweighted category.

4.1 Do the short-listed industries contain high-tech companies?

The next section presents the results of an analysis of the extent to which the short-listed industries (Table 5) include high technology companies and whether any industries have been overlooked. We collected four high-technology company lists from meeting participants and other sources, and assessed the percentage of the listed companies coded to the short-listed industries. In other words, we asked the question: do the high-tech industries reflect data collected from certain well-known BC high-tech companies? A second and closely related question that is also addressed by this analysis is: are there any SICs, not included in the high-tech industry short-list, in which known high-tech companies are clustered.

The first list consists of high-tech companies that received a survey from the Science Council of British Columbia. This list excludes government organizations and Crown Corporations, as well as agents, distributors and stores. It includes 169 BC companies that:

a) embody advanced technologies in their final products, not just in their production process;
b) have intellectual property in BC;
c) are service or systems specialists only if they serve markets beyond BC or have intellectual property in BC.

SIC codes were found on the BR for 139 of the companies on the Science Council list, for a match rate of 82%. Of these matched companies, 96 (69%) were found in the unweighted industries of the high-tech group, and 9 (7%) were found in the weighted portion. Overall, then, 76% of the high-tech companies were found in the short-listed high-tech industries. The remaining 34 companies were spread out over 23 industries as indicated in Table 6.

A clustering of companies is apparent in SICs 5731 and 5743, both of which are wholesale industries. As well, two health laboratory SICs, representing three companies, are cited. According to the Science Council, these companies are involved in biotechnology and the development of health products. The Health and Social Services industry, is in the “gray area” of Table 4 and meeting participants suggested we identify the specific components of this two-digit SIC in which high-tech activity is concentrated.

Table 6: Industries identified by Science Council Company List and not included in High Technology Industry Short-list

SIC	Industry	Science Council designation	Number of companies
0239	Other services incidental to agriculture N.E.C.	biotechnology	1
0929	Other service industries incidental to mining N.E.C.	biotechnology	1
1099	Other food products industries N.E.C.	biotechnology	1
1599	Other rubber products industries	sub-sea	1
2819	Other commercial printing industries	electronic	1
3193	Sawmill and woodworking machinery industry	electronic	1
3252	Motor vehicle wiring assemblies	electronic	1
3281	Boatbuilding and repair industry	sub-sea (2)	2
3971	Sign and display industry	electronic	1
4512	Non-scheduled air transport, chartered, industry	aerospace	1
5512	Trucks and buses, wholesale	electronic	1
5731	Industrial machinery, equipment and supplies, wholesale	electronic(2)	2
5743	Electronic machinery, equipment and supplies, wholesale	electronic (1), hardware (2), software (1), telecom (2)	6
5744	Computer and related machinery, equipment and packaged software, wholesale	electronic(1), software (3)	4
5793	Professional machinery, equipment and supplies, wholesale	health products	1
7511	Operators of residential buildings and dwellings	software	1
7739	Other accounting and bookkeeping services	software	1
7749	Other advertising services	biotechnology	1
7761	Offices of lawyers and notaries	biotechnology	1
7771	Management consulting services	biotechnology	1
8681	Medical laboratories	biotechnology	1
8689	Other health laboratories	biotechnology (1), health products (1)	2
9999	Other services N.E.C.	biotechnology	1

Note also that two subsea companies were found in SIC 3281, Boatbuilding and repair, rather than SIC 3271, Shipbuilding and repair; the latter is included in the weighted portion of the high technology industry. This raises the question of how much of the subsea industry is coded to Boatbuilding and thereby excluded from the high-tech industry definition.

To answer this question, we examined a list of 28 subsea companies operating in the Capital Regional District. SIC codes were found for 17 of the 28 companies, for a match rate of 61%. Twelve of these 17 companies, or 71%, were found in the high-tech industries; the remaining 5 companies were found in 4 different SICs as indicated in Table 7.

Table 7: Industries identified by Capital Regional District Company List and not included in High Technology Industry Short-list

SIC	Industry	List designation	Number of companies
1931	Canvas and related products industry	subsea	1
7771	Management consulting services	subsea	2
7799	Other business services N.E.C.	subsea	1
8684	Public health laboratories	subsea	1

The subsea company list provides no further evidence to support adding Boatbuilding to the definition. Medical laboratories do appear again however, with one subsea company being coded to SIC 8684, Public health laboratories.

A third check on the short-listed industries comes from the mailing list for a survey of the Marine Technology Industry in western Canada conducted by Western Economic Diversification (WED). Their survey focused on companies that engage in the research and development, manufacturing, and marketing of selected advanced technology products and services, such as: marine robotics and subsea vehicles, navigation, imaging and communication equipment etc. We removed government organizations and research institutions (universities etc.) from the list and attained SIC codes for 34 companies. Out of these, 27 (79%) were in the short-listed industries. The remaining 21 percent were found in the SICs listed below.

Table 8: Industries identified by Western Economic Diversification Company List and not included in High Technology Industry Short-list

SIC	Industry	List designation	Number of companies
3281	Boatbuilding and repair	marine technology	1
6222	Television, radio and stereo stores	marine technology	1
7215	Holding companies	marine technology	1
7771	Management consulting services	marine technology	2
7799	Other business services N.E.C.	marine technology	1
8684	Public health laboratories	marine technology	1

The appearance of SICs 8684, Public health laboratories, SIC 3281, Boatbuilding and repair, and SIC 7799, Other business services, reflect duplication of coverage between the various lists. This is not, therefore, new evidence to support the inclusion of these SICs. Again, there is not a sufficient clustering of companies to warrant inclusion of these SICs in the high-tech industry group.

Finally, the Ministry of Employment and Investment provided a list of thirteen high technology companies. SIC codes were found on the BR for ten of the companies, for a match rate of 77%. Eight of these companies were found in the high-tech industries; 6 in the unweighted portion and 2 in the weighted portion. One of the companies that did not belong to a short-listed high technology SIC was coded to SIC 7771, Management consulting. This SIC was excluded from the definition on grounds that the knowledge being applied relates to the social rather than the pure sciences. The other company, which is involved in biotechnology, is coded to SIC 8689, Other health laboratories.

These lists suggest that some companies involved in biotechnology and marine research may be coded to SIC 8680, Medical and other health laboratories. Five different BC companies from this SIC were cited by the four lists examined above. We will include this SIC, representing 138 BC establishments, in the weighted portion of the high technology industry.