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Ten Steps to a High Tech Future:
The New Economy in Metropolitan Seattle

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ABSTRACT

Since the mid-1990s, Seattle has been one of the rare cities to have a level of high tech job growth comparable to its surrounding region. This paper seeks to understand the location pattern of high tech firms in the Seattle metropolitan region and to learn what factors influence their location decisions within the region itself. Drawing on the Seattle example, the paper describes ten steps that city officials interested in facilitating the development of a high technology presence can take, from investing in human capital, to streamlining public services, to applying information technology in the public sector.

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EXECUTIVE SUMMARY

Seattle's downtown is being transformed in the latest wave of high tech development. Older buildings are being rehabilitated to house high tech companies. A crumbling pier on the waterfront will soon house an Internet-based company. A seedy residential and commercial district on the north edge of downtown, near the waterfront, has become the hottest market in town with new office and condominium buildings going up at a rapid pace. The focus of the "new economy" companies on downtown is eagerly supported by public officials who have been seeking a way to concentrate jobs and housing, while linking these two essential functions of cities with mass transit. Growth management policies laid out those land use goals, but high tech development is a significant contributor to achieving them.

This study was sparked by a sense that there may be something replicable and valuable in the Seattle story, a lesson about the geographic distribution of growth that leaders in other cities may want to understand. The specific purpose of this inquiry is twofold:

- to understand the location pattern of high tech firms in the Seattle metropolitan region and to learn what factors influence their location decisions within the region itself; and

- to identify public policy strategies that can encourage metropolitan high tech development in urban centers.

Jobs and Job Growth in Metropolitan Seattle

According to a Cleveland State University Study for The Brookings Institution, from 1993-1996, 23,000 jobs were added in Seattle, and another 23,000 were added in suburban Redmond, producing the most equally balanced job growth picture among the 200 metropolitan areas examined in that study. This balanced growth pattern was a major driving force for this study. The forces that produced that balance, if understood, may include policy variables that other cities can manipulate to produce more balanced urban/suburban growth patterns.

Looking at the growth by sector, Seattle itself saw 6,000 new high tech jobs from 1995 to 1998, while the region as a whole saw 27,000 new high tech jobs. Most of the growth occurred in the software/computer services/internet cluster, which nearly doubled inside the city of Seattle.

Jobs in
Seattle and the Region by High Tech Sector

	Seattle		Region	
	1995	1998	1995	1998
Biotech	4,000	6,000	9,000	11,000
Electronic/Computers/Instrument	2,000	2,000	18,000	24,000
Software/Services/Internet	5,000	9,000	29,000	46,000
Telecommunications	5,000	5,000	14,000	16,000
Total	17,000	23,000	72,000	99,000

Why Do Firms Choose Urban or Suburban Locations?

On the most fundamental level some individuals, given a choice, prefer a suburban office park or campus environment as a place to work. Its horizontal orientation, groomed lawns, trees, auto friendliness with access to parking and likely proximity to one's residence makes it extremely desirable for a segment of metropolitan residents. The Eastside (of Lake Washington) which is comprised of several suburbs and cities including Bellevue, Redmond, Issaquah, Kirkland and Bothell, offers many lower density office and manufacturing parks within a forty five minute drive of national forest trails and ski slopes. The Eastside is served by Interstates 90 and 405.

On the other hand, many metropolitan residents prefer a vibrant urban environment with its vertical character, specialty shops, street life, entertainment and the proximity to a great mixture of businesses and cultural activities. Downtown Seattle and downtown fringe locations offer historic as well as state of the art buildings, excellent public transportation, ethnic restaurants, professional sports stadiums, and a "coolness" factor with a music and art scene.

Location Factors

Interviews with key high tech players in the siting process - real estate managers or other senior managers of high tech companies, real estate developers and brokers, and municipal planning agency managers - reveal distinct location preferences in each sector. Firms within a sector tend to be clustered in certain locations based on staff and entrepreneur's preferences, infrastructure requirements, transportation needs, environmental factors, and land costs.

High tech manufacturers are more likely to be found in suburban industrial parks than older in-city industrial districts due to cost factors or the difficulty of assembling sufficient land to accommodate future expansion, or simple entrepreneurial preference. New telecommunications companies tend to prefer downtown locations, along with internet content and e-commerce firms. Software entrepreneurs have shown up all over the urban area, although the competition for talent has driven an increasing number into attractive redeveloped quarters in and adjacent to downtown. Biotechnology firms need to be located near research institutions and hospitals for research and development activities, but have tended to put

manufacturing facilities in suburban industrial parks. These patterns are fairly consistent, suggesting that much of the apparent shift to downtown is due to the proliferation of certain types of firms that happen to prefer in-city locations.

10 Steps to a High Tech Future

High tech industries are clustered in certain central city and suburban locations within the Seattle metropolitan area. These locational preferences, along with the rapid expansion of employment and the accretion of wealth in these industries, suggest an urban public policy agenda. How can cities attract or nurture high tech, so as to garner a share of the jobs and wealth these new industries are creating? Based on the experience in the Seattle area, ten policy steps are recommended for urban leaders who are devising a high tech strategy for their own cities. These steps have strong inter-relationships, but they need not all be present for cities to attract more of the high tech development occurring within their metropolitan areas. They may be configured differently in urban centers across the country, but they represent an excellent starting point:

1. *Understand high tech firms in your region and your city's competitive advantages.*
2. *Invest in human capital.*
3. *Create a research and development presence.*
4. *Invest in physical capital.*
5. *Invest in quality of life.*
6. *Streamline permitting, planning, and other public services.*
7. *Adapt other local laws (such as special tax policies and administrative procedures).*
8. *Provide venture and seed capital.*
9. *Create support programs for entrepreneurs.*
10. *Apply information technology in the public sector.*

A high quality, innovative, and efficient local government can facilitate the development of high tech industries if it is also careful to understand trends in local industries and the needs these companies have with respect to their public sector partners. This puts a unique importance on vibrant, esthetically appealing urban settings with workable transportation systems and affordable neighborhoods. This latest wave puts cities in an advantageous position vis à vis suburban locations, creating a favorable environment in which good public

policy can meet company needs and satisfy many citizen aspirations for an improved quality of life. In that sense there is an historic opportunity that must be seized by city leaders, but with the proviso that patience is also going to be necessary.

I. INTRODUCTION

Seattle is in the midst of a new Gold Rush that has resulted in the creation of thousands of new companies in rapidly growing software, biotech and electronic commerce industries. The metropolitan area has vaulted much higher in the per capita income ranks, thanks to annual earnings in the software industry in excess of $300,000 on average for the 67,000 employees in this sector. The wealth generated by Microsoft and other software companies has saved the Seattle metropolitan area from two recessions; in fact, the state has not experienced a recession in 18 years. The region houses the nation's most valuable company (and biggest antitrust controversy), and the area has spawned several thousand millionaires and at least four billionaires.

This study was sparked by a sense that there may be something replicable and valuable in the Seattle story, a lesson about the geographic distribution of growth that leaders in other cities may want to understand. Other metropolitan regions in the United States have seen similar patterns of growth, including Portland, Denver, the Los Angeles basin, Austin, San Antonio, Atlanta, Washington, D.C., and Boston. Silicon Valley of course serves as the model for all of these smaller high tech nodes. Many other cities would like to join this group of cities that are benefiting from high tech growth.

Seattle's downtown is being transformed in the latest wave of high tech development, which began in the mid-1990s. A healthy downtown with a strong retail core, as well as traditional office functions, is experiencing a new round of intensive development. Older buildings are being rehabilitated to house high tech companies. A disused hospital is now home to Amazon.com. The historic Smith Tower, once the tallest building west of the Mississippi and used for years to house public agencies, is now home to a "dot-com" company. A crumbling pier on the waterfront will soon house another Internet-based company. A seedy residential and commercial district on the north edge of downtown, near the waterfront, has become the hottest market in town with new office and condominium buildings going up at a rapid pace. Real Networks has moved from a fashionable redeveloped warehouse district to an older trade center building in this district, and Visio, now a subsidiary of Microsoft, established itself in a new building developed by the Port of Seattle on the edge of this district known as "Belltown." Following the trend set by distinguished leaders in the industry, the Washington Software Alliance, the industry's leading advocacy organization, moved from a traditional suburban location into facilities in the new Port-owned development.

It is the focus of the "new economy" companies on downtown Seattle itself, as opposed to more typical suburban office park locations, that distinguishes this recent wave of high tech development. This trend is eagerly supported by public officials who have been seeking a way to concentrate jobs and housing, linking these two essential functions of cities with mass transit. Growth management policies laid out those land use goals, but high tech development is a significant contributor to making the goals real. In this context, the research team has sought to

understand the motivations of the high tech firms, their founders and key executives, and the links to public policies.

A. Methodology

The specific purpose of this inquiry is twofold:

- to understand the location pattern of high tech firms in the Seattle metropolitan region and to learn what factors influence their location decisions within the region itself; and

- to identify public policy strategies that can encourage metropolitan high tech development in urban centers.

To investigate the location pattern issues, we developed databases and maps showing the location of different types of high tech firms and interviewed a variety of key individuals. Several types of data were assembled, including the number and location of firms entering the public equity through Initial Public Offerings (IPOs), the number and location of firms that made patent applications, and the number and location of firms identified in a locally-produced Advanced Technology Directory. By tracking these trends and showing the location of firms on maps, we are testing two complementary hypotheses about the location choices of high tech firms:

- certain types of firms have consistent location choices vis à vis central city and suburban locations, and
- the frequency of formation of firms in different sectors has changed, and it is this sectoral frequency that is driving an apparent shift from suburban to central city and central business district locations.

The second research objective includes identification of factors that attract high tech firms; these could include high-speed, broadband internet infrastructure, good public transportation, affordable housing, and quality of life issues. In addition, we wanted to understand the role of human capital in this round of high tech development. Firms at the cutting edge of innovation compete for the scarce resource of a creative and competent workforce, which is increasingly younger and urban oriented. Therefore, firms may locate in Seattle for the urban amenities of street activities, clubs, restaurants, art, entertainment, proximity to others, pedestrian orientation, etc. A final research objective was to identify locational preferences and requirements that differ between innovators in the variety of high tech sectors.

We investigated these issues through a set of interviews with key high tech players in the siting process—real estate managers or other senior managers of high tech companies, real estate developers and brokers, and municipal planning agency managers (see Appendix A for a map of interviewed high tech companies). Through these interviews, we obtained a broader

view of the motivations of the firms and the influences of public policy on their choices, and a much richer understanding of the use of location choice and both interior and exterior design to make these workplaces appealing to the kind of staff the firms seek to attract.

Most of the interviews were conducted in person in the offices of high tech firms by two skilled researchers[1] using an interview protocol that covered company history, size, lines of business, location requirements and preferences, and future needs. In several cases interviews were conducted by telephone for the convenience of the interviewee. We conducted interviews with at least four representatives of firms in five high tech industry categories:

- Electronic/Computer/Instrument Manufacturing
- Telecommunications
- Biotechnology Research and Manufacturing
- Software
- Internet Content and Commerce

In addition we met with city officials of Seattle, Redmond and Bellevue, and with three brokers and developers in the Seattle metropolitan area.

B. Defining High Tech Firms

Before studying high tech location choices, it is necessary to decide what "high tech" really is. We reviewed a number of studies to determine how to define high tech industries.[2] Two major criteria have frequently been used in defining high tech:

- The proportion of industry employment in "research and development occupations" such as scientists, engineers, and technicians, and
- The proportion of industry revenue invested in research and development.

The research team did not have access to industry revenue data, and many of the startup companies do not have much revenue and are engaged almost entirely in

[1] Most interviews were jointly conducted with Greg Easton, principal of Property Counselors, a Seattle real estate economics firm retained by the City of Seattle to analyze high tech firm real estate needs for the next ten to twenty years.

[2] William B. Beyers and Peter B. Nelson, *The Economic Impact of Technology-Based Industries in Wasington State in 1997*, Report for the Technology Alliance by the Department of Geography, University of Washington, August 1998; Frederick Bolin, *Biotech Century Dawns in the Western U.S.: An Economic Geography*, Denver: Center for the New West, 1998, Daniel Hecker, "High-technology employment: A broader view," *Monthly Labor Review*, June 1999, pp. 18-28; American Electronics Association., *Cyberstates Update*, Santa Clara, 1998; Joseph Cortright and Heike Mayer, *A Comparison of High Technology Centers*, Regional Connections Working Paper 4, April 2000, Portland: Institute for Portland Metropolitan Studies, Portland State University (www.upa.pdx.edu/IMS/regecon.html); Ross C. DeVol, *America's High-Tech Economy: Growth, Development and Risks for Metropolitan Areas*, Santa Monica: Milken Institute, 1999; Puget Sound Regional Council, *1999 Central Puget Sound Regional Economic Report*, Seattle, 1999.

developmental activities at this stage in their life cycle. Accordingly, we decided to rely on research and development employment as a proportion of total employment as our primary selection criterion for the trends and geographic analysis. In addition, through simultaneous work with colleagues at the Washington Technology Center (WTC), we obtained access to listings of firms by industry category from the state's employment agency. By reviewing these lists with the director of the WTC, industry categories were removed on the grounds that they primarily apply technology in a routine way and are not "pushing the envelope" out into new technological frontiers. Medical and dental laboratories are an example of an industry that meets the research and development employment criterion but failed the second more judgmental test.

The resulting set of high tech companies fall into three major categories: software and internet-based companies,[3] wireless and other new technology telecommunications companies (not including traditional telephone utilities, or radio and television broadcast companies), biotechnology companies, and advanced technology manufacturers. The last category includes the region's largest employer, The Boeing Company. About half of the local high tech employment base consists of Boeing employees and local subcontractors who make parts and systems for Boeing and its major competitor Airbus. These aerospace companies were not included in our study because they are not participants in the current wave of high tech growth. In fact, Boeing has been laying off employees throughout much of the recent high tech boom, fueling the boom indirectly by downsizing and thereby supplying qualified technical staff to many of the new companies.

[3] Internet based companies tend to show up in two places in the Standard Industrial Classification system: within the computer and data processing sector 737, particularly in 7374 and 7379 if they are pursuing a "business to business" model, and somewhere in retail trade if they are pursuing a "business to consumer" model.

II. JOBS AND JOB GROWTH IN METROPOLITAN SEATTLE

A. Overview of High Tech Growth

High tech employment represents a growing share of total employment in the four county central Puget Sound region. Of the 1.6 million jobs in the greater Seattle region about 100,000 or 6 percent are in high tech sectors other than aerospace, and Boeing and its subcontractors add another 100,000 or so employees in very sophisticated manufacturing firms. This percentage in high tech other than aerospace is growing over time due to rapid growth among high tech companies, particularly in software and electronic commerce. The software sector has been growing at a 10-17 percent year over year pace in terms of employment. Rapid growth is clearly occurring among e-commerce companies, but these companies cannot be distinguished as a separate class in the published employment statistics. Part of the reported software industry growth is due to e-commerce companies however, rather than traditional software product or custom computer programming services companies. Many "dot-coms" are classified as retailers and contribute to reported growth of employment in that sector.

Seattle Region High Tech Jobs in Context

	1995	1998
High Tech jobs*	72,000	99,000
Total Jobs	1,404,730	1,573,660
High Tech as %	5.1%	6.3%

Source: Puget Sound Regional Council, *1999 Central Puget Sound Regional Economics Report*
*Not including aerospace

Looking at the growth by sector, Seattle itself saw 6,000 new high tech jobs from 1995 to 1998, while the region as a whole saw 27,000 new high tech jobs. Most of the growth occurred in the software/computer services/internet cluster, which nearly doubled inside the city of Seattle and grew by 17,000 in the region. Large and successful companies such as Microsoft and Attachmate added substantially to their labor force, and many new, smaller software companies were formed. Seattle began to attract a higher percentage of the growth in software/computer services/Internet, and biotechnology, during this period, while suburban locations continued to garner a more substantial share of the growth in advanced technology manufacturing and telecommunications. These sectoral differences appear to have produced an exactly balanced pattern of growth between Seattle and its suburbs during this four-year time period. According to a (CSU/Brookings study), 23,000 jobs were added in Seattle, and another 23,000 were added in suburban Redmond during the 1993-96 time period, producing the most equally balanced job growth picture among the 200 metropolitan areas examined in that study.[4]

[4] John Brennan and Edward W.Hill, *Where Are the Jobs?: Cities, Suburbs, and the Competition for Employment,* The Brookings Institution, November 1999.

Jobs in
Seattle and the Region by High Tech Sector

	Seattle		Region	
	1995	1998	1995	1998
Biotech	4,000	6,000	9,000	11,000
Electronic/Computers/Instrument	2,000	2,000	18,000	24,000
Software/Services/Internet	5,000	9,000	29,000	46,000
Telecommunications	5,000	5,000	14,000	16,000
Total	17,000	23,000	72,000	99,000

	Seattle as % of Region		**Avg. Annual Growth**	
	1995	**1998**	**Seattle**	**Region**
Biotech	48%	55%	11%	6%
Electronic/Computers/Instrument	13%	10%	1%	9%
Software/Services/Internet	17%	20%	25%	17%
Telecommunications	36%	32%	0%	5%
Total	23%	23%	11%	11%

Source: Puget Sound Regional Council, *1999 Central Puget Sound Regional Economics Report Property Counselors*

The Initial Public Offering (IPO) data confirm that the Seattle area is experiencing a balanced growth pattern with both the central city and suburban locations sharing the growth. A total of 45 Seattle area firms "went public" through IPOs from 1994 to 1999. These 45 firms currently employ approximately 7900 people according to reports available on the Internet. The following tables show the distribution of these companies by industry and by location within the metropolitan area. Seattle's central business district houses nearly 30 percent of the firms and a quarter of the employment, and other commercial districts inside the city house another 18 percent of the firms and 16 percent of the employment. Suburban locations got 53 percent of the new firms, and nearly 60 percent of the employment.

Distribution of Initial Public Offering Firms, 1994-99

	Number of Firms	Percent of Firms	Estimated 1999 Employment	Percent of Employment
Seattle-central business district	13	28.9	1,981	25.0
Seattle-other location	8	17.8	1,262	15.9
Suburban	24	53.3	4,671	59.0
Total	45	100.0	7,913	100.0

Source:data compiled by authors from http://www.ipo.com

Distribution of Initial Public Offering Firms by Industry, 1994-99

Industry	No. of Firms
Computer programming and data processing	22
Manufacturing	11
Biotechnology	6
Telecommunications	4
Services	2
Total	45

Source: data compiled by authors from http://www.ipo.com

B. Location of High Tech Growth

The total jobs map (Map 1) shows a significant concentration of employment in downtown Seattle, and secondary nodes in neighborhoods in Seattle's north end, east of Lake Washington in Bellevue and other suburban cities, in Everett (20 miles north of Seattle) and in Tacoma (30 miles south of Seattle). In addition, the Duwamish/Tukwila/Kent Valley industrial and warehousing district is clearly shown, extending south of downtown to as far south as the city of Tacoma. According to recent Washington State Employment Security Department counts, a total of 1.6 million non-agricultural jobs exist in the multi-county metropolitan area, 60 percent of the state's total nonagricultural employment of 2.7 million in April of 2000.

The high tech jobs map (Map 2), generated using the Puget Sound Regional Council's definition of high tech industries,[5] demonstrates that high tech jobs are both concentrated and dispersed far more than total jobs. The most dense concentrations of high tech jobs are in downtown Seattle and several cities east of Lake Washington including Bellevue and Redmond. In addition, many neighborhoods throughout the metropolitan area have 143 or fewer high tech jobs per 160 acre "cell" shown on the map, [6] particularly north of Seattle and extending into Snohomish County, and in all of the cities and many neighborhoods east of Lake Washington. Software development companies sometimes start in the entrepreneur's home, and many of the firms are quite small. Over 90 percent of the 2,500+ business establishments in the software industry in Washington State have less than 50 employees, and at least 500 of them consist of a lone entrepreneur or independent contract worker.[7] Biomedical product and other advanced technology manufacturing companies also tend to start out quite small, and may operate out of an entrepreneur's home or some other nearby location for some time before hitting a growth phase and moving into an industrial park. The small scale of these establishments permits a wide range of location choices, which is reflected in the high tech job map.

[5] Puget Sound Regional Council, 1999 Central Puget Sound Regional Economic Report: Employment Patterns and Trends, 1995-98, Seattle, n.d., p. 19 (report available on the Internet at http://psrc.org).
[6] Each small square on these maps equals 160 acres.
[7] Author's calculations from establishment level data supplied by the Washington State Employment Security Department.

Note, however, that many cities and neighborhoods in the Puget Sound region are not well represented on the high tech job map. Compared to the total jobs map, the northern and southern cities of Everett and Tacoma have relatively few of these jobs, and while Seattle's northern neighborhoods have many high tech jobs, the southern neighborhoods and suburban jurisdictions extending south towards Tacoma have not shared much of the high tech boom.

Biotechnology jobs are far more concentrated than high tech jobs in general, preferring locations in downtown Seattle; and a few adjacent areas to the north and east of downtown. The University of Washington and the Fred Hutchinson Cancer Research Center are major biotechnology research institutions around which the commercial firms are clustered. Many of the staff in the for-profit companies have close ties to the researchers at UW and FHCRC, and a number of the senior scientists at FHCRC have joint appointments within the UW Medical School faculties. Frequent meetings among these scientists, along with visits to patients undergoing experimental therapeutic procedures, require tight geographic concentration of the companies, research organizations, and hospitals to minimize travel times. A few suburban locations east and north of Lake Washington host a few more biotech companies, primarily those with manufacturing facilities or “virtual biotech firms” consisting mainly of managerial/administrative staff who contract with university-based or other scientists for research and development services. Telecommunications companies (see Map 4) are also very concentrated, with downtown Seattle and selected suburbs east of Lake Washington hosting most of the employment.

These maps powerfully demonstrate the clustering tendency of high tech sectors. The reality of this pervasive clustering needs to be considered in interpreting the interview results presented below. Individual respondents in these companies may not think that being near to other similar firms is an important factor in the firm's location choice, but the maps say otherwise. High tech is not uniformly distributed across the commercial and industrial business locations of the Seattle metropolitan area; rather, high tech is concentrated in downtown Seattle and in selected eastside suburbs. The reasons for that clustering will be explored in the next section of the report, and will be considered again in the policy section of the report.

III. WHY DO FIRMS CHOOSE URBAN OR SUBURBAN LOCATIONS?

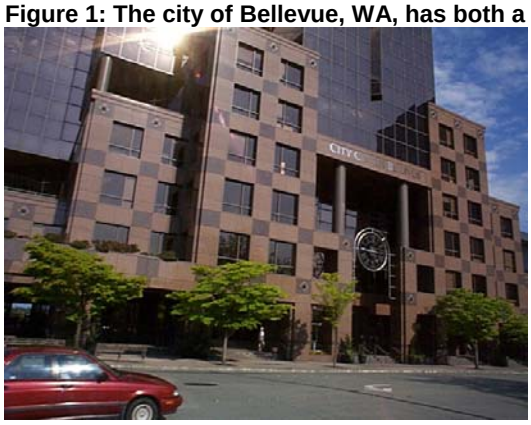
A. Suburban Style

On the most fundamental level some individuals, given a choice, prefer a suburban office park or campus environment as a place to work. Suburbia's horizontal orientation, groomed lawns, trees, auto friendliness with access to parking and likely proximity to one's residence makes it extremely desirable for a segment of metropolitan residents. The Eastside (of Lake Washington) which is comprised of several suburbs and cities including Bellevue, Redmond, Issaquah, Kirkland and Bothell, offers many lower density office and manufacturing parks within a forty five minute drive of national forest trails and ski slopes. The Eastside is served by Interstates 90 and 405, and a state highway, SR 520, linking the various suburban office and industrial parks, shopping centers, and residential areas.

There are three types of suburban high tech business locations on the Eastside. The first type is the self-contained suburban campus represented by the Microsoft campus in Redmond. The second type is the office and/or manufacturing park of one or two story buildings with large floor plates. The buildings are often surrounded by landscaped grounds and ample parking in suburban jurisdictions including Bothell, Redmond, Bellevue and Issaquah. The third type is downtown Bellevue, which is the metropolitan area's second downtown and meets many criteria in Joel Garreau's definition of an edge city (a million or more square feet of office space). Downtown Bellevue is zoned for dense development and is served by public transportation, but it does not have the pedestrian-orientation or "urban gritty" quasi-industrial feel of downtown Seattle. Bellevue is a "suburban city."

Redmond and Bellevue together have roughly forty thousand high tech jobs compared to Seattle's twenty three thousand. Thirteen thousand jobs are at the Microsoft campus out of a total metropolitan area Microsoft workforce of about 18,500. The 5,500 Microsoft jobs not housed on the company's corporate campus in Redmond are scattered in several locations: downtown Bellevue, Redmond in the Willows Office park and along SR520, and downtown Seattle (due to the acquisition of Visio which is housed near the Seattle waterfront). Downtown Bellevue has clusters of new high-rise office towers and plans for a more pedestrian friendly environment, although distances, arterial highway sizes and development patterns lead to auto use for most trips. Agile Software is a two person regional office of a Silicon Valley-based firm in downtown Bellevue. The regional director believed his location choice was perfect as he could easily drive to his customer base, the electronic manufacturers along I-405. His office is located in a building with many of his competitors and other service providers to the high tech manufacturing industry including telecommunications and other software firms.

Figure 1: The city of Bellevue, WA, has both a downtown core(left) and suburban office parks(right).



High tech manufacturers as a group favor suburban locations. Land and buildings are available at lower cost per square foot in suburban manufacturing park environments as compared to Seattle's industrial districts. In addition, the suburban locations are better tailored to their needs and desired images than Seattle's industrial districts, which tend to be dominated by older operations such as machine shops, wood working establishments, and cement kilns.

B. Urban Style

On the other hand, many metropolitan residents prefer a vibrant urban environment with its vertical character, specialty shops, street life, entertainment and the proximity to a great mixture of businesses and cultural activities. Downtown Seattle and downtown fringe locations offer historic as well as state of the art buildings, excellent public transportation, ethnic restaurants, professional sports stadiums, and a "coolness" factor with a music and art scene.

Seattle is endowed with physical attributes of water and lush green vegetation. Office buildings with views of Puget Sound, Lake Union and Lake Washington are very desirable. Decks and balconies, windows and natural light are all desirable features for high tech companies locating in downtown Seattle or the near downtown areas of South Lake Union, Lower Queen Anne and Fremont. Some company executives choose locations which permit kayaking or rowing to work and in a higher percentage of cases, bicycling or walking to work. Go2Net is presently moving its headquarters from its offices in a class A high-rise tower to Pier 70 along the downtown waterfront, placing the entire company over the water. Puget Sound views are a distinct Seattle locational advantage and a prestige factor for business and marketing purposes. Stratos, a high tech product development firm, is located next to the Pike Place Public Market, a location that offers great amenities for employees and views and status that bolster customer confidence and business.

Figure 1: Go2Net, a successful internet company is moving its headquarter from the 40 story Wells Fargo Building (left) to a refurbished Pier along Seattle's waterfront (right).

Almost all the Seattle firms interviewed spoke of the desirability of urban amenities such as excellent public transportation, a mix of restaurants, retail stores, and entertainment and the diversity of Seattle and its neighborhoods. But especially amongst the creative content and dot-com firms there was a value preference to having their own buildings, often at the fringe of the downtown core in a building of historic character or a converted manufacturing building. These structures, typically six stories or less, possess a character which differentiates them from the high rise corporate culture of wood paneled walls, grand lobbies and an office tower world removed from the street. In its place, these new firms value an urban “gritty” feel, a more industrial or adaptive-use character, brick walls, exposed beams, proximity to the street and street life. A considerable number of employees bike to work or want to bring their dogs to work. Employees work long hours, definitely not nine to five, and seek to have recreation, social and other aspects of life nurtured in the workplace. Golf tees, pool tables, basketball courts, and ping pong tables were part of the office environment in firms we visited.

These life style preferences are influencing the way architects and developers are designing and building the next generation of offices for high tech firms. Martin Smith Development Company has just received city approval for a new 85-foot tall office building with 20-foot sidewalks, a broken, pedestrian, inviting street pattern leading to little courtyards (one with a basketball hoop) and storefronts. There will be facilities for pets and views of the Puget

Sound waterfront. The building adjoins the Pioneer Square Historic District and the Port of Seattle Pier 48 container ship terminal.

Figure 2: High-tech work lifestyles include bicycles and video games down the hall.

IV. LOCATION PREFERENCES FOR KEY TECH SECTORS

The interviews with key high tech players in the siting process - real estate managers or other senior managers of high tech companies, real estate developers and brokers, and municipal planning agency managers - reveal distinct location preferences in each sector. Firms within a sector tend to be clustered in certain locations based on staff and entrepreneur's preferences, infrastructure requirements, transportation needs, environmental factors, and land costs. High tech manufacturers are more likely to be found in suburban industrial parks than older in-city industrial districts due to cost factors or the difficulty of assembling sufficient land to accommodate future expansion, or simple entrepreneurial preference. New telecommunications companies tend to prefer downtown locations, along with internet content and e-commerce firms. Software entrepreneurs have shown up all over the urban area, although the competition for talent has driven an increasing number into attractive redeveloped quarters in and adjacent to downtown. Biotechnology firms need to be located near research institutions and hospitals for research and development activities, but have tended to put manufacturing facilities in suburban industrial parks. These patterns are fairly consistent, suggesting that much of the apparent shift to downtown is due to the proliferation of certain types of firms that happen to prefer in-city locations.

High tech company founders and employees have a lot to say about where the company locates. For example, a study of the biotechnology industry in Washington State found that the single most important factor in locating biotech firms was that the CEO or founder wanted to live in the area.[8] Similarly when Immunex sought to move from downtown Seattle, a poll of its employees showed that they did not want to move to a suburban location as they valued their opportunity to bike or take a ferry to work, had established living and commuting patterns and preferred the urban environment. The company decided to stay in Seattle and is developing a new waterfront headquarters. Interviews with Microsoft real estate executives revealed a corporate culture that revolved around the Redmond campus and its horizontal nature, which permitted employees and work groups the flexibility to redeploy as assignments and responsibility changed.

While we found some examples of firms that moved from suburban to urban locations or vice versa, most want to stay in the milieu they know best. For the most part, expansion or change of facilities occurs within either the urban or suburban zones. The notable exception to this generalization is firms that have both research/development as well as manufacturing functions. In such cases, mostly biotechnology, laboratory research is located in or next to downtown Seattle corporate headquarters of these firms, while manufacturing occurs in suburban manufacturing and distribution parks.

[8] Washington State Biotechnology Survey Analysis, January 1991, Peter Haug and Philip Ness, available on the web at WaBio.com.

A. Biotech[9]

The firms interviewed in this category included the non-profit Fred Hutchinson Cancer Research Center (FHCRC), and three for-profit research and development firms – Immunex, ICOS, Zymogenetics. All four entities are 25 years or less in age. FHCRC offers the most diversity with laboratory, research, clinical treatment, and population studies, all the research information remaining in the public domain. The for-profit firms are exploring a variety of proprietary pharmaceutical products or treatments. Immunex has products already on the market while the other companies have products in various stages of testing and trials leading to FDA approval.

The facility needs vary greatly depending upon whether the company has a commercial product. Immunex has a manufacturing facility in suburban Bothell in addition to its headquarters in downtown Seattle. ICOS will likely develop a manufacturing facility adjacent to its headquarters in Bothell, when any of its products are approved for manufacturing. The potential need for a large satellite manufacturing facility is particularly important for Zymogenetics. One of its products is an artificial insulin, which must be produced in high quantities given the regularity of its use. This firm's headquarters and laboratories are housed in an historic, redeveloped former electric power plant.

***Factors**:* FHCRC, as a nationally designated Cancer Research Center, conducts basic research in the public interest. Its researchers often have joint appointments or associations with the region's major research university, the University of Washington, and the major hospitals in Seattle, most notably Swedish Hospital on First Hill. "The Hutch", as it is known locally, is located in the South Lake Union district just north of downtown Seattle and equidistant to the medical and research institutions with which its researchers collaborate. FHCRC employs 2400 people in a former warehouse/commercial area, which it is turning into a 16-acre campus. When it outgrew its First Hill location next to Swedish Hospital, it looked for a place where it could expand and have easy access to the University. FHCRC now operates a shuttle van that links the three institutions.

FHCRC also serves as a magnet for other biotech firms. Zymogenetics is one block away, as is a new applied research center spun off from the University of Washington. Clustering is a definite factor for biotech in the South Lake Union area. Immunex is currently located in downtown Seattle near the waterfront in what is becoming an upscale residential and retail center. However, twenty years ago when the firm located there, it was inexpensive space with few amenities in a sturdy old five story commercial building. When it outgrew its present headquarters, Immunex planned to move to Bothell on the eastside, but quickly discovered that the employees wanted to stay in Seattle for its urban amenities and ease of access from employees' residences. Determined to stay in the city, the company, the city, and the port

[9] Summary paragraphs for this section were adapted from the report *High Tech Real Estate Needs Study,* prepared for the Office of Economic Development, City of Seattle by Property Counselors, May 2000.

agreed to develop a waterfront site on Elliot Bay north of downtown. This required the city to build a new overpass so cars could cross a main rail line and the port to make a policy decision to make waterfront land available for non-marine purposes. Immunex did, however, locate its manufacturing facility in the Canyon Park industrial center in Bothell.

Figure 3: The Fred Hutchinson Cancer Research Center anchors Biotechnology activities along South Lake Union. Fred Hutchinson is creating 12 acre campus located midway between downtown Seattle and University of Washington. Photo below credit: St4rode Eckert ; Photo right credit: Eckert & Eckert.

Other biotech firms are following Immunex's lead developing new facilities along Elliot Avenue, capturing the same view of Elliot Bay and Puget Sound. Like firms in other high tech sectors, biotech firms compete for scarce, high priced talent. Corporate offices with views and other amenities are factors in this competition. One company official described his strategy for recruiting a scientist from Columbia University in New York by saying that Seattle's views are "competitive" with Manhattan's, but the housing costs and informal, relaxed lifestyle proved to be the competitive advantages which wooed this scientist to Seattle.

ICOS is also located in Bothell and asserts that the location suits them very well, offering the option to develop its manufacturing plant next door when the time comes. Information from research activity at the university can be obtained electronically and in journals. Furthermore, contacts with research universities are not confined to the Seattle area, but extend to major research centers nationally.

Wet and dry biotechnology laboratories are very expensive to construct, and the facilities require containment and disposal capabilities for radioactive and biological substances. Very high standards are required for ventilation, security, floor loads, and the quality and abundance

of electrical power and water. Digital equipment and sensitive experiments cannot tolerate fluctuations in electrical voltage or microscopic microbes or particles in water. These infrastructure requirements and high initial costs make biotechnology less mobile than the other high tech sectors.

Figure 4: Zymogentics built its lab and office in an old Seattle city light electric generating plant next to Fred Hutchinson Center, an excellent example of adaptive use of a historic building.

B. Electronics/Computers/Instrument Manufacturing

The firms interviewed in this category included Optiva, maker of the high tech Sonicare toothbrush; AVTECH, a manufacturer of avionics and aviator electronic equipment; Schippers and Crew, a contract manufacturer of electronic equipment and instruments; and Stratos, a product development company, providing design and development services.

The four firms vary greatly in their location, from Avtech and Schippers and Crew in the Wallingford and Shilshole neighborhoods (respectively) north of downtown Seattle, Optiva in the town of Snoqualmie at the eastern edge of the metropolitan growth boundary, and Stratos in a downtown high-rise office. Three of the firms have significant manufacturing operations, and are most interested in facilities with adequate square footage and truck access at a reasonable cost. Stratos is more interested in offering an attractive and productive work environment to its employees, and having a prestigious location with a view to impress clients.

***Factors**:* Stratos represents the most specialized, one-of-a-kind product development as opposed to production efficiency requirements sought by Optiva. As previously discussed, Stratos wants its downtown location to retain its specialized workforce that want to be downtown (some of whom like to bike to work), and as a marketing tool for its clients. Optiva recently moved from Bellevue as it needed larger manufacturing facilities. By moving further east along I-90 as the first tenant in a new commercial park, Optiva got a very good deal on the land and the guarantee of additional land for future expansion. Much of its workforce lives in Seattle and

the move necessitates longer commutes. Transit is not readily available and van pools have been established.

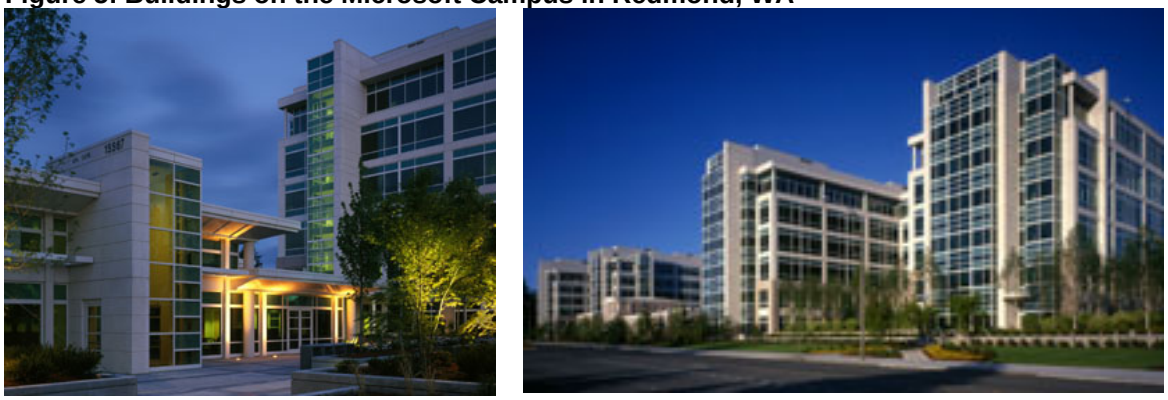
The two remaining firms interviewed are located in light industrial areas within the city of Seattle. The city has adopted policies that set aside light industrial and manufacturing land to retain that base of employment for living wage jobs for people who do not have college educations. Schippers and Crew indicated that they planned to look for less expensive space outside of Seattle with better truck and highway access. Avtech produces airplane components in a converted commercial bakery; Boeing is a principle client. It is located mid-way between Boeing's Renton and Everett commercial airplane manufacturing centers. In an earlier study, Avtech indicated it was able to ship and receive goods easily with UPS service.[10] Such access to timely transportation service is critical to a manufacturer serving a just-in-time client such as Boeing.

C. Software

The four firms interviewed in this category varied in size from Microsoft with 18,500 local employees to Agile Software with two employees in its Bellevue office. Active Voice and Visio (recently purchased by Microsoft) are both located in Seattle with 350 and 650 employees, respectively. All four firms offer prepackaged software products as well as a variety of customer services. Microsoft offers a broad array of operating system software, various applications, networks operators and content; Visio offers software for graphics uses; Active Voice offers Personal Computer-based messaging systems; and Agile provides sales and service of its business management applications.

Microsoft occupies its own campus in Redmond. The other firms occupy leased office space. Other than the small local office of Agile, the firms have grown steadily and rapidly and are continuously seeking new space.

Figure 5: Buildings on the Microsoft Campus in Redmond, WA



[10] *Urban Goods and Intercity Freight Movement,* Klastorin, Pivo, Carlson etal, Washington State Transportation Center, November 1994.

***Factors**:* Software developers are the techies who hang out in darkened offices with an array of computers, writing code for the next new application or computer program. They want private offices or well defined cubicles, and the ability to work at all hours. Software firms require redundancy in power sources and access to telecommunication lines, back up power, and space to expand their operations. Of course, there is much more that goes on in the more mature software corporations than software development. Firms like Attachmate, Adobe, and Microsoft have large floor plate office buildings accommodating many other functions from marketing to finance. The offices are modern, spacious and offer both private offices with windows and views and large public spaces for informal meetings and the occasional putting exercise on the built-in golf green in one of Visio's lobbies.

D. Internet Content and Commerce

This category is a subset of the software category and also closely related to telecommunications. Internet companies include both e-commerce companies that sell products or services over the Internet, and e-infrastructure firms that provide the software, hardware, consulting and other services that facilitate Internet activity. The five firms interviewed in this category include Go2Net, a network operator providing Internet content as well as technologies; Aventail, a company that provides Internet security for business clients; Activate.Net, which downloads satellite signals and converts them for distribution over the Internet; Expedia.com, an on-line travel agency spun off from Microsoft; and iStart, an incubator for new internet companies. All five firms are four years or younger in age and range in size from 20 to 400 employees.

Figure 6: High Tech firms often prefer their own building, less than 6 stories in height, of industrial or commercial heritage, at the edge of CBD. iStart (right) is located in a brick building in Pioneer Square. Aventail is located in the Roffe Building which until recently was home to the Roffe outdoor athletic wear company.

With the exception of Expedia, which is located in Factoria, a Bellevue neighborhood at the intersection of two major freeways, all these firms are located in Seattle in leased office space. The rapid growth of these businesses has put extensive pressure on their facilities

requirements. All have plans to multiply the amount of space they occupy. Go2Net will fill its new space at Pier 70 when it opens this summer. [11] Aventail is still searching for space to meet their needs. Expedia selected its space in Factoria because it had just been vacated by another Internet firm which moved to Seattle. All these firms acknowledge the fierce competition for qualified staff, and the importance of providing an attractive workplace. That usually means a casual environment with urban or natural amenities.

***Factors**:* Internet related firms combine high tech infrastructure and creative content requirements. Specifically, they need ready access to high bandwidth telecommunications systems such as fiber-optic cable. Competing technologies include laser beams to transmit data from building to building, and microwave transmissions. Activate.Net needs unobstructed satellite dish space to receive satellite signals, which it translates into Internet content. Its unique requirement was met by finding an older commercial building south of the downtown core with a large roof space, surrounding zoning that precluded taller buildings, and proximity to an underutilized fiber optic cable.

Figure 7: By locating outside the downtown core along Rainier Avenue, Activate.net protected its rooftop satellite dishes from high-rise shadows and interference.

Many of the dot-com companies have fewer hardware requirements because they may house their servers in data centers, large facilities constructed specifically to house the servers of multiple companies. These "server hotels" are becoming a significant factor in local electric power demand due to the proliferation of dot-coms and their server requirements. Seattle City Light, a municipally owned electric power utility, is planning major electric power distribution system upgrades and contracting for additional power supply to meet the needs of data centers and dot-com companies. The dot-coms themselves require the kind of physical space that enables creation of new content for Internet sites. This often means a combination of open spaces where employees can work jointly on developing ideas and concepts and private office spaces where software development or meetings can take place. Dot-coms are among the

[11] Several weeks after our interview, Go2Net was merged with InfoSpace, a company headquartered in Bellevue. It is not clear how the merged firm will deal with space issues with both current facilities, including the Pier 70 development, basically full of staff on the date of the merger.

newest, fastest growing firms. The creative side of the content and the kinds of people attracted to the dot-com world lead many of these firms to locate in urban Seattle for the amenities, and the coolness factor. These newer firms are more flexible as to space and floor plate requirements and may be expected to move around as they grow, merge, or fail.

E. Telecommunications

Telecommunications is a large established sector, which has experienced tremendous change. While employment industry-wide has been steady or declining, there is tremendous growth in wireless and Internet telecommunications. The four firms interviewed in this category included AT&T Local Services, the operator of local network services for business clients in metropolitan areas; Metawave, the manufacturer of base station equipment for cellular broadband networks; Wolfenet/RMF, an internet service provider; and Comwest, a sales and service company for on-premise phone systems. All but Metawave, which is located in Redmond, are located in downtown Seattle. In every case, the firms are involved in expanding bandwidth, the capacity of telecommunications networks to transmit audio, visual and data signals.

***Factors**:* The Westin Building is a downtown office building formerly housing corporate offices of Westin Hotels and United Airlines, and assorted legal and financial offices. Today it is one of the hotspots for telecommunication and Internet providers. Underneath the Westin Building lies a main juncture of fiber optic cables from several providers. The building has been reconfigured to serve the needs of Internet Service Providers (ISPs), e-commerce, and other high tech firms. One elevator was removed from the building and its shaft utilized to accommodate the expanded telecommunications infrastructure required by these new tenants. Visitors to the offices of the state's major economic development agency, housed in the Westin Building, frequently encounter technicians moving racks of computers and telecommunications equipment in the elevators. As that public agency struggles to define its role in facilitating the development of the New Economy, that economy is literally being created above and below the agency's Seattle office.

Figure 8: The Westin Building in downtown Seattle sits atop the juncture of several fiber-optic trunk cables.

V. 10 STEPS TO A HIGH TECH FUTURE

How can Seattle's experience guide other cities hoping to attract or nurture high tech industries? While some studies suggest that New Economy firms are agglomerating in only a handful of metropolitan regions[12], it is also likely that enterprise revolving around new technologies will increase and that the sector will grow and influence commerce in metropolitan areas nationwide. It is important to recognize that city governments and their actions cannot control markets. Nonetheless, results of our interviews and analyses in the Seattle metropolitan region suggest that city policy and practice can make a difference in a variety of areas. There are 10 key steps urban area leaders can utilize in devising a high tech strategy for their city. These steps have strong inter-relationships; they need not all be present to win and they may be configured differently in urban centers across the country, but they represent an excellent starting point:

1. Understand high tech firms in your region and your city's competitive advantages.

The high tech sector is not monolithic and regions specialize in different subsectors, each of which has distinct location requirements. Cortright/Mayer (2000) examined high tech development trends in 13 urban areas.[13] They concluded that only Silicon Valley has a diversified high tech sector with strengths in virtually all industry segments. The other 12 high tech urban areas in the United States have developed specialties around one or more types of advanced technology industries. Austin is known for semiconductors and computer technology; Seattle for software and biotechnology; the Research Triangle for pharmaceuticals and computers; etc. Cities need to understand their region's specialization and the dynamics of these specialized clusters of industries if they are to succeed in attracting and retaining firms because each cluster has a different growth trajectory and distinct needs in terms of workforce, siting, infrastructure, and tax policy. Publicly controlled resources may well be important factors across the spectrum of high tech industries, but each sector's distinct view of these factors needs to be well understood as public policies are being shaped and as implementation of policy goes forward.

For example, this case study of the Seattle area demonstrates that biotechnology, software and internet-based companies, and advanced technology manufacturing companies have very distinct location preferences.

Biotechnology is still an infant industry and critically dependent on close associations with university-based researchers. Basic research and proprietary development work are

[12] Matthew Zook, a Ph.D student at the University of California, Berkeley has identified six cities with the most significant concentration of Internet based activity. They include Boston, Chicago, New York, San Francisco, Seattle and Washington DC.

[13] Cortright, Joseph and Heike Mayer, *A Comparison of High Technology Centers*, Regional Connections Working Paper 4, April 2000, Portland: Institute for Portland Metropolitan Studies, Portland State University (www.upa.pdx.edu/IMS/regecon.html).

closely intertwined, and many university faculty also work in private companies. As a consequence these firms are usually located quite close to an urban research university. In the Seattle area, several biotech firms are located within 5 miles of the University of Washington campus, and a major private non-profit research institute operates a special shuttle bus jointly with the University to shuttle faculty and company personnel to and from those two institutions and nearby hospitals where patients are undergoing experimental drug trials and researchers share joint appointments.

Software and internet-based companies have essentially one tangible "asset," the talented software developers and entrepreneurial thinkers who walk in and out their doors every day. These key staff members are paid large salaries and frequently receive company stock options as well. They know that other companies are eager to hire them if compensation and local living conditions are not to their liking. Attracting and retaining these key staff members are among the highest priorities of the owners and managers of these companies, and for that reason, an attractive urban environment is also a key asset of the company. Seattle area companies tout views of the Puget Sound or Lake Washington or the nearby mountains in describing the favorable quality of life in this region, along with an active urban environment with many eating, drinking, exercising, and entertainment options.

Some software and internet companies choose urban settings, often in older industrial districts such as Seattle's Pioneer Square or Belltown, with brick warehouses and older office buildings with interesting terra cotta facades that can be rehabilitated to serve the needs of rapidly growing companies with young, urban-oriented employees. These rehabilitated historic structures are a drawing card for Seattle area companies recruiting scarce talent in key technical fields. In addition, company leaders hope that the design of these structures will spark the creative imaginations of staff in mulitmedia and internet-content companies whose competitive edge is dependent on the creativity embedded in their products and services. Few firms in these industries gravitate to the tall downtown skyscrapers more often occupied by law firms and banks. While some high tech companies end up in such spaces, even those firms take the opportunity to move to low-rise urban settings. For example, Amazon.com has grown very quickly, and needed to move out of a downtown skyscraper. This Internet retailer has redeveloped a disused hospital with a distinctive art deco architecture and sweeping views of downtown and Puget Sound to serve as its corporate headquarters.

For *advanced technology manufacturers* in fields such as biomedical products or navigation instruments, affordable space is a priority along with access to housing that is affordable for a blue-collar workforce that builds the product. These characteristics lead manufacturers toward suburban locations that combine affordability for both the company and the workers with a high quality of life. Optiva, a manufacturer of sonic toothbrushes, is a good example of this trend. After out-growing space in a Bellevue commercial area, Optiva chose to move to a new industrial park in an eastside suburb at the edge of the urban growth boundary. There it found a combination of low cost space with room to expand and good access to a

freeway to make commutes manageable for workers. Other Seattle area biomedical product manufacturers have concentrated in industrial parks in northern and eastern suburbs.

These three examples of high tech industries that have a significant presence in the Seattle area illustrate the need to understand the location preferences of particular high tech sectors evolving in a given city. In other cities it may be important to understand the needs of computer manufacturers, networking companies, sophisticated transportation equipment companies, or advanced material manufacturers, based on the mix of advanced technology sectors taking root in their particular region. Once this understanding is in place, attention can turn to particular policy issues that cities control or can at least influence.

2. Invest in human capital.

Having a readily available and qualified workforce is one of the best investments that state and local governments can make. Local governments can support workforce training initiatives to provide the qualified workers local employers need. Many cities have an economic development office with staff who understand company priorities and can serve as a funnel for information. Seattle's Office of Economic Development, through its Seattle Jobs Initiative (SJI), brings together employers looking to hire skilled entry-level workers and Seattle residents seeking living wage employment. Currently, SJI is "teching up" its successful office occupations program and is implementing a new training sequence helping low-income Seattle residents obtain entry level jobs in the information technology industry. SJI has made direct contact with several high tech companies in Seattle to learn more about their employment needs and to recruit an advisory body on the development of the new information technology training program for low-income residents. Representatives from Microsoft, WRQ and Onvia.com have volunteered to participate as trainers and advisors. The Chamber of Commerce has already agreed to assist in seeking high tech industry CEOs' support.

Those urban areas that do a better job of gearing up engineering and scientific academic programs and attracting bright students into these fields offer a competitive advantage to growing high tech companies. Cities that do their best to hang on to talented workers when industries restructure will also create enduring competitive advantages. Many reports have examined the adequacy of Information Technology programs in the nation's universities and community colleges in the face of rapidly expanding demand for software developers and computer engineers. Other studies over many years have addressed the need to attract more students into engineering and scientific disciplines.

In Seattle, The Boeing Company is a huge employer of engineers, computer programmers, and skilled machinists. Local colleges and universities can point to many examples of programs that support Boeing's workforce needs, and to support from Boeing and other companies that has aided these programs in building their capacity to educate students and build research capacity. As the biotechnology industry matured and limited pharmaceutical manufacturing began in the region, companies collaborated with a community college to create

a biotechnician program to train workers for biotechnology production plants. Recently, the demand for software developers and related technical occupations from software and internet-based companies has resulted in expansion of information technology programs at area colleges and universities.

But what role do cities really play in the education arena? In the western states, mayors and city councils typically do not operate or fund the K-12 schools, nor do they directly operate community colleges or universities. East of the Mississippi River, city governments may have a more direct role in the provision of education, especially for K-12 schools and community colleges. However, in every area city leaders play an important role in creating a favorable climate for educational institutions through zoning and transportation policy. Mayors and council members also have access to the "bully pulpit" that comes with public office, and can use speeches, op eds, and community meetings to articulate the importance of focusing educational resources in fields that meet the needs of expanding sectors of the economy that can influence the allocation decisions of educational institutions, and the decisions young people and their parents make concerning fields of study. Seattle's experience indicates that whether or not municipal government has a direct role in education, it has a leadership role ensuring that the common schools, community colleges, and universities have math, science, and IT programs of first rate quality, and these institutions can attract faculty and expand to meet probable needs of local companies and the demands of students for access to seats in relevant programs. [14]

3. Create a research and development presence.

Advanced technology does not blossom in the desert after a rainfall; it is the result of long term, high quality research programs that at some point bear fruit in terms of commercializable technologies. The personal computer and pre-packaged software industries emerged 20 years ago after many years of work in both public and private research settings. Biotechnology as a commercial sector is the result of decades of funding of medical research by the national government, and critical public policy decisions about who can own selected findings resulting from that research program. The Internet is an offshoot of defense industry communications work. Cities can facilitate and help to fund public/private ventures that establish and maintain leading edge research centers and educational institutions. In-kind contributions such as a gift of land may be possible as well as hard cash grants or contractually funded research. Tax policy may have some impact on the viability of non-profit or for-profit research institutions.

[14] A report on a symposium held by Seattle area leaders in 1986 poses questions about how to encourage high tech development in Seattle and mentions that aerospace and software are likely to be key sectors for the future in this region. This symposium report also explores the key role of local universities in fostering the development of high tech through both research and education activities. See *Proceedings of the Business-Government Symposium on High Technology in the City*. The City of Seattle and others, September 11, 1986.

In Seattle's case, municipal policy has helped to shape the two key institutions that have collectively spawned the 8,000 worker commercial biotechnology industry in the Puget Sound region. Public policy influences on the development of high tech in Seattle include issues around the expansion of the University of Washington Medical Center, the size of the leased space university-affiliated organizations occupy near the university campus, and years of discussions over how to shape the development of lands south of Lake Union and north of the central business district to accommodate biotechnology institutes and companies, along with other technology-based businesses. One example of the outcomes of this long series of discussions is redevelopment of a former electric generating plant to become the corporate headquarters for Zymogenetics, one of the larger biotechnology firms in the area. The City of Seattle was also involved in creating biotechnology incubator space using facilities relinquished by the Fred Hutchinson Cancer Research Center after it moved into a new campus in the South Lake Union area. Neither the "Hutch's" new campus nor the re-use of their old laboratory space would have been possible without extensive city involvement.

4. Invest in Physical Capital.

Good infrastructure is important to high tech firms as they carry out their business and as they recruit staff based in part on a high quality of life. Infrastructure that is critical to the direct operations of high tech companies includes water and electric power services as well as fire protection that is sensitive to key features of high tech industries. Water quality is a very important issue to biotechnology firms and certain advanced technology manufacturers such as chip fabricators. Electric power quality is a municipal responsibility in some cities that control their own power generation and distribution facilities as Seattle does. Non-interruptible power that is not subject to voltage spikes or other aberrations is very important to biotechnology laboratories, Internet-based companies and the co-location facilities that house Internet servers of several companies. Rate structures are becoming an important public policy issue for those regions hosting facilities variously known as data center, co-location centers, or "server hotels." Large data centers, housing internet servers for one or more internet-based companies have power requirements approximating that of a small to medium sized town, with unusually high requirements for power reliability. Municipally-owned Seattle City Light is planning major substation investments and is contracting for additional power supplies. Regions that can accommodate the requirements of the data centers may gain a competitive advantage from the desire other internet-companies may have to locate near these data centers.

Telecommunications capacity may or may not involve a direct public role, but access to public right of way is almost always required. In places not already served by multiple providers of broadband telecommunications capacity, public sector organizations may have a role to play. Cities can be important "launch customers" to entice a private provider into areas that they do not currently serve. Transportation services are usually provided by public authorities, and the roads and highways are almost always built and maintained by governments. Airports are often a public responsibility as well. All of these infrastructure services are essential to a high tech company, and if any are absent or of poor quality, entrepreneurs are likely to rule out that

location. In some cases, high quality infrastructure at favorable costs can be an inducement to a firm shopping for a site, but in most situations it is simply a prerequisite that must be in place before firms will consider a site for development.

In Seattle, city government has been aggressive about making infrastructure information available to the high tech community. The Office of Economic Development, the Department of Information Technology (DOIT) and the City's Geographic Information Systems (GIS) Office have recently updated information on the fiber optic network in the City. The agencies are currently preparing an updated map of the major fiber optic network in the City to be publicly available to high tech companies and developers. A number of the firms interviewed for this study expressed an interest in this type of information, and noted that it is currently difficult to obtain, complicating their siting decision processes.

At times, municipal responsibilities for physical infrastructure will have to be approached in a creative way to solve problems for particular companies. Immunex's acquisition of waterfront property for a future campus provides a good example. The city has agreed to build a new ramp from Elliot Avenue over the railroad tracks to the new Immunex headquarters site, and without this public investment, Immunex would not have considered the site. The city has also gone beyond its traditional role in helping FHCRC develop its site along the east shore of Lake Union, and in converting the old Lake Union Steam Plant to house Zymogenetics. In these instances the city has been active partner in the development process. Partnerships of this sort may be necessary in the future in order to aid firms in redeveloping sites with unique historical values, special access or other infrastructure considerations, or a legacy of pollution that must be overcome to permit redevelopment.

5. Invest in quality of life.

Cities can take steps to encourage a vibrant, diverse setting for cultural activities, eating and drinking, shopping, and entertainment. While hard to measure, the quality of life that firms seek for their employees depends on the availability of a wide range of sports, entertainment, artistic offerings; good restaurants; shopping facilities that are accessible, and an esthetic quality that is appealing. In Seattle, public and private dollars have gone into a new world-class concert hall, three new or revamped sports facilities for major league teams, and downtown parks and outdoor spaces. A new library is under development that will be a world class architectural "statement" as well as a useable new public facility. An expanded convention center and a new exhibition hall directly benefit industries courting business on a global scale. Private entrepreneurs have supported public efforts with restaurants, hotels, and a "music experience project."

Planning by the City has focused on preserving views, historic structures, zoning for mixed use buildings and neighborhood quality of life. These efforts that are aimed at increasing urban neighborhood and downtown vibrancy, healthiness and safety, key factors which attract high tech firms and their employees to city locations. The result is a "street scene" that visitors

and residents find appealing, and that high tech companies definitely view as an asset in recruiting employees. Several Seattle locations notably around the Pike Place Market, historical and arts oriented Pioneer Square, and the close in Fremont Neighborhood have the “coolness factor” which Dot.com businesses crave.

Seattle’s vibrant Downtown has become an attractive destination for young high tech workers as a place to live, work and play. To continue building on that vibrancy, the city is pursuing several policies and programs: expanded support for Business Improvement Areas; the creation of a new program to provide incentives for developers of office towers to also invest in new housing development; and the submission to voters of a levy to purchase land for open space and make improvements to existing parks. An example is the proposal to convert a formal oil barge facility into a premier sculpture garden in Downtown on the waterfront. The project has attracted tremendous attention from condo developers who are planning to build new projects next door to the new park.

6. Streamline permitting, planning, and other public services.

High tech firms and workers approach public policy issues and processes from very different perspectives than older industries. Since knowledge workers can choose where they live and work, a city's competitive edge will be affected by how well it handles basic government services such as planning and permitting, providing police and fire services, and hauling away the garbage.

City government can be a partner or major obstacle in resolving these issues. If the fire department does not understand the nature of biotechnology, it may insist on fire safety systems that are unworkable. If the health department and the building permit section are not on speaking terms, firms may not be able to resolve outstanding issues in a timely way. The predictability of a city's decision-making process is as important to high tech firms as the nature of the requirements themselves. Thus, cities should concentrate on creating replicable processes for getting complicated permitting issues resolved, especially when many departments implementing distinct pieces of legislation are involved in a case.

How quickly designs can be approved and construction can begin are critical variables in a high tech firm's planning process. An advantage that Silicon Valley touts to businesses that few other areas can emulate is the availability of a million or so square feet of ready-to-occupy office space. For other areas, development from the ground up, or redevelopment on sites that come with a host of problems is more often the reality. In Seattle, an interesting case involved the development of a laboratory facility. Public officials, proud of completing a facility from design through permitting and construction in only five months, were immediately advised by high tech industry representatives that five months is now the "benchmark" for completion of such projects, and that the procedures created to move this particular project along should be turned into the city's standard operating procedures. In response, Seattle has launched an initiative to further streamline the permitting process by creating a “one stop” environment in

which permit applicants can get easy access to the variety of city departments that have regulatory responsibility for various aspects of construction, namely the utility and fire departments.

Planning can help by identifying certain districts for redevelopment, and scoping the infrastructure investments needed, the environmental hurdles that must be overcome, or possible neighboring use conflicts in advance. For example, the Seattle area was required to develop comprehensive land management plans under a new growth management law passed by the state legislature about a decade ago. A multi-county planning organization was instrumental in developing a vision of dense development nodes within already urbanized parts of four counties, linking these nodes with mass transit. When the latest wave of intense development began as software took off and the Internet phenomenon emerged, much of the planning was already done and developers were putting forward projects for new office buildings and condominiums in downtown Seattle. Currently, the City is considering major infrastructure investments at five nodes within the city to encourage further high tech development.

When Adobe wanted to move out of cramped quarters in Pioneer Square and its employees clearly indicated a preference for an in-city location in lieu of suburban alternatives, the City was prepared to be a partner in helping Adobe develop a site north of the central business district along the Lake Washington Ship Canal. Real Networks made a similar move from Pioneer Square to a redeveloped trade center, and Amazon.com shifted from downtown high rises to a redeveloped hospital. Immunex, Visio, and others have found new locations within the city in part because there has been consistent effort to plan for growth within city boundaries and to improve the efficiency of the permitting process.

The combination of economic development policies and land use policies implemented through zoning codes generates conflicts in some situations. In Seattle it is a difficult political decision to encourage expansion of high tech activity that will displace more traditional manufacturing activity. In other cities this may or may not be a significant issue. Other zoning considerations may come to the fore, particularly in the conversion of older buildings and districts in the downtown core. Questions of historic character, height and density, and conversion of existing buildings are particularly relevant as such environments appear attractive to high tech software and creative content firms. Additional zoning decisions will be required to accommodate biotech labs and to integrate mixed uses such as retail, restaurants and housing to make high tech areas vibrant parts of the urban fabric.

7. Adapt other local laws.

Local policies on tax and administrative issues need to be sensitive to the special needs and perspectives of tech firms. For example, the State of Washington has no provision for corporate income taxes at either a state or local level; however, both the state and municipalities can levy a gross receipts tax that has different rates for various industry

classifications. A lawsuit brought by one Seattle software company over its industry classification led to a special study committee co-chaired by a city council member and the city's finance director. This committee investigated alternative taxes based on the number of employees or the square footage a firm occupies to avoid arguments over the most appropriate industry classification for new industries that don't fit pre-existing categories.

Technical requirements of various types of high tech companies also point to needs for reconsideration of a variety of municipal codes and regulations. For example, municipalities may need to review carefully and update building and fire codes for retrofitting and building new office and commercial space that accommodates more cable, back-up power facilities, microwave antennas, and laser optics in the floors, walls, basements and roofs. Biotechnology laboratories may pose special challenges for building and fire codes.

8. Provide venture and seed capital.

Some cities have established special funds to invest in start ups, "smart buildings" and incubators. Other jurisdictions, including Seattle, face stringent legal constraints on investing in for-profit projects. However, Seattle's Office of Economic Development utilized a revolving loan fund to assist in redevelopment of laboratory space vacated by the Fred Hutchinson Cancer Research Center to create an incubator for biotech companies. While public entities in Washington State cannot establish venture capital funds, the local Chamber of Commerce has organized an "angel investor" network among local people with a high tech background and an interest in reinvesting some of the wealth they earned as early employees of Microsoft, McCaw Cellular, or other successful high tech companies. These examples demonstrate that there are many ways to use the powers of city government to augment private capital sources and encourage high tech development.

9. Create support programs for entrepreneurs.

Many entrepreneurs leave a university or research laboratory with an idea for a product or service, but little or no business experience. Michael Lewis' book *The New New Thing* chronicles the all-too-familiar tale of a technically sophisticated entrepreneur who loses control of his company because he was not sophisticated in business management. Jim Clark was lucky in that he lost control of his first venture, Silicon Graphics, but made a lot of money and went on to found other companies including Netscape and Healtheon. Other entrepreneurs have lost not only control, but all personal assets as bad management decisions have led to bankruptcy.

Local support can help young entrepreneurs develop viable business plans and manage start up operations. City leaders can play a significant role in fostering organizations and venues that nurture entrepreneurs and help them become successful business owners. Incubators are often opened with this intent. Public leadership can also encourage establishment of industry associations that can nurture their own. For example, the Washington

Software Alliance was created with assistance from a state economic development agency. Another group called the Technology Alliance was created under Chamber of Commerce auspices to bring together entrepreneurs from several high tech sectors. Public agencies have also provided meeting places or other support for diverse industry support organizations in the Seattle area such as a Personal Computer User Group, the local activities of the MIT Enterprise Forum, an Artificial Intelligence Forum, and a Science and Technology Roundtable within a multi-sector Technology Alliance.

10. Apply information technology in the public sector.

There are multiple applications for IT in the public sector which can support tech development in the regional economy. As Michael Porter has noted, competitive industries are built on a base of strong local demand from customers who know what they want and demand the best.[15] Government can be part of that local base for the IT industries. Many government agencies are realizing that complicated eligibility rules and complex regulations can be effectively communicated to citizens through use of the Internet, and that citizens doing business with the permitting or regulatory agencies can efficiently track their applications on well-constructed websites. Outmoded mainframe systems that are expensive to build and maintain can be replaced with web applications. Statistical agencies can put their data on the web, eliminating expensive paper reports and delivery of data via the mail. Email and streaming media open up government decision-making processes to many more interested citizens who do not have to leave their homes or offices to participate.

This exciting transition to a new, more modern, more efficient, and more responsive government creates business opportunities for software and web development companies. Several of the startup and more established companies in the Seattle area are concentrating on products and services for public sector organizations. For example, Real Networks has a division devoted to developing applications of streaming media products in the public sector to improve citizen access to governmental decision-making processes.

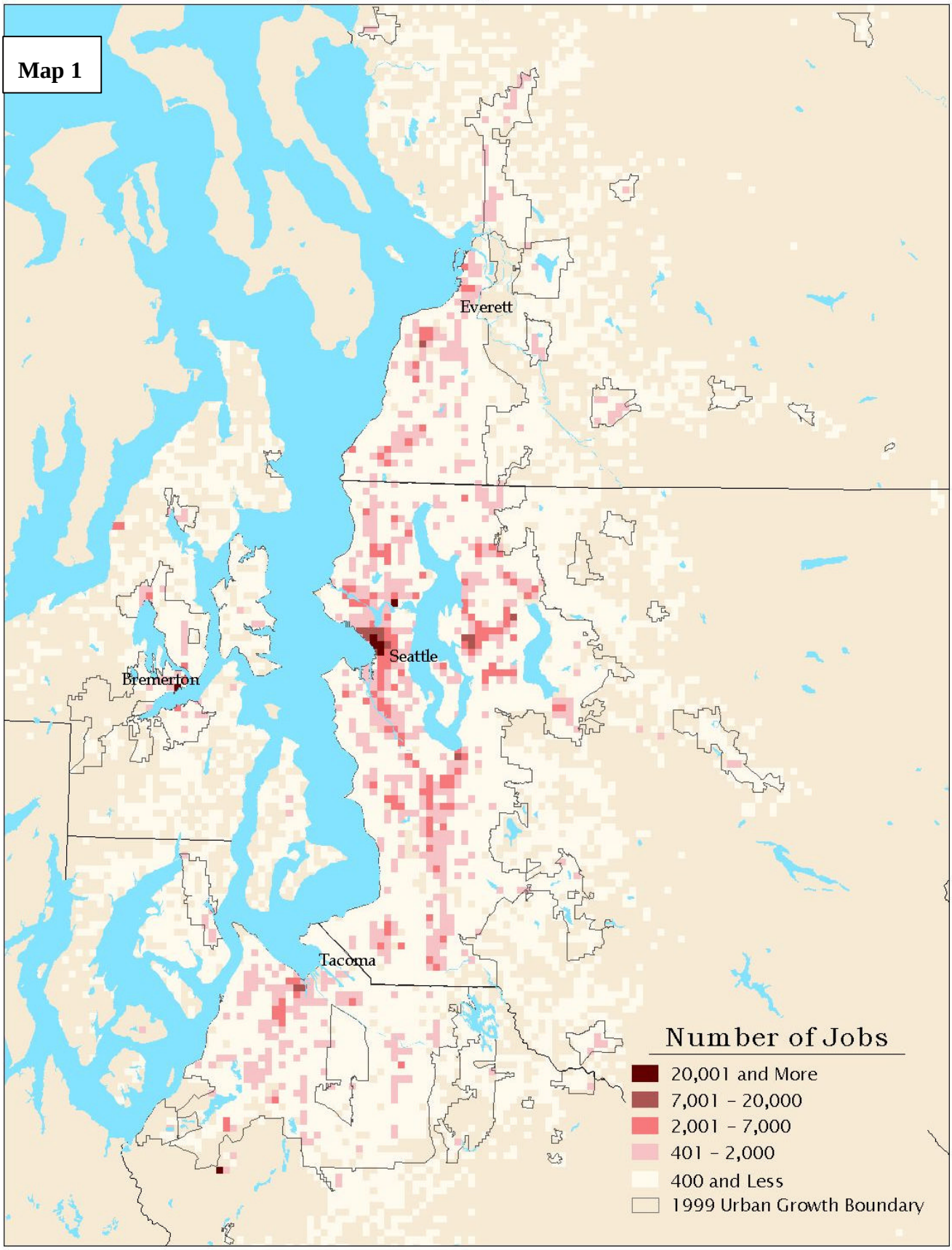
[15] Michael Porter, *The Competitive Advantage of Nations*, New York: Free Press, 1990.

VI. CONCLUSION

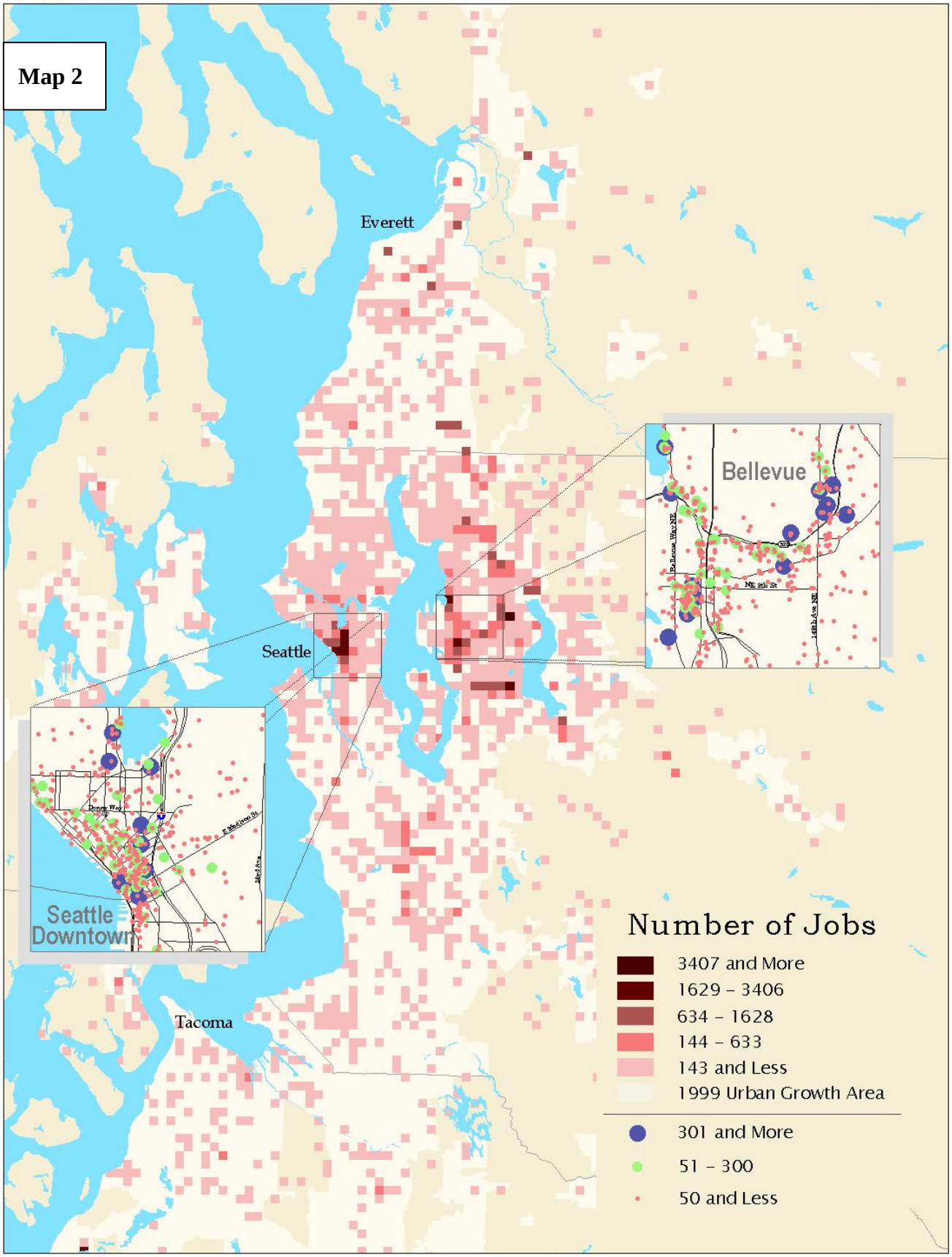
A high quality, innovative, and efficient local government can facilitate the development of high tech industries if it is also careful to understand trends in local industries and the needs these companies have with respect to their public sector partners. In addition, good land use planning may anticipate conflicts between older and newer land uses and find ways to accommodate various interests prior to the moment when a high tech firm or developer presents a building plan with a request for expedited approval. In a variety of ways, cities can create a healthy climate for high tech by stepping out beyond traditional roles on infrastructure, fostering and promoting research institutions, and encouraging world class education systems. Patience and persistence are also necessary virtues. Leaders in Seattle were talking about and planning for a high tech future at least 15 years ago, before Microsoft was a household name or subject of daily news stories, before the Internet began to transform work environments, and before the term "biotechnology" was widely known. The local university emerged as a strong research campus at least 40 years ago with strong public support. Staying the course is an essential characteristic of good public policy to encourage and sustain high tech.

The latest wave of high tech development puts a unique importance on vibrant, aesthetically appealing urban settings with workable transportation systems and affordable neighborhoods. This latest wave puts cities in an advantageous position vis à vis suburban locations, creating a favorable environment in which good public policy can meet company needs and satisfy many citizen aspirations for an improved quality of life. In that sense there is an historic opportunity that must be seized by city leaders, but with the proviso that patience is also going to be necessary.

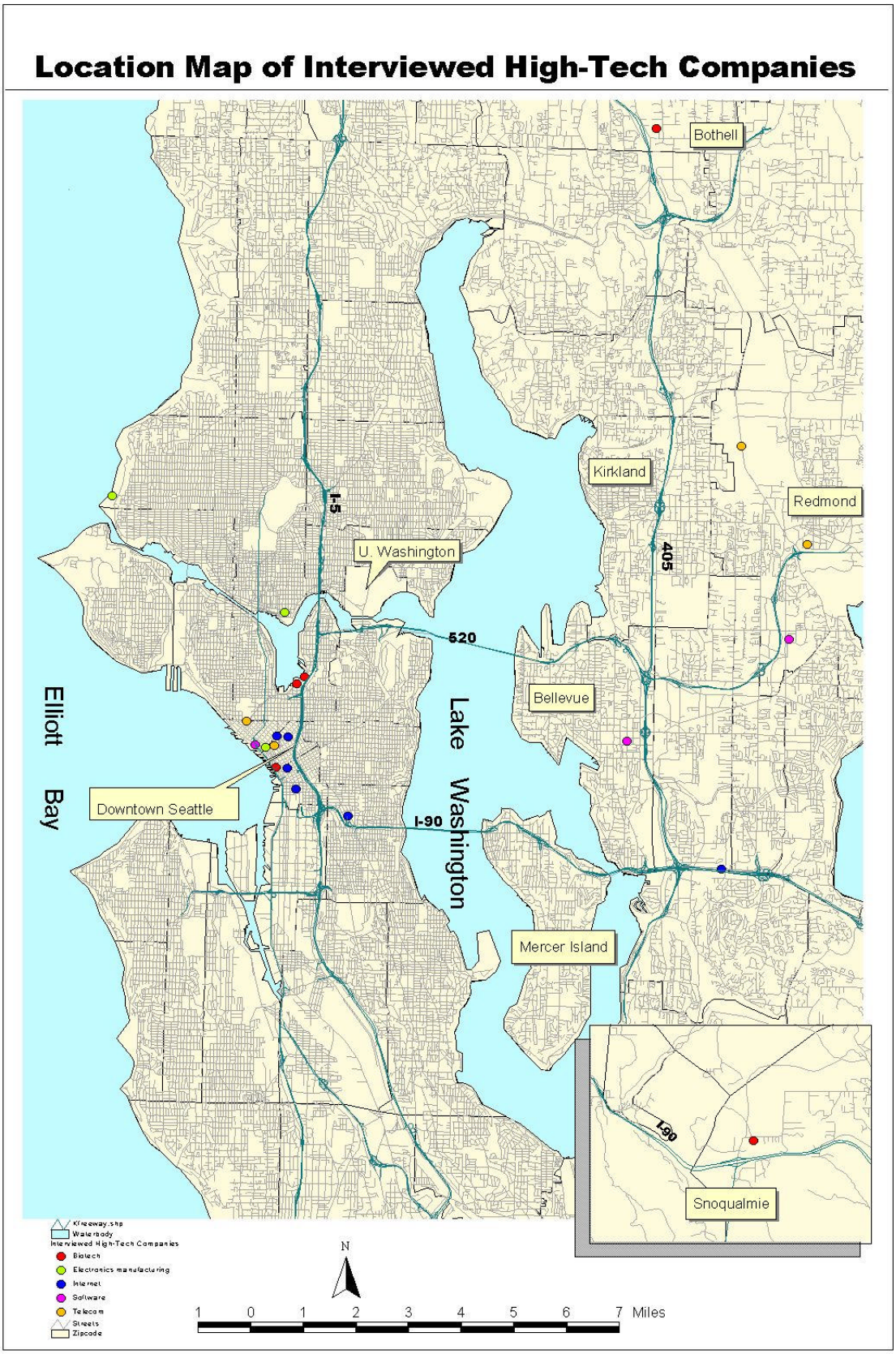
Jobs in the Central Puget Sound Region



High-Tech Jobs



Appendix A


Location Map of Interviewed High-Tech Companies
Bothell
Kirkland
Redmond
U. Washington
I-5
405
520
Bellevue
Lake Washington
Elliott Bay
Downtown Seattle
I-90
Mercer Island
I-90
Snoqualmie
Kfreeway.shp
Waterbody
Interviewed High-Tech Companies
Biotech
Electronics manufacturing
Internet
Software
Telecom
Streets
Zipcode
N
1 0 1 2 3 4 5 6 7 Miles

Appendix B: High Tech Industry Definitions

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
28	Chemicals & Pharmaceuticals							part							
281	Industrial chemicals				281				281 combined with 286	281			part		
2812	Alkalies and chlorine	2812											2812		
2813	Industrial gases	2813											2813		
2816	Inorganic pigments												2816		
2819	Industrial inorganic chemicals, NEC												2819		
282	Plastics materials and synthetics								282	282			part		
2821	Plastics material synthetic resins, and nonvulcanizable elastomers	2821											2821		
2822	Synthetic rubber												2822		
2823	Cellulose manmade fibers	2823											2823		
2834	Manmade organic fibers, except cellulosic												2824		
283	Drugs				283				283	283	283		part		
2833	Medicinal chemicals and botanical products	2833											2833		
2834	Pharmaceutical preparations	2834											2834		
2835	In vitro and in vivo diagnostic substances	2835											2835		
2836	Biological products, except diagnostic substances	2836											2836		
284	Soaps, cleaners, and toilet goods								284	284					
285	Paint and allied products								285	285					

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
286									286 combined with 281	286					
2865	Cyclic crudes and intermediates, organic dyes	2865													
2899	Chemicals, Industrial organics nec	2899													
287	Agricultural chemicals				287				287	287					
289	Miscellaneous chemical products								289	289			part		
2891	Adhesives and sealants												2891		
2899	Chemicals and chemical preparations, NEC	2899											2899		
291	Petroleum refining				291				291	291					
30	Rubber & Plastics														
303	Reclaimed rubber									303					
34	Fabricated Metals														
348	Ordnance and accessories, NEC								348	384					
35	Industrial Machinery														
351	Engines and turbines				351				351	351					
353	Construction and related machinery				353				353	353					
354	Metalworking machinery									354					
355	Special industrial machinery				355				355						
356	General industrial machinery								356	356					
357	Computer and office equipment		part	357	357	357	357	357	357	357	357	357	part	357	357
3571	Electronic Computers	3571	3571										3571		
3572	Computer Storage Devices	3572	3572										3572		
3575	Computer Terminals	3575	3575										3575		

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
3577	Computer Peripherals	3577	3577										3577		
3578	Calculating and Accounting Machines	3578	3578										3578		
3579	Office Machines	3579	3579										3579		
36	Electrical Equipment						all	part				all		part	
361	Electric distribution equipment				361		361		361	361		361	part		361
3612	Power, distribution, and specialty transformers	3612											3612		
3613	Switchgear and switchboard apparatus	3613											3613		
362	Electrical industrial apparatus				362		362		362	362		362	part		362
3621	Motors and generators	3621													
3624	Carbon and graphite products	3624											3624		
3625	Relays and industrial controls	3625											3625		
3629	Electrical industrial apparatus, NEC	3629											3629		
363							363					363			
364							364					364			
365	Household audio and video equipment		part	365	365	365	365		365	365		365	part		365
3651	Household audio and video equipment	3651	3651										3651		
3652	Phonographic records and prerecorded tapes and disks	3652	3652										3652		
366	Communications equipment		part	366	366	366	366		366	366	366	366	part		366
3661	Telephone and telegraph apparatus	3661	3661										3661		
3663	Radio and TV broadcast and communications equipment	3663	3663										3663		
3669	Other communications equipment	3669	3669										3669		
367	Electronic components and accessories		part	367	367	367	367		367	367	367	367	part		367

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
3671	Electron tubes	3671	3671										3671		
3672	Printed circuit boards	3672	3672										3672		
3674	Semiconductors	3674	3674										3674		
3675	Electronic capacitors	3675	3675										3675		
3676	Electronic resistors	3676	3676										3676		
3677	Electronic coils, transformers, and inductors	3677	3677										3677		
3678	Electronic connectors	3678	3678										3678		
3679	Other electronic components	3679	3679										3679		
368							368					368			
369	Misc. electrical equipment and supplies				369		369					369	part		
3691		3691													
3695	Magnetic and optical recording media	3695											3695		
3699	Electrical machinery, equipment, and supplies, NEC	3699											3699		
37	Transportation Equipment							part						part	
371	Motor vehicles and equipment				371				371						
3711	Motor vehicles and car bodies	3711													
372	Aircraft and parts				372				372, 6 combined	372	372				
3721	Aircraft	3721													
3724	Aircraft engines and engine parts	3724													
374	Railroad equipment									374					
376	Guided missles, space vehicles				376					376	376				
3761	Aerospace, guided missiles & space vehicles	3761													
3764	Aerospace, propulsion units and propulsion parts	3764													

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
38	Instruments						all	part				all		part	
381	Search and navigation equipment		part	381	381		381		381	381		381	part		381
3812	Defense electronics	3812	3812										3812		
382	Measuring and control devices		part	382	382	382	382		382	382		382	part		382
3821	Laboratory apparatus and furniture		3821										3821		
3822	Environmental controls	3822	3822										3822		
3823	Process control instruments	3823	3823										3823		
3824	Fluid meters and counting devices	3824	3824										3824		
3825	Instruments to measure electricity	3825	3825										3825		
3826	Laboratory analytical instruments	3826	3826										3826		
3827	Optical instruments and lenses	3827	3827										3827		
3829	Other measuring and controlling devices	3829	3829										3829		
383							383					383			
384	Medical equipment, instruments, and supplies		part	384	384		384		384	384		384	part		384
3841	Surgical and medical instruments and apparatus	3841											3841		
3842	Orthopedic, prosthetic, and surgical appliances and supplies												3842		
3843	Dental equipment and supplies												3843		
3844	X-ray apparatus and tubes and related irradiation apparatus	3844	3844										3844		
3845	Electromedical and electrotherapeutic apparatus		3845										3845		

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
385							385					385	part		
3851	Ophthalmic goods	3851											3851		
SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
386	Photographic equipment and supplies		part	386			386		386	386		386			
3861	Photographic equipment and lenses		3861												
481	Telephone communication services		part	481		481		481					part	481	481
4812	Radiotelephone communications	4812	4812										4812		
4813	Telephone communications	4813	4813										4813		
482	Telegraph and other communications		part	482		482							part		
4822	Telegraph and other message communications	4822	4822										4822		
483	Radio and television broadcasting					483									
484	Cable and other pay television services		part	484		484									
4841	Cable and other pay television services	4841	4841												
489	Communications services, NEC		part	489		489							part		
4899	Other communications services	4899	4899										4899		
504	Wholesale professional and commercial equipment					504							part		
5045	Computers and computer peripheral equipment,software	5045											5045		

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
5065	Electronic parts and equipment, NEC	5065											5065		
573	Radio, television, and computer stores					573									
SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
737	Computer and data processing services		all	737	737	737	737	737	737			737	part	737	737
7371	Computer programming services	7371	7371										7371		
7372	Prepackaged software	7372	7372										7372		
7373	Computer integrated systems design	7373	7373										7373		
7374	Computer processing and data preparation	7374	7374										7374		
7375	Information retrieval services	7375	7375										7375		
7376	Computer facilities management services	7376	7376										7376		
7377	Computer rental and leasing	7377	7377												
7378	Computer maintenance and repair	7378	7378										7378		
7379	Other computer-related services	7379	7379										7379		
87	Engineering & Management Services							part							
871	Engineering and architectural services				871				871						
8711	Engineering services	8711													
873	Research, development, and testing services				873				873				part		

SIC	Industry	WTC	AEA, Cyber-states Update	Cyberstates 3.0	Beyers	Census	Cortwright	DeVol	Hecker	Markusen, Hall, Glasmeier (1986)	NSF	Oregon	PSRC	Saxenian	INTERSECT (6+ cites)
8731	Commercial physical and biological research	8731											8731		
8733	Noncommercial research organizations	8733											8733		
8734	Testing laboratories												8734		
874	Management and public relations services				874				874						