INCREASING HIGHER EDUCATION'S CONTRIBUTION TO ECONOMIC DEVELOPMENT IN WASHINGTON

by

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EXECUTIVE SUMMARY

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I. This report analyzes the relationship between higher education and economic development and discusses ways in which the contributions of higher education to Washington's economy can be increased.

II. Findings

A. Higher education and economic growth are demonstrably linked.

B. Basic economic forces are tightening the links.

C. The key links include common research interests and consulting arrangements as well as educational programs.

D. Among the more common approaches used by states to facilitate campus-driven economic development are:

1. Programs of campus-based technical and management assistance to business;

2. Programs to enhance and expedite technology transfer from university laboratories to marketable products, processes and services;

3. Subsidized job training provided by academic institutions and customized for employers who can show that, without the subsidized training, they would leave the state or not locate in the state;

4. A state-funded seed grant fund, with an industry matching requirement, designed to encourage university-industry cooperative projects on campuses and in departments where these "should" exist but do not;

5. Subsidized, campus-based business "incubators" designed to nurture embryonic companies in fields where the host campus has faculty strength and the facilities to help the company through its difficult early life stages;

6. Subsidized, campus-based research parks designed to attract firms with interest in access to university people and facilities.

III. Conclusions

A. A multi-campus statewide program of expanded and fully-coordinated campus-based management and technical assistance to Washington firms, built upon resources and structures already present on many campuses, appears both feasible and desirable and not very costly. Additional documentation of need and further program design work is necessary, however.

B. Technology transfer offices at UW and WSU are performing well with the resources they have, but are well behind peer universities in both funding and indicators of economic impact.

C. The Washington Technology Center shows early promise of producing a favorable impact on Washington's economy.

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I. Purpose of the Report and Overview

This report is addressed to those interested in the direct contributions of higher education to Washington's economic development. Within this broad area of inquiry, we have sought to identify and focus our attention on types of programs whose potential economic development impact and feasibility are clear. Thus, some of the more exotic but less well-tested ideas (of which there is no shortage) have been set aside in order to look more carefully at what there is good reason to believe will work, and will be applicable and feasible for Washington's colleges and universities.

The report is organized as follows. The next section (Section II) explains the basic logic of the widely-alleged link between higher education and economic development and provides an overview of what is known about the matter. In particular, we focus on the reasons why the link has grown stronger in recent years. Next (in Section III), we describe briefly some of the specific types of higher education-economic development connections that might be applicable to Washington's circumstances but on which we have chosen not to focus our primary attention at this time. A very brief indication of the merits and likely problems with each of these is also given in this section as a guide to possible further work on some of them.

The core of the report is contained in Section IV where we present our suggestions as to which economic-development-related higher education programs merit the highest priority. The rationale for these suggestions is presented, including discussion of the evidentiary base, program design issues and the ways in which our suggestions mesh with existing efforts on Washington's campuses. Our suggested high-priority program areas have two broad themes: (1) increasing and better targeting campus-based technical and management assistance to firms throughout the state; and (2) expediting "technology transfer", i.e., spurring technological development in Washington drawing upon campus-based research. In the latter area we find support for two types of activities: one is the demonstrably successful efforts of the technology transfer offices at the research universities; the second is the Washington Technology Center, a promising program of targeted research aimed at technologies of potential or current commercial interest.

Of these three major recommendations, only the one regarding increased campus-based technical and management assistance to Washington firms might imply a new program structure. Even in this instance existing activities and programs on many of the campuses could be used to provide much of the infra-structure and support for the type of program we recommend. An implication of all three of our recommendations is to use redirected or modest, but carefully targeted, incremental dollars to extract more economic development payoff from the rich intellectual and physical resources already present on Washington's 33 public campuses. In each case, we will show that there is good reason to believe--

based on experience with similar ventures here and/or elsewhere -- that these payoffs will actually materialize.

The final section of the report (Section V) provides a brief summary of our conclusions and recommendations for the reader's convenience.

II. Does Higher Education Contribute to a State's Economic Development? If So, How?

The relationship between the education level of the labor force and economic growth is now well-established. More educated workers earn substantially more than do workers with less education even after taking account of, to the extent possible, other factors correlated with both education and earnings (Becker 1975; Cohn 1979; Haveman and Wolfe 1984; Solmon 1985). The most authoritative estimate of the contribution of growth in education to U.S. economic growth (over the period 1919-1982) places this contribution at 14 percent of the total growth if only gains in labor force education per worker are counted, or 42 percent if "advances in knowledge" relevant to production are also counted (Denison 1985). Estimates for Washington state derived from Denison's model suggest that education's contributions to growth via labor force education alone approximated half a billion dollars per year during the early 1980's (Stromsdorfer 1986). Recent studies that have attempted to pinpoint the impact of quality of education (mainly higher education) on earnings and economic growth have also found strong positive effects (Solmon 1985).

Not surprisingly, there is strong empirical evidence that firms place a high priority on proximity to academic institutions in their formation and location decisions (see especially Office of Technology Assessment 1984: 28-40, 56-57). This is particularly true for research and development-intensive facilities and is true to a considerable extent also for such desirable high-growth employers as technology-intensive production facilities (OTA 1984: 28-40) and high-wage "producer services" firms (Beyers et al 1986).[1]

Higher Education's Increased Importance in the "New International Economy"

As the data alluded to above suggest, the U.S. and Washington economies are changing rapidly in ways that make postsecondary education even more central to economic growth than it has been in the past. This country is losing or has lost its comparative advantage (roughly speaking, its competitiveness relative to other producing nations) in many manufacturing activities just as most business activities (including both production and marketing aspects) have become more

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[1]On the last category, see especially Beyers et al's 1985 and 1986 survey data on the Puget Sound region. Their analysis shows the producer services industry group to be a critical engine of the region's recent and future economic growth -- producing a high percentage of all Puget Sound region job growth during the 1970's and 80's (Beyers et al 1985: 1-9) -- and one closely tied to higher education. Since these firms have much higher proportions of their work force in professional, technical and managerial occupations than do manufacturing firms (roughly 43 percent versus 11 percent), they require educated workers and continuing education opportunities for them in order to grow, and are very concerned about education quality (Beyers et al 1986: iii, xi-xiii). The "producers services" industry group is defined as firms providing services to other firms or government and includes finance, insurance and real estate firms; architecture and engineering firms; law, accounting, management and computer/information systems consulting firms; health, education and training services; research, development and testing services; and transportation, communications and utilities services; as well as various specialized and miscellaneous business services.

internationally competitive. Interregional competition within the U.S. for markets and jobs has increased as well for much the same reasons. At the same time, the rate of technological change in many products and services and in processes for providing them (e.g., computerization) has accelerated sharply. These conditions create both a challenge and an opportunity for the U.S. and for Washington, proportionally the nation's largest exporting state. The state's competitive niche in the "new international economy" is almost certain to lie increasingly in providing the R&D behind new processes, products and services and their initial production and marketing, and less than in the past in long-term, large-scale production of established products using established technologies. In the increasingly competitive world economy these types of production activities are continuing to show a tendency to migrate to low-cost regions of the nation and world.[2]

In such an internationalized, technology-oriented and rapidly-changing economic environment high-quality colleges, universities and technical training institutions take on a new level of importance. Not only are they the source of the initial education and training of key components of the higher-quality work force successful firms need in the competitive new economy,[3] but they must also be prepared to provide the increasingly necessary continuing education and

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[2]Resource-based industries and manufacturing of products heavily dependent on local raw materials and/or local markets are less prone to these pressures, but even they face incentives to become more productive lest lower-cost competition from other regions and nations erode their established markets.

[3]A surprisingly large component of this work force consists of entrepreneurs (firm founders) themselves. This is so because new firm formations are so important in the new economy and new firms tend to be small (see Beyers 1986; Birch 1986).

retraining required by a skilled work force that needs to be at, or at least able to cope with, the cutting edge of change. This applies to regions of the state seeking to diversify a narrow economic base or to revitalize via new technology traditional industries where markets have become more competitive, as well as to the already technology-intensive regions.

Contributions of Higher Education to Economic Development Via Research and Technological Equipment and Expertise

The increasingly important role of high-quality postsecondary education and training to Washington's long-term economic future now holds the attention of the state's opinion leaders and policymakers. The education and training of students is the role played by academic institutions that is best known and understood by them. But there are other important roles these institutions play, or could play, that are directly related to Washington's economic development. These are distinct from the education and training role, although closely related to it. It is an important purpose of this report to help explicate these other economic development roles of academic institutions for the benefit of state policymakers as well as to suggest actions to enhance the institutions' performance in them. The economic development roles on which we will focus here are those that do or could grow out of the research capability and scientific, technological and management-related expertise present on the state's campuses. First, these capabilities and their links and potential links to industry and business need to be outlined.

At the outset, the economic importance of the sheer quantity of federal research dollars brought into Washington by the state's institutions of higher education, largely but not exclusively by the University of Washington[4] and Washington State University, should be recognized. This sum was in the neighborhood of $150 million in FY1984. Since this is purchasing power that would not otherwise be present in the state and it has a substantial multiplier effect in terms of creating demand for goods and services produced in the region (and for labor), it is a very important part of the state's economic base. Moreover, this already productive resource can be made significantly more productive for the state in ways we shall detail later.

Research and technology-driven links between academic institutions and industry are increasingly important in the new economy if academic research is to be of maximum value to industry and rapidly utilized to improve processes, products and services. As is true in most other states, Washington's universities and firms have increased, and even institutionalized, their interactions in recent years. The four-year institutions have prepared an inventory (appended to this report) including a number of kinds of links with industry, many of which have been developed within the last few years as firms and universities have seen that they have more and more common interests. Perhaps the best available single indicator of the increased industrial interest is the recent trend in industrial support of

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[4]The University of Washington ranked fourth among the nation's universities in FY1984 in federal research awards. It was the only public university receiving more federal than state funds in that year, suggesting a powerful economic leverage effect from the state funds spent on the campus (in particular from that part of the university's state budget base that keeps it at least nearly competitive with other research universities competing for the same grants and grant-seekers).

university research, which has grown at the University of Washington from $7.2 million (3.5% of the total) to nearly $ 11 million (4.6% of the total) in just the last two years. At Washington State the proportion of industrial support has grown from 3.0% in FY1984 to 4.5% in FY1986.

Also of importance, faculty and other professional staff (and, to some extent, students) provide professional services, i.e., technical and/or management advice and assistance, to hundreds of Washington firms each year, though the exact amount and impact of this diverse activity is impossible to document at present. There are some formal, campus-based programs of business and, to a small extent, technical assistance (to be described more fully later), but much of the activity is informal or conducted outside the provider's university role entirely.[5] Thus, it isn't measured, much less coordinated or systematically evaluated.

In addition, colleges and universities have valuable scientific and technical facilities and equipment, not all of which is utilized by campus users all of the time. At the same time firms, especially but not exclusively small, technically-oriented companies with limited resources but significant growth potential, have need of such facilities and equipment which they are often unable to purchase for themselves. Leanly-funded universities could obtain revenue from charges for use of such facilities for many purposes, including desirable maintenance and updating of the facilities themselves. Again, it is not known how much of this

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[5]University policies typically permit faculty and other academic personnel to spend up to one day per seven day week in "outside professional activities," including consulting for compensation. Personnel are supposed to clear such activities before the fact with their administrative superiors but no policy-relevant information seems to be compiled from these records.

kind of mutually beneficial utilization of existing resources occurs now since no one seems to organize or keep track of it centrally.

Thus, science and technology-based firms, and to some extent firms in traditional resource-based or manufacturing industries who seek to use new technology to improve productivity, have reason to favor locations near campuses not only for the formal educational opportunities they provide but also for the proximity to research and technical expertise they afford. Not surprisingly, this is most strongly the case with respect to location of R&D facilities, but industrial location decisionmakers also find proximity to quality academic institutions desirable for manufacturing facilities. Indeed, the presence of such an academic institution seems to be a key ingredient in the transformation of regions with substantial high-technology production plants but little if any dedicated R&D facilities into "seedbeds" of innovation (Office of Technology Assessment 1984: 28-40, 53-69). This is significant because it is the R&D facilities that tend to produce rapid growth via spinoffs and new start-ups as well as rapid growth of existing firms, while branch-plant production facilities of high-technology firms have shown a tendency to be "footloose", i.e., quite ready to move when cost advantages shift.

The value to such firms of proximity to academic research may require some elucidation. Such proximity can provide a firm with a "window" on academic research in fields of interest to it. In addition, close ties to university departments or research institutes provide firms with access to faculty as

research performers and consultants and to students as potential employees. Institutions and departments, as well as firms, can do more or less to promote and institutionalize such relationships via such mechanisms as those illustrated in the Council of Presidents inventory (appendix).

However, to the extent that a state or region's economic development strategy is built upon attracting existing technology-intensive firms to the area, it is likely to find this a very competitive market in which it is now becoming costly to compete successfully. North Carolina's "Research Triangle" area (a geographic zone of considerable size including three major research universities and the $50 million Research Triangle Institute) is often cited as a success story, but its success took many years to build from a unique initial base and it now represents a very strong competitor (and not the only one) for others seeking to emulate its accomplishments.

High-Technology As a Source of Employment Growth

A second model for substantial technology-based contributions by academe to regional economic development has fewer elements of a zero-sum competitive game. This model, while not ignoring the attraction of firms new to the area or service to established firms with technology-oriented needs, focuses most directly on creating the conditions to become a seedbed for technology-oriented business start-ups and rapid growth. The logic of this strategy derives from the proven employment growth potential of high-technology, especially from new firm formations and growth of small, independent firms, in recent years.

Brookings Institution researchers prepared a report for the federal Office of Technology Assessment on the formation and growth of high-technology firms, defined to include certain business services as well as manufacturing firms,[6] which is appended to the OTA report cited earlier (Armington, Harris and Odle 1984). They compare various indices of growth in high-technology, manufacturing and business services industries with growth in two other subgroupings: (1) "low-technology" manufacturing and business services; and (2) all other industries. Overall in the United States, they found that high-technology industries' employment grew by 19.4 percent over the 1976-80 period while employment in all industries grew by 15.2 percent. High-technology industries had an edge on this measure in all four of the regions into which they divided the country. In the West region, high-technology employment growth over this period was 29.3 percent, compared to a 26.7 percent job growth rate for all industries. For the Seattle Standard Metropolitan Statistical Area, the high-technology job growth rate (including the aircraft industry) was a remarkable 160.1 percent, compared to 41.7 percent for all industries (Armington et al: 116).

In terms of sources of employment growth, high-technology manufacturing and business services led low-technology industries in these same broad categories in both employment growth as a result of new firm formations and growth as a result

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[6]There is no fully standard methodology for defining "high-technology" industries. The Armington et al methodology is a composite of techniques based on the share of employees who are in scientific, engineering and technical occupations, and techniques based on R&D expenditures as a percentage of product value, with some special procedures for business services designed to focus on the truly "high-technology" group (Armington et al: 118-119).

of firm expansion in all four regions. Significantly, net employment growth among high-technology firms was fastest among independently-owned firms (37 percent for the U.S. as a whole over the period), then among local affiliates of companies headquartered in the same state (26 percent), followed by affiliates of out-of-state firms (18 percent), with owning establishments of multi-establishment enterprises growing slowest (8 percent). The fastest job growth rate of all (57 percent) occurred among independently-owned high-technology firms in the West, followed by such independents in the South (53 percent), with local affiliates of in-state firms in the West third (43 percent). Significantly also, among all industry groups employment growth was most rapid in the smallest category of firms (0-19 employees) and slowest in the largest category (100+ employees). High-technology firms with less than 20 employees were far and away the fastest growing subgroup with 70 percent job growth.

High-technology firms in Washington have also shown rapid employment growth in recent years. Using definitional criteria especially designed for Washington by the Washington High Technology Coordinating Board (1985b),[7] Figure 1 shows steady

[7]The following industries were classified in the high-technology group by the Washington High Technology Coordinating Board. Data on the number of companies and their employment in Washington as of September 1984 are given below. (Data are from High Technology Coordinating Board 1985b: 8).

SIC Code	Industry	Companies	Employment
281	Industrial Inorganic Chemicals	29	7,723
282	Plastics and Synthetics	7	218
283	Drugs	8	351
286	Industrial Organic Chemicals	12	407
287	Agricultural Chemicals	18	517
351	Engines and Turbines	13	161
357	Office and Computing Machines	23	4,900

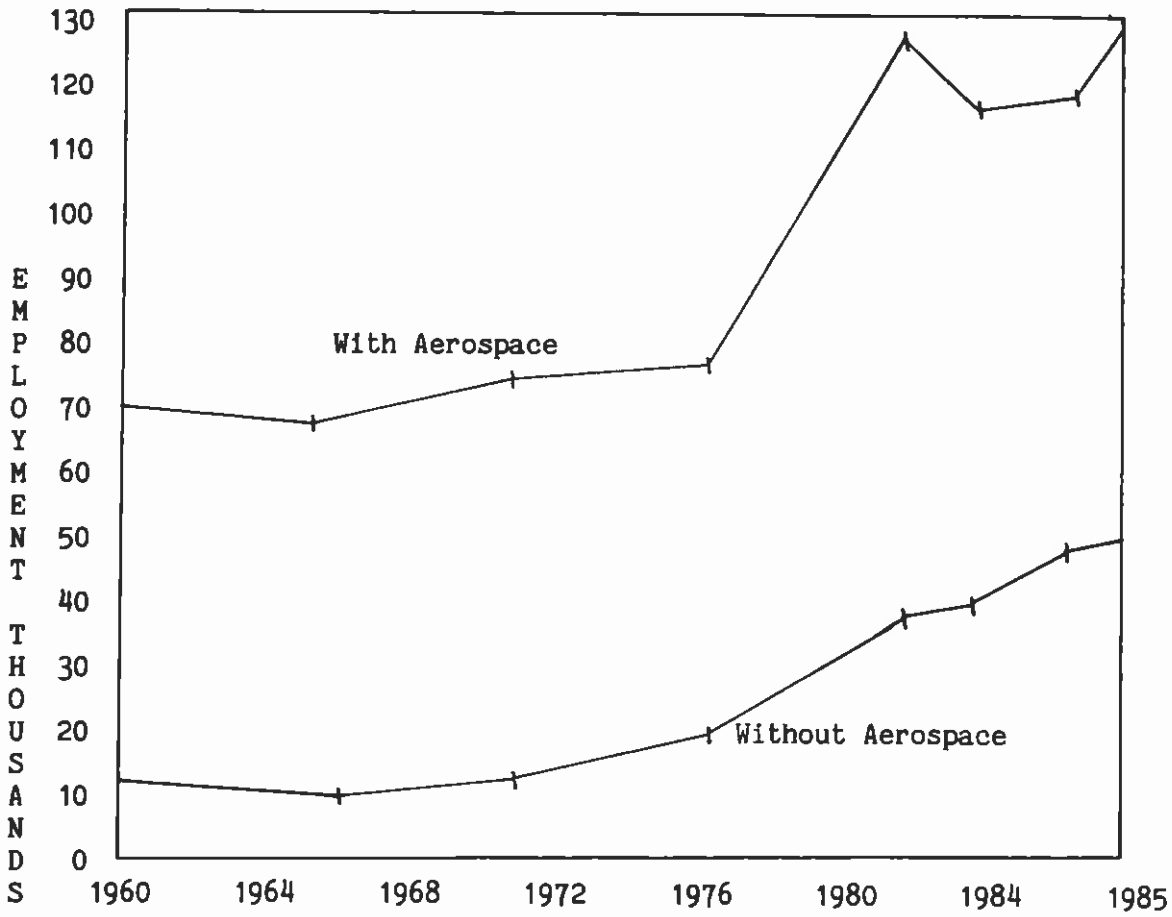
growth in high-technology employment (especially since 1975), if the aerospace industry is excluded. As is true elsewhere, many of Washington's high-technology industries (excluding aerospace) are dominated by small companies, including the important data processing, instruments and electronic components industries (HTCB 1985b: 7). On the positive side, Washington's high-technology industries are among its highest paying, even when the very-high-paying aerospace industry is excluded (HTCB 1985b: 16). On the other hand, this employment is highly concentrated in the King-Snohomish-Pierce and Clark County areas, though Benton County had nearly 13,000 high-technology jobs and Spokane County nearly 5,000 in late 1984. Of 121,000 total high-technology jobs in the state, only 4,000 were located outside the above six counties (HTCB 1985b: 13).

361	Electric Trans. & Dist. Equip.	22	490
362	Electrical Industrial Apparatus	18	366
365	Radio & TV Receiving Equipment	10	192
366	Communication Equipment	63	4,648
367	Electronic Components	103	4,377
369	Misc. Electrical Machinery	12	87
372	Aircraft and Parts	121	68,388
376	Missiles & Space Vehicles	NA	800*
381	Scientific Instruments	12	405
382	Measuring & Controlling Inst.	41	6,880
383	Optical Instruments	8	24
384	Medical & Dental Instruments	42	2,136
386	Photographic Equipment	8	213
737	Computer & Data Proc. Services	625	7,234
7391	R&D Laboratories	109	6,011
TOTAL HIGH TECHNOLOGY (w/ Aerospace)		1,304	116,528
TOTAL HIGH TECHNOLOGY (w/o Aerospace)		1,183	47,340

NOTES: NA denotes not available.
* denotes estimate.

SOURCE: Washington, Employment Security Department. Employment and Payrolls in Washington State, Third Quarter 1984, September 1985.

Figure 1. Employment in Washington High Technology Industries, 1960-1985



SOURCE: Washington Employment Security Department. Employment and Payrolls in Washington State, quarterly, as reported in High Technology Coordinating Board 1985:10.

The "high-end" services industries (i.e., producer services as defined above) in the Puget Sound Region studied by Beyers and his colleagues not only show steady employment growth in the past and a sharp increase in their contribution to the region's crucial export base over the last two decades, they project a 31 percent five year employment growth rate over the 1984-89 period (Beyers et al 1985: 112). This represents more than 26,000 jobs (when multiplier effects are included more than 65,000) among only the 1,103 firms Beyers and company interviewed. (These firms represented about 30 percent of total service sector employment in the region.) Not all of these firms are classified as high-technology, but many of them use computer and other rapidly-changing technology extensively, and they have important similarities to high-technology firms in terms of key workforce characteristics and requirements.

Vital academic institutions are by no means the only ingredient in the mix required to sustain a seedbed for new firm formations and growth, but they are universally acknowledged to be essential. New firms in high-technology fields and, to a lesser extent, producer services firms are often founded by technical specialists with university affiliations or very recent university experience, e.g., as university graduate students or researchers (Beyers et al 1986). Beyers' research shows that a large majority of the recently-established producer services firms in the Central Puget Sound region were located there because the founder lived in the region, had no wish to leave, and found the business climate (including, as a major consideration, access to universities and university people) attractive (Beyers et al 1985 and 1986). These founders usually did not seriously consider establishing their new businesses elsewhere; their real choice

was between establishing the new venture here or continuing to make their living by working for someone else in the same region. Access to appropriate educational institutions was clearly the most important factor in maintaining growth in this critical sector (Beyers 1986: ii-iii).

While we found no similar study of high-technology product firms in Washington, the literature suggests that their founders' decision processes are probably similar. The would-be entrepreneur -- often a recent university graduate, postdoctoral researcher or even faculty member -- could make a good living in a number of ways and would rather not leave the region; the question is whether he/she will view the economic climate and available support resources as adequate to start a new venture.[8] Analysis of the determinants of business formations and employment growth by Armington et al (1984) showed that "the quality of the labor supply and the pool of potential entrepreneurs, as measured by the proportion of workers using scientific and technical skills," were strongly related to high-technology business formations, much less so to firm start-ups in low-technology industries, and not at all to other business start-ups (Armington et al 1984: 133). The relationships were similar with respect to explaining net employment growth though less strong, apparently because so much of the employment base is in already-existing facilities (Armington et al 1984: 134).

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[8]Surprisingly for many of these new firms the size of the local market is not the primary consideration (Beyers et al 1985: 55). This is because both high-technology product firms and many producer services firms are heavily involved in "export" markets, i.e., sales outside the region (OTA 1984; Beyers 1985: v-vi). From an economic growth standpoint, such firms are especially desirable because their export sales bring <u>new</u> purchasing power into the region (Beyers 1985: 10-34).

Implications For Washington

Because they operate in fields where progress is rapid, the literature indicates new technology-based firms need university-generated research and knowledge and university-based consultants and educational opportunities (including conferences and informal sessions as well as formal courses and programs). Also among their most critical needs in the crucial early stages of their life are ready access to low-cost management (financing, marketing, planning, etc.) and technical help. These are areas in which academic institutions -- and not just the "research" universities -- could help more than they now do, as we shall explain in Section IV.

In a diverse state like Washington, it is also important that academically-linked economic development strategies not neglect potential contributions to the state's traditional resource-based, manufacturing and service firms. The Council of Presidents' inventory shows that many such links already exist at the four-year campuses (and there are additional ones involving the state's community colleges). One example is the Washington Technology Center's $750,000+ (approximate 1985-86 spending) plant biotechnology research program, involving both Washington State University and University of Washington researchers, which is aimed at both crop land and forest product technological development (Washington Technology Center 1986a: 19). Our examination of programs operating in other states with important "traditional" industries suggests that Washington's academic institutions could usefully play a larger direct role in helping to revitalize the state's existing industrial base.

In general, we were impressed during the course of our research with the level of activity in many other states in helping to forge and consolidate links between higher education and economic development and, in particular, with the number of program designs in use elsewhere that might serve as partial models for programs in Washington. Without being large in quantity, new state funds can serve as an important symbol of the state's commitment to working partnerships among academe. industry and government, and, if carefully targeted for incentive purposes and properly evaluated, can almost certainly substantially increase the level of economically productive activity undertaken by the two "operating" partners (institutions and firms). Data from a recent survey of cognizant university officials at its member institutions by the Association of American Universities strongly supports this position (AAU 1986), as does a wealth of more anecdotal evidence reported in the literature. We will provide specific examples in Section IV.

III. Possible Future Steps State Government Could Take to Try to Increase the Economic Returns from Higher Education

In the course of our research we thoroughly reviewed the outpouring of recent literature on higher education and economic development, as well as some of the related work on economic development generally. We also interviewed, mostly by telephone, or corresponded with scores of specialists and program administrators in the higher education and economic development business in Washington and around the nation. (See list of sources consulted.)

This search produced no shortage of plausible ideas as to what has been or might be done to increase higher education's connections to industry and economic development, though it is disappointingly short on evidence as to impacts in relation to costs and as to what works best where. To be fair, it should be noted that the field had been neglected for a long time and new initiatives have been in place only a short while.[9] Still, it is remarkable how limited the attention given to impact assessment has been, especially given that scarce state funds are often involved.

In any case, based on such expert assessments and theoretical perspectives as could be drawn from the literature and our interviews, we narrowed the field to some half a dozen categories of state initiatives that have at least some appeal for Washington. The two categories with the most immediate promise form the basis of the discussion in Section IV. The other four types that may merit some attention in the future are described briefly below along with their apparent attractions and potential drawbacks.

Selective State Subsidies for Customized Job Training

There are some attractive-looking operating models (though little rigorous evaluative data) in other states of programs that provide state subsidies selectively to firms who satisfy certain criteria for employee training and

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[9]The literature is clear on one point - that dramatic results in terms of jobs and economic growth from new investments will often take years to materialize. North Carolina's Research Triangle and Stanford's critical but long-developing impact on the emergence of the Silicon Valley are often cited to illustrate this point.

retraining (Arthur Young and Company 1985; Indiana Department of Commerce Undated). The providers are sometimes academic institutions, often community colleges or vocational-technical institutes, since these are the types of institutions most likely to be able and willing to provide job-specific training.[10] The criteria a firm must meet to qualify for subsidies typically involve a showing that, without the training, jobs would be lost to the state, either because the firm will not locate in the state or because, if already located there, will move to where trained workers are available or simply go out of business. While the precise criteria and machinery for choosing among applicants would need to be carefully thought out, reports from other states do at least suggest some reason for hope that useful results for the state's economy can be achieved without placing insupportable demands on the public fisc. In California, for example, the necessary funds are provided by a new tax on payroll which supplanted a cut in the state unemployment insurance fund's assessment on employers.

In several states, community colleges are reported to be quite aggressive purveyors of job training to local firms, and in Arizona and Illinois, at least, community-college-provided, state-subsidized job training is sometimes an important part of the package the state uses to attract new firms (Jaschik 1986). Washington's postsecondary institutions provide some contract training to local firms (State Board for Community College Education 1984) but the volume of

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[10]Four-year colleges and universities, however, might sometimes be appropriate providers for certain types of courses. In any case, the typical pattern is for the employer to select the provider, which need not be a postsecondary educational institution at all.

activity seems to be quite limited. Seven percent of the 1983-84 community college full-time-equivalent enrollment were supported through contracts. Given that preventing (as well as alleviating) unemployment is a high state priority and that other states provide job-training subsidies to firms that might otherwise stay or locate in Washington, this area of potentially increased higher education-economic development linkage would seem to merit additional attention.

Campus-based Business Incubators

Business "incubators" are programs -- usually but not always including contiguous physical facilities -- designed to help nurture small businesses through the early, high-risk stages of their development. While individual programs vary, the major ingredients are usually subsidized space, subsidized access to basic business services (clerical, accounting, legal, computing, etc.) and, often, access to specialized services appropriate to the particular industries or technologies in which the incubator specializes. Campus-based incubators typically specialize in nurturing new, technology-based firms, often including or even focusing on those "spun off" from the university's own research. (This is the basic idea of Washington State University's recently-established incubator facility. Those associated with community colleges in Washington are less clearly tied to academic research.) An important selling point for the campus-based incubators is proximity to the institution's facilities, to faculty and students as potential teachers, consultants and employees, and to its intellectually stimulating milieu generally.

As the proliferation of such incubators in recent years attests, this is a plausible concept. On the other hand, the idea of publicly-supported business incubators also has some problems. Constitutional or statutory considerations aside, public subsidies to some firms while excluding others are always hard to justify. (This also applies to customized job training, but the criteria that must be employed in the case of subsidies for infant businesses using innovative technologies -- long-term potential for profitability and employment growth in Washington -- are even harder to apply objectively.) Second, it is difficult to attract appropriate management talent -- often drawn from the ranks of experienced entrepreneurs with exciting alternative prospects on their own -- to run business incubators accountable to public authorities. Finally, though there appear to be at least a few apparent success stories at individual campuses,[11] overall it is eminently clear that high-technology-oriented incubators are in an inherently risky business where failure rates are inevitably high. Public policymakers must ask whether public funds should be put at risk in such ventures. The answer would seem to turn at least partly on the results of further investigation of the success of existing campus-based incubator facilities.

Publicly-Subsidized Research Parks

The attractions of proximity to a campus, especially to a research-oriented campus, for industrial R&D facilities should need no further elucidation at this

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[11]Georgia Tech and Rensselaer Polytechnic Institute (New York) have state-funded on-campus incubators that are reported to have produced, since 1980, 350 and 375 jobs and "graduated" 2 and 9 companies, respectively (Finholt 1985).

point. These facilities would, of course, bring with them jobs and other benefits, including potential manufacturing jobs arising out of R&D results. The main problem is that the attraction of R&D facilities has become a very competitive game, and, therefore, it is costly to play in it. To do so successfully today might well require state and/or government subsidies.

Only a few research parks based in or near university campuses have been in operation more than a decade, but some eighty are now in the operational or construction phase and a recent national meeting of the various types of parties interested in research park ventures attracted representatives from about 400 interested campuses. One has to wonder if university-based technology has become so important so rapidly to enough firms to soak up such rapid increases in campus-based research park space. At minimum, such an environment will require that successful competitors perform their assessments of their own strengths and weaknesses and the strategies necessary for success very thoroughly and objectively. Some undoubtedly will not realize satisfactory returns on their initial investments as is evidenced already by reports of space going begging in existing research parks. Washington policymakers should be able to benefit from the experience of Washington State University's new Research and Technology Park, which is attempting to get established with little or no direct public subsidy. This experiment should be watched with interest and the reasons for its outcome, success or otherwise, evaluated as the evidence emerges.

State Subsidies to Encourage University-Industry Cooperative Programs

By "cooperative programs" here we mean such arrangements as personnel exchanges between university faculties and industry, student internships in industry, and departmental "affiliate" programs and the like whereby firms contribute funds in return for priority access to a department's research laboratories, people and results. There is a considerable amount of some of these activities already (see the Council of Presidents inventory), but it is quite unevenly distributed among campuses and science and engineering fields. Undoubtedly, explicit state subsidies for such cooperative efforts could make such programs more attractive to both parties (e.g., by helping to fund development costs), and thus would increase the level of activity. The question is whether this ought to be done.

The literature does suggest that arrangements that increase interpersonal interactions between university and industry people can pay important dividends (see especially Doyle and Brisson 1985: 1-5). In some institutions and departments, a prevailing climate of academic isolation from industry has not been broken down. More, and more frequent, interpersonal contact and movement between the two milieux seem to be a necessary precursor of the kinds of formal, durable arrangements that can bring a department or research institute new resources, and firms and the economy the benefits of increased academic interest in problems with commercial potential.

The fact that some institutions and departments in appropriate fields have developed extensive contacts and cooperative programs with industry while others

have not does not necessarily indicate that the latter could not do so or that the state should wait for the parties to act on their own. As long as there are public benefits (better or cheaper products, employment growth) to be achieved that exceed costs to the state of the modest subsidies that would probably be needed to stimulate beneficial activities, the state is justified in providing help. Perhaps the primary targets should be departments or units with strength in seemingly appropriate fields but with very limited current contacts with industry. Perhaps the appropriate device is a competitive seed grant program requiring both success in an internal competition and success externally in attracting matching industry funds or services. Or perhaps direct support of "entrepreneurial" professional staff is a better bet if the basic problem is lack of such initiative or capacity at the unit level.

This area, then, seems to us a potentially promising one though a good deal of discipline-and institution-specific design work would clearly be necessary before a cost-effective program could be launched.

IV. Highest Priority Areas: (A) Augmenting Campus-based Technical and Management Assistance and (B) Strengthening Technology Transfer Programs

As indicated earlier and developed more fully below, these two high-priority program areas meet the criteria of demonstrated success potential and ready applicability in Washington. Indeed, the necessary operating structures for the types of initiatives we find promising in these areas are already largely in place on the state's public campuses.

A. Campus-based Technical and Management Assistance

College and university people, facilities and equipment can be of considerable value to Washington firms. Activities such as faculty and student consulting, faculty-administered student internships, and business seminars and short courses occur and are used by many types of small and large businesses. But can the State provide the modest wherewithal necessary for colleges and universities to bring more of their existing resources to the attention and disposal of a larger segment of business and industry? More importantly, can these resources be targeted especially to assist new or small firms, which we know are producing most new jobs and who often cannot find or afford on their own the management and/or technical assistance they need to grow?

We believe the colleges and universities in all parts of the state can increase and better target management and technical assistance to Washington firms if they are organized, staffed and provided with incentive to do so. Such help can be provided largely by better utilizing existing resources and need not detract from -- indeed it should add to -- institutions' performance of their central teaching and research missions. We will propose an approach for doing this but first we will describe two programs with features applicable in Washington that are operating successfully in other states and then describe what campus-based business assistance activities are already occurring here in Washington. This will provide the necessary context for the program elements we will then propose.

Models Operating in Other States

The literature we have reviewed provides lots of models. Again, rigorous evaluation is limited since most programs are relatively new but there are some examples of replicable models that are almost certainly more than paying for themselves. One of the older and most acclaimed examples is the Pennsylvania Technical Assistance Program, commonly known as PENNTAP. Begun in 1965, PENNTAP facilitates the transfer of technical, scientific, and engineering knowledge from the campus to any Pennsylvania firm requesting assistance. It is not a management consulting service though PENNTAP puts inquirers in contact with appropriate providers of management-oriented assistance. (In this paper, 'technical assistance' will refer to assistance that is of an engineering or scientific nature.)

PENNTAP is based at Pennsylvania State University, although any firm may contact PENNTAP through any of Penn State's Campus Continuing Education offices located throughout the state. There are no forms to be completed. The only information required in the initial contact is problem identification and a phone number or address for PENNTAP's response. A technical specialist will respond to discuss the client's problems and begin the technology transfer process -- the one-to-one exchange of information between the user and the specialist.

Of the fourteen PENNTAP employees, eight are highly-trained technical specialists and two are technical research librarians. Each has expertise in a particular

field, such as engineering and production, computer and electronic innovation, fire and safety, and energy. These specialists, who are housed in appropriate academic departments, are often able to offer immediately several suggestions in response to a request on the basis of their own background or experience. Otherwise, the specialist conducts a solution search, using the other PENNTAP specialists, Penn State or another institution's faculty or technical librarians, who conduct reference searches. Last year about 125 university faculty were used in various ways by PENNTAP. Many made trips for on-site evaluations. One outcome of this activity has been research grants and consulting contracts for faculty. Another result has been the donation of company equipment to the university.

Problems associated with computers have become the dominant type of problems among PENNTAP's request for assistance. The computer problems among the 1985 cases included applications problems as well as both hardware and software systems concerns. Other problem categories included chemicals, electronics, lasers, fibre optics, PC boards, chips and robotics. PENNTAP reports an increasing trend toward questions that are more technically sophisticated as more firms acquire advanced technologies in order to be competitive in today's business world. The other problem areas requiring technical assistance are shown in the table below.

Table 1

PENNTAP: 1985 Cases by Type of Client Problem

Problem Area	No. Cases	Percent of Total
Advanced Technology	208	20.0
Safety-Fire-Health	167	16.1
Energy	110	10.6
Productivity	98	9.5
Environment	91	8.8
Plant Maintenance/ Construction	70	6.7
New Business/Innovation	37	3.6
Regulations	14	1.3
Transportation	9	.9
Miscellaneous	234	22.5
TOTALS	1038	100.0

SOURCE: PENNTAP Update, 1986

PENNTAP offers its services to a variety of users with business/industry and engineering firms accounting for over half the cases in 1985. Entrepreneurs asking for help in engineering or scientific areas are a growing segment and were ten percent of the caseload in 1985. The table below breaks out the types of users requesting technical assistance.

Table 2

PENNTAP: 1985 Cases by Type of Client

Type	No. Cases	Percent of Total
Business/Industry/Eng.	570	55.0
Entrepreneurs (pending or very recent start-ups)	101	9.7
Government	129	12.4
Schools/Colleges	41	4.4
Other	197	18.9
TOTALS	1038	100.0

SOURCE: PENNTAP Update, 1986

PENNTAP has made efforts to evaluate its economic impact for the past fourteen years. Based on user surveys, known economic impacts (e.g., savings in cash outlays through production and product improvements, cost avoidance in terms of saved effort, operational efficiencies, and impact on the economy represented by induced capital investments in equipment and expansion) achieved through PENNTAP services in 1985 were estimated at $9.8 million. (This figure is based only on clients who responded to PENNTAP's survey; benefits attributable to nonrespondents are estimated conservatively at zero.) Users also credited PENNTAP with having an influence in creating forty new jobs and saving ninety in 1985. While a rigorous independent appraisal of PENNTAP's economic impact was unavailable and certainly beyond the scope of our study, it seems likely that the program more than justifies its cost to the state. The program's total cash budget for 1986 is $775,000 (although the Director says Penn State also pays indirect costs amounting to about $500,000). Of the budget, only $250,000 comes from the state general fund with much of the remainder coming from federal sources (Small Business Administration, Economic Development Administration, Department of Transportation). The response to PENNTAP by Pennsylvania firms seems to be enthusiastic. The program received more than 20,000 client inquiries in 1985, selecting 1,038 cases to handle itself and referring most of the others to other sources of assistance (a valuable service in itself).

PENNTAP is receiving much attention from outside Pennsylvania. Last year thirty states and fourteen countries visited to inquire about its operation. Ohio, Maryland, and Oklahoma recently have begun programs patterned after the PENNTAP model.

A newer and slightly different program is now underway in Michigan. The State Department of Commerce coordinates a technical assistance program called the Technology Transfer Network. Through a network of five technical and business specialists, each based at a different university (including campuses comparable to Washington's regional universities as well as at research institutions), companies have direct access to information about faculty expertise and university equipment that can help them solve technical problems. The objective is to give Michigan companies "front door" access to university resources. Each full-time campus-based specialist and the Department of Commerce are connected through a "computer conference network" called CONFER. Queries that cannot be answered quickly by the specialist are broadcast via computer to the other specialists for assistance. The Network offers the following types of assistance:

* identification of resources to solve a problem;
* direct assistance and technical problem-solving by faculty and researchers;
* testing or research using university equipment or facilities;
* possible joint research efforts;
* evaluation of current products, processes or technology;
* feasibility evaluations of new products or methods;
* access to technical literature, data bases and relevant research findings;
* information on technologies available for potential license;
* referrals for other business needs, including business assistance from state and local economic development agencies.

According to John Pearson, the Specialist at Michigan State University, each specialist works in depth on twenty five calls per month on average, spending typically between four and eight hours per query. The specialist's job is to find information that will solve the client's problem or a faculty person who can assist. This program is offered free of charge unless extensive assistance is required at which point a direct consulting or contractual arrangement may be developed with a consultant or university specialist. Besides accessing faculty knowledge, another goal is to increase the utilization of expensive, sophisticated campus equipment and have outside user fees help pay for repair and maintenance.

There are many more calls received that the specialist is not in a position to respond to directly. These calls are referred to other campus departments, to other universities who have the appropriate expertise but are not in the system and to private firms. Also, the Technology Transfer Network is promoted an as alternative resource for technical assistance, not as a competitor with private consultants. The program's rationale is that they are working in areas of need not being met by the private sector or that they are providing services to those who cannot afford the market price.

Half the cases that the Network itself tackles come from manufacturing companies, most of whom cannot afford to own the equipment or have on staff the expertise necessary to address all problems that arise in their operations. The specialists are hoping to elicit more inquiries from transitional companies-- those that are retooling to meet changing industrial needs -- of which there are

many in Michigan. The other half of the cases come from entrepreneurs involved with start-up companies and from government agencies. Some of the calls coming into the Network are management oriented. However, the Technology Transfer Network tries not to overlap the services offered by the Small Business Development Centers in Michigan, which concentrate on management assistance. Both groups cooperate by making referrals to the other. As is also the case with PENNTAP, the development of a good referral environment seems to be an important factor in the program's apparent success.

The state cost for the first year (1986) was $450,000, distributed evenly among the five campuses. This money leverages university funds; at Michigan State University, for example, the state allotment is matched two-for-one (mostly with in-kind contributions). There is a statewide governing body of university vice-presidents and the Commerce Department chief which decides on policy and broad operational matters. Advice comes from the Business Advisory Council, a group of 24 chief executive officers from Michigan business and industry. Future plans include the inclusion of all 15 public universities and the community college system (29 campuses), since each may offer some technical expertise not available at most other campuses.

Existing Programs in Washington

There are three campus-based management and technical assistance programs presently in operation in Washington. They are the Small Business Development Center, the Small Business Institute, and the Washington Technology Center's

Technical Assistance Program. We will describe each, giving attention to the type and extent of demand for their services and to how and what kind of college and university resources are used.

The Small Business Development Center (SBDC) program is a business outreach effort offering consulting and general management analysis services to new and small enterprises that cannot afford private consulting services. The federal Small Business Administration (SBA) funds the program with the requirement that the state provide a one-to-one match. State and federal support for the SBDC program in Washington reached $1.8 million in 1986. In 1985, the state's dollar-for-dollar "matching" share was $878,000, of which $523,000 represented a direct cash contribution. The SBA funding cap for Washington State is $1,170,000.

The Washington SBDC is based at Washington State University and operates out of nine subcenters, each having a Business Development Specialist, typically an MBA-holder with five years small business experience. Most of the assistance is management-oriented (e.g., business plans, marketing, financial analysis, loan assistance, and the like). Most of the requests for assistance come from persons with an idea for starting a company (not from companies already operating) and less than twenty percent come from existing manufacturing companies. On an informal basis, the Business Development Specialist may contact a faculty person at a university or a community college for assistance but that seems to be infrequent. (The SBDC has no data on the frequency of faculty involvement.)

The SBDC, through funding by the State's Department of Trade and Economic Development ($195,000 in 1985), acts as the State's small business assistance arm. Thus, the DTED refers all small business calls to the SBDC. This year the SBDC completed a microcomputer net. All counseling subcenters are connected via microcomputer with modem to the lead SBDC at WSU.

The Washington SBDC also operates an Innovation Assessment Program, located at WSU and at the Seattle SBDC office. About 100 potentially commercializable inventions are evaluated annually, with the aid of a computer program for technical literature searches at WSU.

Technical assistance requests from businesses form only a small part of the total of requests for assistance, with most clients seeking business management assistance. A "guesstimate" from SBDC is that less than ten percent of its requests are technically-oriented in the sense that scientific or engineering knowledge would be needed to respond. To respond to this type of request, the WSU office has developed a library research service to access both technical and management literature that can then be transmitted to a client. This research service is said to receive substantial use although that is not documented. For a fee, the SBDC research staff will conduct in-depth research directed by an experienced SBDC business researcher. All such original research efforts are reviewed and certified as meeting academic research standards by a faculty member of the WSU School of Business and Economics before publication. In regard to technical assistance of a scientific nature, the SBDC does not emphasize its availability in its brochures, thus probably limiting the actual demand for it.

The SBDC, a free service, seems to be responding to a large demand for management assistance. The Edmonds and Seattle subcenters have waiting lists. Unmet demand is thought to exist in areas of the state not currently served by an SBDC subcenter. Consequently, the SBDC is asking for additional state money to fund 20 more centers to operate in affiliation with community colleges but not on their campuses. The choice against on-campus locations is based on the belief that small business owners are uncomfortable about coming onto a college campus. According to the director, each proposed new center site has passed a "needs test" showing local business demand; this test included business surveys, studies of market needs and local economic conditions and the like.

Though the SBDC is associated with WSU and the community colleges, there is little evidence to show that university and college resources are being tapped in any systematic way other than those resources at WSU that are an integral part of the SBDC program. Furthermore, the proposed expansion of the SBDC is not designed to involve faculty or students in either a management or technical assistance role. Rather, it depends largely on specialized new employees to be hired to provide direct assistance to clients.

The Small Business Institute (SBI) program is expressly designed to draw upon existing campus resources. Funded solely by the SBA, this is supposed to be a comprehensive consulting program, involving both management and technical expertise, that matches undergraduate or graduate students, under faculty supervision, with local companies. The consulting teams meet with a client, analyze company problems, and formulate recommended solutions. At the end of the

term, students write up the case and present it to the faculty supervisor, SBA and client. If the results are satisfactory, the SBA reimburses the school $400 for each case and the students and faculty receive course or teaching credit. While it is SBA's intent for the program to offer technical as well as management assistance, in almost every instance in Washington this "course" is a business school offering. Engineering and other technically or scientifically-oriented departments have not participated on a regular basis.

The SBI seems to do well in Washington, with the colleges at times exceeding their quota of funded cases from the SBA and turning away potential clients. At the University of Washington, for example, the director of the campus SBI program claims the constraint on his program's size is not from limited business demand but from SBA funding and professor incentive to participate. The UW program was funded for 35 contracts in 1985, but, using school resources, performed some additional studies as well. Table 3, below, shows the distribution of SBA-supported consulting projects at Washington campuses in 1985.

A variation of the Small Business Institute has received state funding at Central Washington University. With a State Department of Community Development grant, the City of Ellensburg and CWU have begun a business management assistance program using CWU business school faculty and students. The objective is to offer longer-term management assistance to manufacturing firms in the Ellensburg area. It is felt that the SBA-funded SBI program idea, already perceived as a strong success, would be even more successful if it were not constrained to one academic term of service to a client.

Table 3
Small Business Institute
SBA-Funded Case Workload - 1985

University	No. of Cases
Seattle University	45
University of Washington	35
Eastern Washington University	31
Pacific Lutheran	24
Western Washington University	12
University of Puget Sound	10
Seattle Pacific	9
Central Washington University	9
Gonzaga	8
Washington State University	8
TOTAL	191

SOURCE: Cebe Wallace, Small Business Administration, Western Washington District Office

A third campus-based program is the Washington Technology Center's nascent Technical Assistance Program (TAP). TAP, still in the development stage,[12] is designed to provide technological expertise, scientific information, and consultation on existing and emerging technologies to small and medium-sized Washington companies. The ideal relationship envisioned by the Center is to match a world-class research scientist with the director of manufacturing at a technology-based firm in Washington State. WTC would like to respond to inquiries about product innovation possibilities, not so much to questions regarding the improvement of manufacturing processes. This focus represents the best fit with the Technology Center's primary orientation and research activities but leaves an important class of productivity-relevant needs unmet.

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[12]The idea for this program came from a series of unsolicited inquiries to the Technology Center from smaller businesses.

The actual technical assistance provided under the program is usually performed through a consulting contract between the prospective researcher/consultant and the interested company, administered through the TAP. Equipment in the WTC or elsewhere available on university campuses may be made accessible to industry for an appropriate use fee. However, the emphasis envisioned by WTC is definitely on utilizing more fully their own technologies and facilities.

As presently envisioned, the TAP would remain a small part of WTC's activities and would serve mostly a brokering function, matching a research scientist as a potential consultant with a technology-based company. To publicize this function, WTC is communicating with the state's Associate Development Organizations (part of the Team Washington concept) with the hope that these groups will screen and refer appropriate inquiries to the WTC. Thus WTC's TAP is evolving as a technical referral program whose client base is existing advanced technology companies seeking help in state-of-the-art technology research and application, primarily in regard to technologies already developed at the Center. Thus, it seems that a major part of the demand served by PENNTAP is not addressed in the WTC TAP model.

Summary: Needs Not Now Filled

We found some evidence of excess demand for current institution-based small business consulting services. Currently, the federally-funded Small Business Institute operates at its allowed maximum within the state. There is good evidence that there is much more student and small business interest. But the

program is constrained by lack of funding and, perhaps, by limited institutional support for such programs. As yet, the community colleges do not participate in the SBI program, although Pierce College has requested to join, if given SBA approval.

The Small Business Development Center is the major publicly-funded purveyor of small business assistance in Washington. SBDC's present request for expansion is based on business surveys that show excess demand for its management services, particularly in the geographical areas not now served by the SBDC. Its direction, however, is away from extensive utilization of campus resources and toward the use of professional business consultants. The thought is that business faculty do not have the time, inclination or the experience to offer effective management assistance to firms or entrepreneurs who are unable to afford consulting fees. We question whether this is an accurate assumption, especially if projects with educational value can involve students and earn teaching workload credit. Where credit is not appropriate, faculty (and/or students) might be willing to provide professional services inexpensively. A constraint on faculty consulting activities may well be institutional support for the effort, both moral and in such areas as marketing, coordination and overhead.

Both the SBI and SBDC programs concentrate almost exclusively on business management services. They no doubt provide some valuable services for new and existing small businesses that may be based on sound ideas but lack management expertise to be successful. As for affordable technical assistance, we have found through our investigation of programs operating in Washington State that

this service appears to be much less available and certainly is not provided through any formal, easily identifiable means. As technology becomes increasingly important to most businesses, service and manufacturing alike, the greatest need for additional State involvement may be in this area. The Washington Technology Center has already experienced unsolicited demand by business for technical and scientific assistance and is responding; but as noted above, WTC's assistance will necessarily be focused on new product development by advanced technology firms.

As with general business consulting, technical assistance can be delivered from many of the campuses in Washington, thus providing appropriate geographic distribution. Those campuses other than UW and WSU with engineering and other scientific and technology-based programs could certainly be involved, and the two research institutions could probably do considerably more in this field than they do now. What seems to be lacking at present is incentive and explicit organization for the purpose.

Key Design Elements For Successful Management and Technical Assistance Programs

In our view it would be quite feasible to establish a more comprehensive and cost-effective range of technical and management assistance services on Washington's campuses than now exists. This would more fully utilize the campuses' resources as well as providing educational benefits and enhancing the state's economic development. Our reading of the literature and precedents, and one of the authors' own experience with such programs, suggests a set of design

features which merit at least closer examination before establishing any such expanded program in Washington. In most cases, these features are not inconsistent with existing institutional structures and policies already in place. Of course, existing programs, personnel and organizational structures should be fully utilized and integrated into any broader statewide network or program that might be established.

The design features that our research suggests are important are summarized below.

* Technical and management assistance services (including use of campus facilities and equipment) should be integrated under a single administrative umbrella since many clients need both types of services and overhead costs can be cut this way.

* Effective publicity in the right places (i.e., local marketing) about the availability of the program and resources would be necessary in many locales in the state. This would take some resources. One theme would be to promote an expanded business assistance program as a "front door" to university resources generally.

* The program should be statewide in scope drawing upon all campuses with appropriate resources and interest (including community college campuses), but there is no obviously "right" lead agency or institution. The SBDC and SBI programs are feasible in Washington, and these and other states' approaches (e.g., Michigan's and Pennsylvania's) provide models for central coordination that could be explored. In any case, full-time professionals on all campuses should not be necessary, though each participating campus should have a vehicle (local phone number, referral plan, etc.) for soliciting and responding to local client inquiries. The central office would focus on helping to match clients with campus resources outside their local area, organizational and administrative assistance to campus offices, statewide publicity, quality control and documentation of impact. Another activity to be conducted by the central office and the on-campus contacts is an active referral service for other organizations, public and private, that provide assistance to businesses.

* Target firms need not be strictly limited, but highest priorities should be those with the best growth prospects and most need of unique campus resources (i.e., particularly technically-oriented product and service firms, at least in areas where these firms are numerous).

* In the interest of utilizing existing resources, keeping costs down and maintaining consistency with the educational mission, a key design element is to use faculty and students as much as possible in the actual delivery of services to clients. Thus full-time, nonfaculty professionals would function mainly in a marketing and coordinating role (i.e., soliciting clients and providers and matching the two), though in the interest of motivation and professional development they should probably also participate in client-service activities to some extent. Faculty can sometimes be paid in teaching workload credit and students in academic credit as in the SBI model. Where faculty or students must be paid, there are good reasons to believe that many will be willing to provide their services at effective costs well below the cost of supporting full-time professionals to provide most of the services. (Faculty may also be willing to provide some services in return for use of project materials in teaching or research.)

* Financial arrangements should subsidize target users without giving them free service (to reflect the mix of public and private benefits) and provide effective incentives to university units and people and their facilities and equipment to participate. Some "marketing" of the advantages of participation in the program to academic units and people would also be necessary, especially at the outset. The themes of such "marketing" should include emphasis on the educational and financial benefits for both students and faculty. For faculty the appropriate analogue may be medical school "professional practice plans" in which faculty are guaranteed access to clients without worrying about marketing and overhead, which are probably major deterrents to more consulting by faculty in other disciplines.

* Campuses and campus people are well-positioned to supplement state and fee support with outside (particularly federal) support, as the existing providers in Washington have already done to a considerable extent. Substantial federal support for activities of campus-based programs of management and technical assistance is available from SBA, the Economic Development Administration (EDA), and, probably, other sources (e.g., Department of Energy, OSHA, Department of Transportation, etc.).

* An up-to-date computerized data base about faculty/staff capabilities and facilities and equipment availability is a plausible idea, but its cost-effectiveness needs to be investigated since such data bases are known to be costly to design and keep up to date to meet client needs.

* The program should have an advisory board (probably with local campus boards) with representation from target firms and associations, local chambers of commerce and economic development agencies, as well as from participating academic institutions. Visibility, quality control and flexibility to provide customized services can be facilitated this way.

B. Enhancing Technology Transfer Efforts

"Technology transfer," as it is used here, refers to activities designed to increase the flow of research findings and technological developments from university experimental settings to commercially viable products and processes. This is socially desirable because it should lead to products and services that are better and cheaper than they otherwise would be, and thus to business enterprises that are more viable in the international economy and better able to provide jobs and incomes to the state's citizens. Broadly speaking, there are two avenues for increasing this flow of new technology from academe to the marketplace. First, we can take steps to increase the proportion of existing research results that are utilized (or at least considered) by industry and the speed with which they get considered. Second, it is possible to increase investments targeted at specific fields and projects with high commercial potential. In recent years, the State of Washington and its two research universities have invested modestly along both these avenues. As we shall now explain, the results to date have been promising.

Strengthening Campus Technology Transfer Offices

In the early 1980's the federal government liberalized its policies in regard to university patent and copyright rights and prerogatives on inventions and discoveries accomplished with federal grants. Since then the University of Washington and Washington State University, like most other research institutions, have taken steps to enhance their efforts to encourage faculty

inventions, patent and copyright applications on them, and commercial licensing of patented intellectual property. (Exclusive licenses, typically in return for royalties paid by the licensee to the university out of income from the new product, are usually thought necessary to induce firms to bear the costs and risks of product and market development.) As has been the trend nationwide (see Association of American Universities 1986), the two Washington universities liberalized their patent policies to provide for greater rewards to faculty inventors[13] and reduced their reliance on distant, often desultory contractors to market to potential licensees inventions that did occur. Also, the Washington universities followed the national trend by establishing formal, campus-based offices of technology transfer for the purpose of soliciting invention disclosures from faculty, assisting with patent and copyright applications, and dealing with potential licensees. (Some of the licensing activity is still handled by contractors, but a much lower proportion than in earlier years. Also the recently established Washington Research Foundation, UW's major contractor, is much more closely associated with the University and attuned to its needs and objectives than the University's earlier, New York-based partner.)

From the time it was formally established in 1983 until September 1986, the University of Washington's Office of Technology Transfer (OTT) employed two professionals (plus an administrative/clerical staff person shared with another unit), one of whom (the director) also served in the very demanding role of

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[13]The terms "faculty" and "invention" are used broadly here. "Inventions" should be construed to encompass discoveries and the creation of other licensable intellectual property such as computer software. Also, university-based inventors may be nonfaculty professionals or even students.

Assistant Provost for Research. The second professional person thus carried a great deal of the large workload associated with soliciting faculty invention disclosures, responding to inquiries, providing for assistance with complex patent filings in diverse fields, and soliciting and dealing with potential licensees. (A newly-added professional staff member will provide assistance with this workload, focusing especially on relations with faculty and outside firms.) The unit that performs the technology transfer function at Washington State University has just one professional staff member who also has other duties.

Table 4 compares the staffing and budget levels of the UW and WSU technology transfer offices in 1985 with these levels at universities with either comparable levels of research funding or membership on the Office of Financial Management's (OFM) list of peer institutions, and the capacity to supply us with reasonably comparable staffing and budget data by mail or telephone. (The reader should note the Technical Appendix to Table 4 and succeeding tables describing definitional differences and the like that render any conclusions that might be drawn from them less than fully definitive.) It is clear that the Washington universities' technology transfer offices are minimally staffed relative to the comparison research universities. Table 5 provides some indicators (for fiscal year 1985[14]) of the outputs from university R&D activity, indicators we would expect to also be related (at least in the long run) to expenditures for technology transfer. Again the Washington institutions rank quite low among their peers on all the output indicators. (See Appendix Table 5A for

[14]Data for two earlier years (1980 and 1982) comparable to that in Table 5 are presented in Appendix Table 5A.

confirmation that their standing was not much different in the other recent years for which we requested data.)

Table 4

Technology Transfer Input Indicators
At Washington Universities and Comparable Institutions

University	Federal R&D Support (FY84) $ (millions)	Rank	Tech. Transfer Employees (1985) $	Rank
(UW Comparison Group)				
Washington	137	3	2.3	6
U Cal System (Adjusted)	137	3	6.0	5
MIT	179	1	12.5	1
Stanford	160	2	12.5	1
Wisconsin	100	5	8.0	3
Michigan	95	6	7.0	4
North Carolina	48	7	2.0	7
Arizona	43	Data not collected by university.		
Oregon	12	8	<0.5	8
(WSU Comparison Group)	Total R&D (FY84)			
Washington State	60	1	1.0	4
Oregon State	60	1	2.0	2
U Cal System (Adjusted)	60	1	1.7	3
Michigan State	58	4	0.5	5
Iowa State	54	5	2.5	1

NOTE: Not all universities provided data, therefore rankings were only assigned to those who did. See Technical Appendix for qualifications regarding data collected from each university.

SOURCES: Campus and associated technology transfer officers; for federal R&D support: "FACT FILE", "The Chronicle of Higher Education", February 19, 1986.

Interviews with the technology transfer officials at the two Washington campuses (and comments on the Washington situation from knowledgeable officials at other institutions) tend to confirm the impression from the data that the technology transfer effort in this state is perhaps too modest in scale. There is good

reason to think that substantial additional support for technology transfer could be productively used in activities such as:

* arranging for the evaluation of new discoveries and inventions for patent or copyright potential;

* providing faculty inventors with more timely and complete advice and assistance with often highly-complex patent and copyright applications; this long and complex process is often a major deterrent to would-be faculty inventors and the technology transfer offices have been able to provide only limited help;

* systematically educating researchers about the potential financial benefits to them and their departments of working on and disclosing new inventions and processes, and about the help a better funded office of technology transfer could give with invention evaluation and patent filing;

* perhaps most important, marketing current inventions to potential licensees and maintaining more general contacts with firms with potential interest in lines of research that could, with industry support and encouragement, lead to inventions in the future; this is an area of activity, we were told, that has been especially undersupported in the past.

The relatively low-level of invention disclosures, patent filings, etc. in relation to research dollars[15] shown by Table 5 (following page 48) squares well with anecdotal reports that there is a potentially large pool of untapped possibilities for economically beneficial inventions in Washington's university communities, if it were only properly tapped and nurtured.

One might reasonably ask at this point whether there is reason to believe that the two Washington research universities would competently use increased support for technology transfer activities. If past performance trends are any guide (Table 6), we have reason to believe that they would. While there is inevitably some variability from year to year in frequencies when numbers are small, the overall trends seem to be positive.

Before leaving this topic, we should hasten to acknowledge that the types of "output" measures shown in Tables 5 and 6 are only intermediate indicators of the ultimate results the state seeks in supporting technology transfer activities. Ultimately, the goal is that inventions, patents, licenses and the like will lead

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[15]Two methodological points may be in order here. First, one might expect the output indicators to lag behind research dollars (i.e., to be affected by levels of research support) by more than the single year implied in Table 5. Perhaps so in some cases, e.g., with respect to licenses and royalty income. But since we are interested here in comparisons across institutions, this would only matter if the "standings" of universities in terms of research support varied much from year to year, which they do not. Second, one might seek to explain the relatively low rank of an institution, say the University of Washington, in terms of outputs per dollar of research support by its mix of invention-rich versus invention-poor fields relative to its peers. But the bulk of inventions, patents, etc. come from engineering and medical schools, where UW research in strong and well-funded like that of its peers. Washington State lacks a medical school, but so do half of the "comparable" institutions from which we were able to obtain data.

TABLE 5

TECHNOLOGY TRANSFER OUTPUT INDICATORS
FOR WASHINGTON UNIVERSITIES AND COMPARABLE INSTITUTIONS

UNIVERSITY	FEDERAL R&D SUPPORT (FY84) $ (millions)	RANK	INVENTION DISCLOSURES (1985) #	RANK	PATENT APPLICATIONS (1985) #	RANK	NEW LICENSES (1985) #	RANK	ROYALTY INCOME (1985) $ (000s)	RANK[a]
(UW COMPARISON GROUP)										
WASHINGTON	137	3	47	5	6	6	11	5	76	7
U CAL SYSTEM (ADJUSTED)	137	3	70	4	20	3	13	3	850	4
MIT	179	1	220	1	75	1	12	4	1800	3
STANFORD	160	2	133	2	42	2	31	1	5000	1
WISCONSIN	100	5	83	3	17	4	1	7	4500	2
MICHIGAN	95	6	45	6	13	5	20	2	581	5
NORTH CAROLINA	48	7	21	7	0	7	2	6	171	6
(WSU COMPARISON GROUP)	TOTAL R&D (FY84)									
WASHINGTON STATE	60	1	13	5	4	4	3	5	9	4
OREGON STATE	60	1	25	2	4	4	5	2	n.a.	n.a.
U CAL SYSTEM (ADJUSTED)	60	1	21	3	9	3	4	3	73	2
MICHIGAN STATE	58	4	17	4	11	2	4	3	2204	1
IOWA STATE	54	5	50	1	21	1	12	1	70	3

[a] Not all universities provided data, therefore rankings were only assigned to those who did.

See technical appendix for qualifications regarding data collected from each university.

Sources: Campus and associated technology transfer officers;

For federal R&D support: "FACT-FILE", "The Chronicle of Higher Education", February, 19, 1986

to commercially viable products, increased profits for Washington firms, and new jobs for Washington's citizens. As was indicated earlier, definitive data on such results are not easy to come by, partly because serious technology transfer efforts are quite new and would be expected to take time to lead to marketed

Table 6

Trends in Technology Transfer Input And
Output Indicators At The University of Washington
And Washington State University (Fiscal Years)

	Technology Transfer Employees				Patent Applications			
Institution	1980	1982	1985	1986	1980	1982	1985	1986
Univ. of Wash.	0.5	0.5	2.3	2.3	5	10	6	18
Wash. State Univ.	.0	1.0	1.0	1.0	2	2	4	6

	New Licenses				Royalty Income ($000)			
	1980	1982	1985	1986	1980	1982	1985	1986
Univ. of Wash.	3	2	11	16	26	88	76	360
Wash. State Univ.	1	n/a	3	6	n/a	69	9	17

NOTE: See technical appendix for qualifications regarding data collected from each university.

SOURCE: Campus technology transfer officers.

products and jobs, and partly because no great priority is given to tracking paths to results. (Resources for technology transfer activities are, as we have pointed out, already heavily taxed.) We were however able to put together a suggestive (but undoubtedly incomplete) list of Washington-based firms born, at least primarily, from UW or WSU-based research, together with their 1985

employment and sales data (Table 7[16]). Of course, such a compilation takes no account of economic activity and jobs created at existing firms. It also may include activity and jobs not attributable to the university-based technology but instead to other product lines. Nonetheless, the table serves to document the claim that university research in Washington has in recent years led to significant new economic activity and employment.

The Washington Technology Center

In addition to the efforts just described to more expeditiously transfer technology already present on the campuses, the Washington Technology Center (WTC) provides a vehicle for increased investments in research on the state's campuses that has commercial potential.[17] Established in 1983 as part of the state's "high-technology initiative" of that year, WTC seeks to carefully target its research programs in fields and technologies that have potential economic significance, in particular significance for Washington. Its purposes include strengthening the universities' capabilities in these areas, as well as producing new technologies of immediate commercial interest.

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[16] In a few cases only data for an earlier year were available (see footnotes to table). Data on profits were unavailable on many of these companies, some of which are privately-held.

[17] The Center is based on the University of Washington campus. It also maintains facilities and substantial research programs at Washington State University. Other colleges and universities (including private institutions) are represented on the Center's board but as yet no projects involving them have been funded.

TABLE 7

PARTIAL LIST OF COMPANIES "SPUN OFF" FROM UNIVERSITY RESEARCH IN WASHINGTON

COMPANY	YEAR ESTABLISHED	LOCATION	PRODUCT OR SERVICE	UNIVERSITY RESEARCH BASE	EMPLOYMENT[a] 1985	GROSS SALES[a] $ (000s) 1985
ADVANCED TECHNOLOGY LABORATORIES (ATL)	1974	BELLEVUE	MANUFACTURES MEDICAL INSTRUMENTS	UW	925	195000[b]
BIOSONICS	1978	SEATTLE	MANUFACTURES SCIENTIFIC SONAR EQUIPMENT	UW	40	n.a.
GENETIC SYSTEMS CORP.	1980	SEATTLE	R&D/MANUFACTURE OF MEDICAL PRODUCTS	UW	200	3000[d]
IMMUNEX	1981	SEATTLE	R&D IN THE AREA OF IMMUNE REGULATION	UW	100	3000
INTERNATIONAL BIOMEDICS	1983	ISSAQUAH	MEDICAL INSTRUMENTS	UW	30	n.a.
LAWRENCE MEDICAL SYSTEMS	1980	REDMOND	MEDICAL ELECTRONICS	UW	20	750
METRIGUARD	1973	PULLMAN	TESTING DEVICES FOR FOREST PRODUCTS IND.	WSU	15	750
SCHWEITZER ENGINEERING LABS.	1982	PULLMAN	UTILITY INDUSTRY TESTING PRODUCTS	WSU	10	250
TERRA TECHNOLOGY	1973	REDMOND	MANUFACTURES GEOTECHNICAL INSTRUMENTATION	UW	50	3000
ZYMOGENETICS	1981	SEATTLE	R&D IN PROTEIN GENETICS	UW	65	3000
APPROXIMATE SUBTOTAL EXCLUDING PHYSIO-CONTROL					1455	208750
PHYSIO CONTROL	1959	REDMOND	MANUFACTURES CARDIAC DEFIBRILLATORS	UW	860	91000[c]
APPROXIMATE TOTAL					2315	299750
VERY NEW COMPANIES						
ANIMTECH USA		SPOKANE	EMBRYO SEXSOR TECHNOLOGY (AGRI-RESEARCH)	WSU		
CERETEK		SEATTLE	FOOD SCIENCE TECHNOLOGY	UW	Nonexistent or no data available for 1985.	
COMPOSITE WOE		SPOKANE	WOOD PRODUCTS TECHNOLOGY	WSU		
STIRLING ENGINE COMPANY		RICHLAND	TECHNOLOGY DEVELOPMENT OF STIRLING ENGINES	UW		

Notes:

a Some data are approximate (midpoints in a published range).

b ATL's gross sales are for 1983.

c Physio Control's gross sales are for 1984.

d Genetic Systems Corp. was sold for $341 million to Bristol-Meyers in 1985, indicating that gross sales does not fully capture the worth of a scientist-rich research and development firm.

Sources: "Advanced Techonology Directory," Puget Sound Economic Development Council, 1983, 1984.
"Advanced Technology in the Pacific Northwest," Quanin, Inc., Fall/Winter 1984-85, Fall 1985.

The Center seeks to carry ideas for new commercializable technologies through the "experimental proof of concept" stage, then to transfer the technology to industry for further development. Thus, as is appropriate for an academic enterprise, its projects typically have a longer time horizon to product development and somewhat higher risks than projects normally undertaken by industrial laboratories. Also, many of its projects are sufficiently generic to be of interest to more than one firm, a characteristic that also harmonizes well with the Center's effort to be a useful resource for small firms that cannot afford sophisticated in-house research capability. A very important part of the Center's strategy for accomplishing these ends is to "leverage" the state funds it receives with research funds from industry and the federal government. The idea is to both increase the amount of research that can be supported and tie the Center's programs more closely to industrial interests and needs.

If a program of technology-oriented research is to help a state's economy significantly, it must plan the use of its limited resources very carefully so as to target them at a limited number of specific fields where: (a) the state's institutions are strong relative to the competition or can be made so quickly at acceptable cost; and (b) there is substantial interest among locally-based firms, or strong prospects of attracting interested out-of-state firms to locate in the state in order to be close to the research site. If the program's dollars are spread too thinly across research fields or are spent in fields where other universities are far ahead, both the scientific and economic impact is likely to be limited. Also, such a program is likely to benefit from extensive input from industry as to what fields and projects are of interest to them. If industry

input is limited, the program may be too dominated by academic priorities[18] to be cost-effective in terms of economic payoff for the state.

The Washington Technology Center's initial and ongoing strategic planning processes seem to meet these desiderata. First, the Center's research programs are limited to seven areas[19] so as to permit the application of sufficient funds to each to establish a "critical mass" (Washington Technology Center 1986b: unpaginated). Although the Center's research program commenced well into the 1983-85 biennium, no program area received less than $33,000 in state funds during the biennium or less than $130,000 in total support (WTC 1986a: 15). In the current biennium (the first full one for the Center's research programs), no area is projected to receive less than $155,000 in state funds or $270,000 in total support. The lowest-funded program area is the computer systems and software program. Total expenditures in 1985-87 in all six of the other areas are projected to be well in excess of $1 million (see Table 8, following page 55). Significantly also, the Center's request for a large increase in state

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[18]Some observers have worried that priorities within academe and even academic freedom might be seriously compromised by too-extensive connections between universities and the private sector (see, for example, Nelkin and Nelson 1985). While there is little evidence as yet on the matter, what evidence there is certainly does not confirm the worst fears (Blumenthal et al, 1986). Indeed, it is relatively hopeful on some of the dimensions of concern, such as effects on faculty publication rates and attention to teaching and other university duties.

[19]The seven research program areas are:

* advanced materials technology
* computer systems and software technology
* gallium arsenide integrated circuits and integrated optics technology
* medical biotechnology
* microsensor technology
* plant biotechnology (WTC 1986a: 13)

operating support for the 1987-89 biennium contemplates no new research programs, but emphasizes building upon promising avenues in the existing areas. Also, the evolution of the Center's research plans and programs evidence attention to potentially fruitful interactions and complementarities across program areas, a willingness to redirect resources from less-to-more-promising research thrusts within the program areas (determined on both scientific grounds and by ability to attract industry support), and even to reorganize an entire program area.[20] The areas of research emphasis were initially selected by a process that included both extensive input from Washington industry[21] and an apparently thorough assessment of the comparative strengths of Washington's universities. Within the research areas identified by the Center's long-range planning process, proposals for individual projects are solicited each year from researchers on the campuses of the Center's participating universities. There is an internal scientific peer review process as well as review by advisory councils and a Research Committee with both industry and academic membership. Of course, ability to attract

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[20]The program area reorganized is the plant biotechnology program, created out of the original crop plant biotechnology program based at Washington State University and the forest products biotechnology program based at the University of Washington. Substantial redirection of effort has occurred in the computer systems and software technology program (toward computer-aided systems design), and, to a lesser extent, in the gallium arsenide circuits/optics technology program (WTC 1986a: 13-19, and interviews with Center leadership). Such programmatic redirection can, of course, be read as a sign of failure, but it should be emphasized that some initial misjudgments are inevitable in an enterprise such as this one. Probably most important in the long run is whether the mistakes that do occur are caught early and corrected.

[21]Fourteen of the Washington Technology Center's 25 board members are from industry. The Center's broad areas of research thrust are identified and researched by its Long Range Research Planning Committee (LRRPC), which also has strong industry representation. Every two years the LRRPC conducts an industry/university workshop to solicit input about research directions from representatives of interested companies. Some 200 people participated in the 1986 session (WTC 1986a: 13-14).

federal and industry support also provides both scientific and "market" tests. (Data on this dimension will be presented shortly.)

We can claim no expertise in the substantive fields of the Washington Technology Center's research, so we cannot judge its projects' scientific or commercial promise specifically. The Center does employ well-designed processes for strategic planning, and seems to have a clear sense that it cannot try to do everything at once. The Center leadership seems to be aware of the need for frequent assessments of progress and direction in the rapidly-changing, highly-competitive arenas in which it works. (It is significant in this connection that the Center has avoided hiring a large research staff with specific expertise, but instead hires personnel, largely students and faculty, on a project-by-project basis.) Finally, the Center's provisions for extensive and strategically-placed input from industry, as well as its solicitation of financial stakes from the private sector, provide some insurance against any takeover of the Center's programs by grandiose academic visions with little economic payoff for Washington. On the other hand, the Center's campus base and broad academic participation should help insure that the activities it supports are truly of a generic research nature, not merely product development or other work more appropriate for a company-funded laboratory.

Next, we turn our attention to more tangible indicators of WTC's progress toward state economic development goals. First, it is important to note that the Center has been in existence less than four years and that its key objectives necessarily have long time horizons. Building excellence in technology-oriented

fields, educating the next generation of leaders in such fields and creating new products and jobs are goals that take time to achieve. Nonetheless, it is important that preliminary progress indicators be developed and monitored in the meantime to guide those who must decide about commitments of resources. We will now examine the evidence from such indicators as have been developed by WTC or that we were able to construct from data it collects.

The best-documented in-progress indicator is also one of the most useful -- the level of other support "leveraged" by the State's support of the Center's research programs and operations. The Center's data on this, by program area, are reproduced as Table 8. Assuming the validity of the data, the Center's performance on this score is noteworthy. In the 1983-85 biennium, the State provided $1,377,000 in operating support and $1,468,000 in capital funds (not shown in Table) to the newly-established Center. In addition, the Center attracted $396,000 in federal awards and $1,963,000 in industry support (including a small amount of capital support) in its initial biennium. Thus, the ratio of <u>total</u> nonstate support to <u>total</u> reported State support was .83 (High Technology Coordinating Board 1985a and WTC 1986a: 15), while the ratio of <u>operating</u> support from nonstate sources to state support for operations (probably a better indicator, since capital facilities last many years) was about 1.61 (Washington Technology Center 1986a: 13).

Projections for operations expenditures for the 1985-87 biennium show industry and federal support of $8 million, compared to state support of $3.6 million, a ratio of projected nonstate to state funding of 2.22 to 1 (WTC 1986b). The ratio

TABLE 8

THE WASHINGTON TECHNOLOGY CENTER'S SUCCESS
IN LEVERAGING FUNDS
(Operating Funds Only; Thousands of Dollars)

	1983-85 BIENNIUM		1985-87 BIENNIUM			1987-89 BIENNIUM
	State Expenditures	Non-State Awards	State Allocation	Non-State Awards Year 1 Actual	Non-State Awards Year 2 Projected	BUDGET REQUEST (State Funds)
PHYSICAL SCIENCE AND ENGRG						
Microsensor Technology	457.8	840.5	600.0	604.3	698.1	1,092.9
Ga As IC/Optics Tech	106.8	374.8	350.0	859.9	1,223.4	1,141.9
Computer Systems/Software	82.0	50.0	154.8	39.7	75.1	1.008.3
Manufacturing Technology	46.0	335.9	550.0	318.2	367.5	826.8
Advanced Materials	33.0	564.3	516.1	3,959.0	4,852.4	2,156.6
Sub-Total	725.6	2,165.5	2,170.9	5,781.1	7,216.5	6,226.5
BIOTECHNOLOGY						
Medical Biotechnology	130.0	0.0	411.5	1,727.3	1,995.1	1,653.4
Plant Biotechnology	126.6	50.0	320.0	646.4	746.6	1,078.7
Sub-Total	256.6	50.0	731.5	2,373.7	2,741.7	2,732.1
EXPLORATORY RESEARCH PROJECTS	104.4	0.0.	127.6	36.2	41.8	450.0
TOTAL RESEARCH PROGRAM	1,086.6	2,215.5	3,030.0	8,191.0	10,000.0	9,408.6
TECHNOLOGY ASSISTANCE PROGRAM (TAP)	0.0	0.0	80.0	0.0	0.0	150.0
OPERATIONS	290.2	0.0	495.0	0.0	0.0	700.0
TOTAL OPERATING BUDGET	1,376.8	2,215.5	3,605.0	8,191.0	10,000.0	10,258.6

SOURCE: Washington Technology Center (1986a: 15).

of reported actual FY1986 expenditures from industry and federal sources to expenditures from state funds was even more favorable at 2.44 to 1. Put another way, just 29 percent of the Center's FY1986 expenditures were funded by the state, with industry providing 45 percent and federal agencies 26 percent. Projections for 1987-89 are speculative, but the Center foresees its request for $10.26 million in state funds leading to $21+ million in industry and federal awards. Of course, WTC is also requesting nearly $14.5 million in capital funds from the state.

In short, these data suggest that the Washington Technology Center has the ability to leverage its basic state support to attract other funds for its research programs. This is one test of both the scientific merit of the Center's research programs (particularly evidenced by the federal awards, most of which are based on rigorous peer review), and of their commercial promise as shown by the industrial support (though other explanations for generous early industrial support are not inconceivable). The federal dollars and the part of industry support that comes from out-of-state companies (or would otherwise be spent out-of-state by Washington firms) has immediate economic significance in that it brings new purchasing power and thus demand for labor into the state.

The distribution of WTC-reported industrial research grant and contract awards by firm and firm location over the period from the Center's inception to June 30, 1986 is shown in Table 9. Of the total of $6.437 million in industrial grants over this roughly three year period, $4.785 million (74 percent) came from firms with operations in Washington while $1.652 million (26 percent) came from out-of-

TABLE 9
BUSINESS INVESTMENTS+ (FY1983-86)
IN
THE WASHINGTON TECHNOLOGY CENTER
AT THE

UNIVERSITY OF WASHINGTON

SIC#	Company Investor	In-State Location	Research Grant & Contract Awards & Gifts to WTC	Company Employees in WA State
2834	Abbott Laboratories	(N. Chicago IL)	$ 59,712	---
3334	Aluminum Company of America (ALCOA) (Pittsburg, Penn)	Vancouver, Addy, Wenatchee	59,911	2,100
3679	Boeing Aerospace Company	Kent	263,752	17,000
3721	Boeing Commercial Airplane Company	Renton	467,114	37,000
3674	Boeing Electronics Company 3679	Seattle	797,686	2,600
3825	Chemfet Corporation	Bellevue	49,286	4
3679	Corning Medical and Scientific Company/ Corning Glass Works 3841, 3811	(Medfield, MA)	132,887	---
2411	Crown Zellerbach Corporation 2621, 2611 (San Francisco, CA)	Seattle, Bellevue, Cathlamet, Port Angeles Sekiu, Camas	92,500	2,700
7394	CSSI Corporation	(Sunnyvale, CA)	22,500	---
2834	Deseret, Incorporated/Warner-Lambert Co. 2831,3841	(Sandy, UT)	15,000	---
5081	Digital Equipment Corporation 7372	Bellevue	32,244	175
3841	E.I. DuPont de Nemours and Company	(Wilmington, DE)	210,753	---
3674	Fairchild Semiconductor Corporation/ Schlumberger Company (Cupertino, CA)	Puyallup, Bellevue Federal Way	15,000	650
3559	Flow Industries	Kent	12,500	250
3679	John Fluke Mfg. Co., Inc. 3825, 5065	Everett	100,000	2,800
8922	Genetic Systems Corporation	Seattle	19,247	250
7379	Hewlett-Packard Company 5081 (Palo Alto, CA)	Camas, Everett Spokane, Bellevue	134,638	2,750
3662	Honeywell Corporation 5063, 7391 (Minneapolis, MN)	Everett, Mercer Island Bellevue	25,000	1,265
5081	IBM Corporation 7379 (Armonk, NY)	Olympia, Seattle Spokane, Tacoma, Everett	2,128,912	950
7379	Intel Corporation (Santa Clara, CA)	Bellevue, Spokane	15,000	14
3842	Johnson & Johnson Company	(New Brunswick, NJ)	105,000	---

+not including federal awards

TABLE 9 (con't)

3662	Kureha Chemical Company Limited	(Tokyo, Japan)	10,000	---
3299	Martin Marietta Corporation	(Bethesda, MD)	72,760	---
3841	Physio Control Corporation 3693	Redmond	146,129	1,140
3825	Seattle Silicon Technology	Bellevue	39,823	80
3728	Sundstrand Data Control Inc./ Sundstrand Corporation	Redmond	7,000	1,500
3674	Sumitomo Chemical of Japan	(Osaka, Japan)	45,000	---
3573	Valid Logic Systems	Bellevue	146,250	10
0821	Weyerhaeuser Company 2611, 2421, 2411, 2611, 2653, 2654, 0851, 0811, 0821	Tacoma, Snoqualmie Falls, Raymond, Aberdeen, Chehalis, Enumclaw, Cosmopolis, Longview, Olympia, Union Gap, Vancouver, Kent, North Bend, Rochester, Sequim	91,924	>10,000

AT WASHINGTON STATE UNIVERSITY

SIC#	Company Investor	In-State Location	Research Grant & Contract Awards & Gifts to WTC	Company Employees in WA State
3721	Boeing Commercial Airplane Company	Renton	$ 60,608	37,000
3761	Boeing Military Airplane Company	Seattle	14,681	30,000
2881	Genentech, Incorporated	(San Francisco, CA)	506,436	---
3721	General Dynamics Corporation 3728	(St. Louis, MO)	89,529	---
2083	Great Western Malting Company/Penwest Ltd.	Vancouver	30,000	150
8071	Norden Labs Inc./ SmithKline Beckman Corporation	(Lincoln, NE)	380,604	---
2819	Allied Corporation/Allied-Signal Inc. (Morristown, NJ)	Vancouver, Tacoma Anacortes	5,000	40
3841	COBE Laboratories Incorporated 3825	(Denver, CO)	1,732	---
3679	John Fluke Mfg. Co., Inc. 3825, 5065	Everett	24,430	2,800
3531	PACCAR, Incorporated 3711	Bellevue, Seattle, Renton	6,000	2,750

+not including federal awards

TOTAL INDUSTRIAL AWARDS	FROM WASHINGTON FIRMS	FROM OUT-OF-STATE FIRMS
$6,436,548	$4,784,635 (74.3%)	$1,651,913 (25.7%)

SOURCE: Washington Technology Center (1986a: 6-7).

state firms. This last figure provides a crude measure of the volume of out-of-state industrial funds coming into the state as a result of WTC operations. Added to the Center's approximately $1.7 million in federal support over this period, the total of out-of-state funds attracted is nearly $2.4 million, compared to a total state investment over this period (including capital) of about $4.3 million.[22] Thus, out-of-state funds brought in come reasonably close to matching the state's roughly $2.8 million of operating support provided to the Center through FY1986.

Another useful type of indicator that the Center was doing useful work and would likely have a long-term impact on technology transfer to industry would be the number and level of involvement of various types of personnel (e.g., industry scientists and engineers, graduate students, faculty, etc.) in Center research projects. The Center's data on this are limited, but they do show a rapid growth in employed personnel from three full-time-equivalents in FY1984 to 74 in FY1986. Table 10 shows how these break down by types of personnel charged to the Center's budget, but does not give any indication of involvement by industry personnel.

The table shows that 17 regular faculty and 125 students (headcount) were involved with the Center in 1986, and no doubt a substantial fraction of these

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[22]We do not mean to imply by this analysis that investments by Washington firms in the Center's programs are not also valuable. They clearly are important in that they represent some evidence that in-state firms think the Center's work will be of value to them, which should eventually translate into new products, profits and jobs, many of which should be based in Washington. However, to the extent the funds these firms invest in WTC now would have been spent in Washington anyway, there is little or no immediate economic impact.

increased their awareness of industrial research interests and needs, and perhaps made enduring contacts with industry personnel, as a result. We have emphasized

Table 10

Washington Technology Center
FY1986 Employment by Type of Employee

	# of Persons	Equal to Full-time (FTE)
regular faculty	17	10
research faculty	5	4
research assistants (students)	63	34
classified staff	20	8
exempt staff	7	6
hourly staff (students)	62	12
TOTAL	174	74

SOURCE: Washington Technology Center (1986a: 13).

before that establishing such professional/personal networks across the two sectors seems to be a key factor in productive technology transfer programs. Thus, data on industry as well as academic personnel involvement would be a useful in-progress indicator of the Center's likely ultimate impact to collect and report regularly.

After just a bit more than three years, it is not realistic to expect even a technology-oriented research program like the Washington Technology Center to have created large numbers of new jobs as a result of its efforts. In most fields the time from the Center's "experimental proof of concept" stage through product and market development (not to mention financing) to active production for sale is likely to be anywhere from two or three to ten or more years. Still, to date the Center claims that its technology is directly responsible for 18 new

jobs (17 in the $15-30 per hour range), mostly jobs for scientists and design engineers (WTC, 1986a: 9).[23] These "early-stage" employees could, of course, be the precursors of many more and diverse types of workers if their product development efforts are successful.

Two companies account for most of these jobs. The companies are Seattle Silicon (located in Bellevue with offices in four other cities across the country) and Chemfet Corp., which moved to Bellevue in 1983 from Cleveland, Ohio. Seattle Silicon was founded in 1983 and produced its first product in 1985. It now employs 92, 10 of whom WTC claims are attributable to its technology. The firm projects 300 employees by 1988 (WTC 1986b). The company has provided the Center with $263,000 in support since 1984. Chemfet employs six people now. Its first product is expected to be ready for market in the first quarter of 1987, and it projects employment of 100 (WTC 1986b). Chemfet's founder is quoted as saying, "Without the WTC, we wouldn't be in Washington State. We'd be in Ohio or California" (WTC 1986b). It has invested $95,000 to date in WTC research, and final negotiations are underway for more than $500,000 in additional support.

These two early examples of the economic impact of WTC research certainly do not make the case for the Center by themselves. Unfortunately, the Center was not able to supply us with trend data on such useful intermediate indicators of impact as inventions, patent filings and the like, licenses negotiated and royalty income. WTC argues that these are not complete measures of the economic

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[23]The reader should note that we did not attempt to verify independently WTC's claims regarding employment generation.

potential of its activities, which is certainly true. However, they are useful and widely-accepted indicators and in-progress indicators are much needed when substantial investments from public authorities are requested in the name of promised large long-term benefits.

In summary then, at this stage the Washington Technology Center's economic impacts on the state already appear to be significant and the prospects for the future appear promising. Most significant, the Center's data indicate an ability to attract substantial funding from Washington firms as well as to bring out-of-state dollars into the state. The volume of industrial investment suggests that the private sector expects the Center's research to have commercial payoff, which is the first test of the appropriateness and potential of its research programs. These programs, however, must continue not only to attract new industry and federal dollars, but also to show increasingly concrete evidence that they are leading to job-creation and economic growth in Washington to merit continued state support. Also, the Center needs to give careful attention to ways in which it can more widely distribute its activities and impacts around the state. The developing Technology Assistance Program is one step in this direction but the Center might also consider broadening the geographic dispersion of its research activities and other such steps.[24]

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[24]Geographic balance among state-supported campus-based facilities has understandably been an important issue in other states with state-aided technology research programs. A few states have gone so far as to locate technology research facilities at campuses not usually thought of as major research centers. Useful evidence as to the results of such investments will not be in for some time yet. Perhaps it will not prove fruitful in terms of economic impacts to locate major technology research enterprises away from established research centers, in which case alternative economic development strategies for these other areas will surely need to be devised.

V. Summary and Conclusions

In this report we have sought to show how higher education is linked to economic development, how changes in technology and the world economy have tightened these links, and how higher education in Washington can increase its contributions to the state's economic growth. We found in the recent literature on the subject numerous examples and descriptions of a broad range of state-supported initiatives to foster economic development via new programs or activities on the state's campuses. A major problem in assessing the implications for Washington is that most of them have been in place only a short time and cannot yet be rigorously evaluated.

Nonetheless, based on such evidence as is available and our own assessment of this state's needs and resources we identified six types of state initiatives worthy of further attention. These are listed below.

1. Programs of campus-based technical and management assistance to business;
2. Programs to enhance and expedite technology transfer from university laboratories to marketable products, processes and services;
3. Subsidized job training provided by academic institutions and customized for employers who can show that, without the subsidized training, they would leave the state or not locate in the state;
4. A state-funded seed grant fund, with an industry matching requirement, designed to encourage university-industry cooperative projects on campuses and in departments where these "should" exist but do not;
5. Subsidized, campus-based business "incubators" designed to nurture embryonic companies in fields where the host campus has faculty strength and the facilities to help the company through its difficult early life stages;

6. Subsidized, campus-based research parks designed to attract firms with interest in access to university people and facilities.

Given limited resources, we focused primary attention on the first two categories above, though we provide a brief discussion of the other four types of programs and their attractions and potential drawbacks (Section III). The technical and management assistance and technology transfer categories were selected for closest study because both have shown signs of success in the field and because they are consistent with existing infrastructure and practice on Washington's campuses.

Campus-based Technical and Management Assistance

Our review supports the tentative conclusion that a fully coordinated, statewide (i.e., multi-campus) program of campus-based technical and management assistance to Washington firms would be worthwhile. Such a program should build upon the institutional base provided by the existing Small Business Development Centers (based at WSU and nine community college campuses), Small Business Institutes (now operating on a number of public and private campuses in Washington), and the Washington Technology Center's nascent Technology Assistance Program (TAP). Our conclusion on the need for an expanded, better-integrated program is tentative because the data on the true demand for the program, while suggestive, is "soft." Thus, we recommend an independent needs assessment be done before proceeding further.

Assuming this first step shows that such a program would have substantial benefits for the state, our research indicates that the following types of design elements should be strongly considered for inclusion in the final program design.

1. Provision of substantial technical (i.e., engineering, scientific, etc.) as well as management assistance under one umbrella program; some targeting of types of clients to be served to emphasize firms (such as small, technology-oriented manufacturing companies and producer services firms) with the greatest growth potential and need of university connections.

2. Primary use of faculty and students to provide services, in return for credit (teaching workload credit for faculty who supervise consultants, academic credit for students) in many cases, gratis or for fees where credit is not appropriate; full-time professional staff to serve mainly in a marketing and coordinating role (not primarily as service-providers), with each professional typically covering several campuses.

3. Assistance with grant-seeking (such as proposals to the federal Small Business Innovative Research program) should be a significant part of the service campus-based consultants would provide.

4. The program could encompass efforts to market rentals of campus-based equipment and facilities that are not now fully utilized on campus but too expensive for small firms to afford to purchase.

5. Clients would be required to pay a part of the cost of all services provided beyond the initial inquiry both to insure seriousness and to reflect the fact that benefits from the services are private as well as public.

6. The program should have local advisory councils including firms similar to the program's targets, other local business interests and economic development organizations, as well as campus representatives.

This type of program could be designed to cost in the neighborhood of $500,000-$750,000 per year statewide (including some state funds already budgeted for existing programs), based on the experience of other states.

Technology Transfer Programs

We examined two types of technology transfer programs on the state's research university campuses and found each of them performing well, although their economic impacts are limited by their modest funding. Our research indicates that the technology transfer offices at the University of Washington and Washington State University are doing a creditable job per dollar spent given their limited scale. The performance of UW and WSU on such proxy indicators of economic development potential as invention disclosures, patent applications, licenses awarded and royalty income is behind that of peers with comparable or even lower levels of research support. This strongly suggests that there is untapped economic development potential in Washington's campus research laboratories.

Second, the Washington Technology Center (WTC), the state's effort to direct a part of its academic research effort toward technologies with commercial promise, also qualifies as a promising vehicle for increasing the economic returns from the state's investments in higher-education. The Technology Center has been in existence only about three and a half years so evidence of long-term economic impact is necessarily limited. However, the large amount of external support brought in by the Center -- 45% of its FY1986 budget came from industry and 26% from federal grants and contracts, as against only 29% from the state--represents an endorsement of both the commercial promise and the scientific merit of the Center's research program. Further, our assessment of WTC's strategic planning processes and choices indicates that it appears to have made appropriate

choices about priorities, has taken the concerns of Washington industry appropriately into account, and is focusing its resources (including the new resources it is requesting) on a limited set of areas where the state's universities have demonstrated strength. However, the WTC should develop and report regularly for evaluation by State authorities indicators (such as those mentioned in the previous paragraph) of the economic development impact and potential of its work. The Center should also consider developing its programs of out-reach to areas of the state outside the vicinity of its installations on the two research university campuses. With these provisos, our conclusion is that the Washington Technology Center shows early promise of helping the state achieve some of its economic development goals.

Appendix Table 5A

TABLE 5 A

TECHNOLOGY TRANSFER OUTPUT INDICATORS
FOR WASHINGTON UNIVERSITIES AND COMPARABLE INSTITUTIONS

UNIVERSITY	FEDERAL R&D SUPPORT (FY84) $ (millions)	INVENTION DISCLOSURES			PATENT APPLICATIONS			NEW LICENSES			ROYALTY INCOME $ (000s)		
		1980	1982	1985	1980	1982	1985	1980	1982	1985	1980	1982	1985
(UW COMPARISON GROUP)													
WASHINGTON	137	25	21	47	5	10	6	3	2	11	26	88	76
U. CAL. SYSTEM (ADJUSTED)	137	70	per year ave.		28	per year ave.		13	per year ave.		325	575	850
MIT	179	220	per year ave.		55	65	75	12	per year ave.		2000	n.a.	1800
STANFORD	160	142	142	133	27	54	42	20	24	31	n.a.	2500	5000
WISCONSIN	100	72	75	83	30	18	17	10	5	1	n.a.	n.a.	4500
MICHIGAN	95	n.a	30	45	n.a.	n.a.	13	n.a.	n.a.	20	<220	518	581
NORTH CAROLINA	48	7	14	21	9	2	0	0	3	2	34	129	171
ARIZONA	43	Data not collected by university						Data not collected by university					
OREGON	12	0	1	1	0	0	0	0	0	0	Unknown		
(WSU COMPARISON GROUP)	TOTAL R& D (FY 84)												
WASHINGTON STATE	60	7	7	13	2	2	4	1	n.a.	3	n.a.	69	9
OREGON STATE	60	n.a.	n.a.	25	n.a.	n.a.	4	n.a.	n.a.	5	n.a.	n.a.	n.a.
U. CAL. SYSTEM (ADJUSTED)	60	21	per year ave.		9	per year ave.		4	per year ave.		28	49	73
MICHIGAN STATE	58	13	18	17	6	9	11	5	7	4	1071	1066	2204
IOWA STATE	54	48	52	50	19	35	21	n.a.	n.a.	12	52	33	70

TECHNICAL APPENDIX FOR TECHNOLOGY TRANSFER DATA TABLES (TABLES 4-6)

TECHNICAL APPENDIX FOR TECHNOLOGY TRANSFER DATA TABLES (Tables 4-6)

R&D SUPPORT: Some universities (e.g., MIT and Iowa State) receive millions of dollars in federal funds for special-purpose laboratories that are associated with the campus. These dollars are excluded from the reported federal research dollars in the tables because they produce very little commercial technology transfer activity. Washington State and its peers are compared on total rather than strictly federal research funding because nonfederal research dollars are a substantial part of their total research support, unlike for UW and its peers.

LICENSES: Copyrights are not included; thus, software "inventions," a growing area of on-campus activity, are not shown.

FISCAL YEAR: All institutions reported data on a July 1 - June 30 fiscal year basis except Michigan State University, the University of North Carolina and Stanford University, which reported on a calendar year basis.

IOWA STATE UNIVERSITY AND UNIVERSITY OF WISCONSIN: These two universities rely solely on private foundations legally independent of the university for the technology transfer function. The employee and budget data reported in the tables for these institutions come from the foundations. Entries for the other universities represent expenditures by the institutions themselves. These other institutions, including the Washington universities, rely on independent foundations or other contractors for some patenting and licensing functions, but, because of the diversity of these arrangements, we were unable to get comparable data on their personnel and total expenditures. Our best estimate is that the

personnel and expenditures as reported in the tables are at least roughly comparable across institutions.

MIT: Data are estimates from John Preston, MIT's technology transfer director, but are believed to be within five percent accuracy.

UNIVERSITY OF CALIFORNIA: Technology transfer operations within the nine-campus University of California system are largely centralized at systemwide headquarters in Berkeley, making valid comparisons using individual UC campuses impossible. The systemwide office was unable to provide us with data on their campus-level operations, so the figures reported in the table understate the number of employees and total expenditures on technology transfer. The adjustment of the University of California data referred to in the tables involved simply scaling the raw UC data (on both the input and output indicators) to take account of this multicampus system's much larger volume of R&D support as compared to either of the individual Washington campuses. For the comparison with the University of Washington (there are two UC campuses on the OFM list of UW peers), the gross UC figures were reduced by a factor (multiplier) equal to the fraction the University of Washington's federal R&D support in FY1984 represented of the University of California's federal support (i.e., $137 million/$490 million). Thus, the table shows UC's federal R&D support and technology transfer input and output indicators adjusted to the University of Washington's federal support level of $137 million. A comparable procedure was followed to compare Washington State University to the University of California system (which includes one OFM peer -- UC Davis), but, since WSU has a large proportion of nonfederal R&D support (the same is true for WSU's peers in this

table), its total R&D support was compared to UC's total support to derive the scaling factor (i.e., $60.5 million/approx. $700 million).

UNIVERSITY OF NORTH CAROLINA: Data on patent applications were not available, only on patents awarded. Thus, we estimated patent applications from the data on patents awarded by using the national average relationship between awards and applications from university-based filers.

UNIVERSITY OF ARIZONA: Virtually all technology transfer activities are contracted out to private firms. The university does not maintain the type of data we requested.

UNIVERSITY OF OREGON: The university does not have an engineering or a medical school; this helps explain the low level of federal research support.

WASHINGTON STATE UNIVERSITY: There is no formal technology transfer office; the one full-time employee performs the technology transfer activity on campus as well as performing other duties.

COUNCIL OF PRESIDENTS

A Partial List of Current Activities
Related to Economic Development at Each Four-Year
Public Institution

A Partial List of Current Activities Related to Economic Development at Each Four-Year Public Institution

UNIVERSITY OF WASHINGTON

Contact Person: Vice Provost Alvin L. Kwiram (after 1-1-87) (206) 543-6616

Economic Development Activity	For Information Call
• Joint University/Industry/Government Programs	
1. Aerospace and Energetics Research Program	(206) 543-6321
2. Brittle Materials Design Center	(206) 543-2613
3. Drug Studies and Clinical Trials	(206) 543-1060
4. Forest Products, Center for International Trade	(206) 543-2730
5. Grants and Contracts	(206) 543-4043
6. Institute for Public Policy & Management	(206) 543-0190
7. Internship and Cooperative Education Program	(206) 543-2410
8. School of Medicine - Funds for New Building & Remodeling of Existing Space (1981-86)	(206) 543-1060
9. The Placement Center	(206) 543-0535
10. Center for Process Analytical Chemistry	(206) 543-1655
11. "Partnership for Excellence"--A Proposal for Increased State Funding of Research at UW	(206) 543-5900
12. Products Marketed Commercially as Consequence of School of Medicine Research	(206) 543-1060
13. Puget Sound Maritime Industries Conference	(206) 461-7233
14. Washington State Transportation Center	(206) 545-2481
5. Very Large Scale Integrated Circuit Consortium	(206) 543-1695
16. Washington Technology Center	(206) 545-1920
17. Washington Sea Grant Program	(206) 543-6600
• Affiliate Programs	
18. Center for Study of Banking & Financial Markets	( )
19. Computer Science Affiliate Program	(206) 543-1695
20. Engineering Affiliates Program	(206) 543-0340
21. Forest Stand Management Cooperative	(206) 543-9527
22. Industrial Affiliates Program	(206) 545-2300
23. Research Programs between Biotechnology firms and UW School of Medicine	(206) 543-1060

24.	Oceanography: Joint Oceanographic Institutions	( )Wash DC
25.	Center for Retailing, Transportation, and Distribution Management	
26.	Small Business Institute	(206) 543-4452
27.	Wind Tunnel, F. K. Kirsten Aeronautical Laboratory	(206) 543-4398 (206) 543-0439

• High Tech Services

28.	Academic Computer Center	(206) 543-5970
29.	Botany Electromicroscopy Laboratory	(206) 543-7441
30.	Program in Coho Salmon Broodstock Development	(206) 543-6546
31.	Databank (Economic & Demographic Data Base)	(206) 543-8983
32.	Distiller's Dried Grains & Solubles, Utilization of	(206) 543-4281
33.	Electron Microprobe	(206) 543-2079
34.	Electron Spectrometer for Chemical Analysis	(206) 543-2250
35.	Fish Populations, Quantitative Methods for Assessing	(206) 543-1191
36.	Fishing: Foreign Fishing Observer Program	(206) 543-4650
37.	Forest Nutrition Research Project	(206) 543-9527
38.	Gamma Ray Irradiation Facility	(206) 543-4281
39.	Inductively Coupled Plasma Optical Emission Spectrometer	(206) 543-9544
40.	Marine Acoustics, Program in	(206) 543-1300
41.	Maritime Management & Policy Sciences, Program in	(206) 545-2430
42.	Materials Analysis Center	(206) 543-2557
43.	Microcomputer Support Group	(206) 543-0621
44.	NMR Laboratory	(206) 543-0730
45.	Nuclear Physics Laboratory	(206) 543-4080
46.	Nuclear Reactor Irradiation Services	(206) 543-4170
47.	Pacific Oyster Breeding Program	(206) 543-6546
48.	Pacific Oysters, Induction of Polyploidy in	(206) 543-6546
49.	Pacific Salmon, Induced Polyploidy & Gynogenesis in	(206) 543-6546
50.	Polar Science Research Programs	(206) 543-6613
51.	Polymeric Composites Laboratory	(206) 543-9371
52.	Radioanalysis Laboratory	(206) 543-4650
53.	Shipborne Sensor Systems	(206) 543-1300
54.	Structural Research Laboratory, Civil Engineering	(206) 543-6503
55.	Submarine Target Technology & Systems	(206) 543-1300
56.	Underwater Acoustic Systems	(206) 543-1300

• Technology Transfer

57.	Battelle Development Corporation	(Ohio
58.	Biotechnology and Bioinstrumentation Research	(206) 543-1060
59.	Major Area Industries which have Evolved from the Initiative of Researchers, School of Medicine	
60.	Office of Technology Transfer	(206) 543-1060
61.	Research Corporation	(206) 543-5900
62.	Washington Research Foundation	(Arizona (206) 633-3569

- Curricular Programs

63.	Architecture and Urban Planning, Undergraduate & Graduate Programs in	(206) 543-4180
64.	Asian Law Program	(206) 543-5643
65.	Basic Biomedical Sciences, Undergraduate & Graduate Programs in	(206) 543-1060
66.	Business Administration, Undergraduate & Graduate Programs in	(206) 543-4750
67.	Education, Undergraduate & Graduate Programs in	(206) 543-5390
68.	Educational Opportunity Program	(206) 543-6598
69.	Engineering, Undergraduate & Graduate Programs in	(206) 543-0340
70.	Forest Resources, Undergraduate & Graduate Programs in	(206) 543-2730
71.	Input/Output Study, Business Administration	(206) 543-4484
72.	International Studies, Henry M. Jackson School of	(206) 543-4370
73.	Laboratory Medicine, Undergraduate & Graduate Programs in	(206) 548-6151
74.	Medical Programs, Undergraduate & Graduate	(206) 543-1060
75.	Ocean and Fishery Sciences, Undergraduate & Graduate Programs in	(206) 543-6605
76.	Pacific Rim Project	(206) 545-1929

- Continuing Education

77.	Continuing Medical Education	(206) 543-1050
78.	Executive MBA Program	(206) 545-1333
79.	Executive Programs in Business Administration	(206) 543-8560
80.	Televised Instruction in Engineering	(206) 545-2242
81.	University Extension	(206) 543-2300

- Information Resources

82.	University of Washington Libraries	(206) 543-0242
83.	School of Public Health & Community Medicine	(206) 543-1144

- Information Packages Developed to Attract Out of State Industries

84.	Package for Chinese and Japanese Firms	(206) 543-7632
85.	Package for General Motors (Saturn Facility)	(206) 543-7632
86.	Package for Software Productivity Consortium	(206) 543-7632

- Public Relations

87.	Achievements Brochure	(206) 543-2580
88.	Economic Development Brochure (in process)	
89.	Examples of Research with Benefits to Society	(206) 543-2560
90.	Package for Health Sciences	(206) 543-3620
91.	Pacific Northwest Executive Magazine, School & Graduate School of Business Administration	(206) 543-1819

92.	Seattle/King County Economic Development Council Questionnaire	(206) 543-7632
93.	University Resources: AUW Consultant Directory	(206) 543-2560

WASHINGTON STATE UNIVERSITY

Contact Person: Dr. Robert V. Smith (509) 335-3535

Economic Development Activity	For Information Call
• Joint University/Industry/Government Programs	
1. Agricultural Research Center - Alternate Crops	(509) 335-3475
2. Agricultural Research Center - General Support of Agriculture	(509) 335-4563
3. Agricultural Research Center - Ground Water Quality	(509) 335 3475
4. Agricultural Research Center - Labor Intensive Enterprises	(509) 593-8506
5. Agricultural Research Center - Physiology of Bovine Reproduction	(509) 335-5521
6. Agricultural Research Center - Protection of the Public	(509) 335-4563
7. Agricultural Research Center - Quality for Sustained Economic Growth	(509) 335-4563
8. Agricultural Research Center - Reduced Tillage	(509) 335-4563
9. Agricultural Research Center - Use of Range Lands	(509) 335-6166
10. Agricultural Research Center - Water Use	(509) 335-4563
11. Agricultural Research Center - Wood Business	(509) 335-6166
12. Biomedical Biotechnology	(509) 335-6030
13. Communications Disorders Clinic	(509) 335-1509
14. Environmental Science & Regional Planning Programs	(509) 335-8536
15. Farm Financial Stress Management Workshops	County Extension Office
16. Human Relations Center	(509) 335-3587
17. IMPACT Center	(509) 335-6653
18. Laboratory Animal Resources Center	(509) 335-6246
19. Laboratory for Atmospheric Research	(509) 335-1526
20. Pharmacology/Toxicology Research	(509) 335-5622
21. Southwest Washington Joint Center for Education	(206) 699-0420
22. Water Research Center	(509) 335-5531
• Affiliate Programs	
23. Computer Aided Design and Analysis in Natural Sciences Laboratory	(509) 335-5322 or (509) 375-2653

24.	Hotel & Restaurant Administration	(509) 335-5766
25.	Nursing Education and Research	(509) 458-6107

- High Tech Services

26.	Bioprocessing Research Center	(509) 335-4332
27.	Health Research & Education Center, Spokane	(509) 335-4750
28.	Materials Research Center	(509) 335-5593
29.	Materials Science	(509) 335-4914
30.	Nuclear Radiation Center	(509) 335-8917
31.	Plant and Animal Biotechnology	(509) 335-4389
32.	Radiation Safety Office	(509) 335-8916
33.	Research and Technology Park	(509) 335-5526
34.	Space Manufacturing Research Center	(509) 335-3221
35.	Veterinary Field Disease Investigation Unit	(509) 335-0711
36.	Washington Animal Disease Diagnostic Laboratory	(509) 335-9696
37.	Wood Engineering Research Center	(509) 335-4916
		or (509) 375-2653

- Technology Transfer

38.	Electric Power Generation & Transmission Research Center	(509) 335-8148
39.	Fluid Sciences Research Center	(509) 335-8654

- Curricular Programs

40.	Undergraduate Engineering Programs	(509) 335-5593
41.	Washington Higher Education Telecommunications System	(509) 335-6511

- Continuing Education

42.	Conferences and Institutes	(509) 335-2946

- Information Resources

43.	Center for Northwest Anthropology	(509) 335-6681
44.	Division of Governmental Studies & Services	(509) 335-3329
45.	Drug Information Center	(509) 335-1402
46.	Humanities Research Center	(509) 335-6414
47.	KWSU Radio-Television Services	(509) 335-6511
48.	Office of Applied Energy Studies	(509) 335-8688
49.	Recreation and Leisure Studies	(509) 335-4593
50.	Social and Economic Sciences Research Center	(509) 335-1511
51.	Transportation Economic Analysis	(509) 335-6651
52.	Washington Archaeological Research Center	(509) 335-1530
53.	Washington State University Libraries	(509) 335-2691
54.	Washington State University Press	(509) 335-3518

- Information Packages Developed to Attract Out of State Industries

55. Small Business Development Center (509) 335-1576

- Public Relations

56. 4-H Youth Program County Extension Office

CENTRAL WASHINGTON UNIVERSITY

Contact Person: Lawrence A. Danton (509) 963-1955

Economic Development Activity	For Information Call
• Joint University/Industry/Government Programs	
1. Animal & Plant Identification Services	(509) 963-2731
2. Cardiographic Services	(509) 963-1188
3. Central Washington Archaeological Survey	(509) 963-3489
4. Chemical Analysis Laboratory	(509) 963-2811
5. Conference Center Services	(509) 963-1141
6. Demographic Data Analysis	(509) 963-3201
7. Ecological Surveys and Inventories	(509) 963-2731
8. Economic Analysis Services	(509) 963-2664
9. Foreign Language (Translation) Services	(509) 963-1218
10. Geographic Information Systems Laboratory	(509) 963-3489
11. Land Use Planning	(509) 963-1188
12. Mineral Identification Services	(509) 963-2701
13. Occupational Development Safety Center	(509) 963-3218
14. Resource Management Services	(509) 963-1188
15. Small Business Assistance Program	(509) 963-3339
16. Small Business Consultation Program	(509) 963-3339
17. Testing of Structural Services	(509) 963-1756
18. Water Testing Laboratory	(509) 963-3013
• Continuing Education & Training Programs for Business	
19. Accounting Continuing Education Seminars	(509) 963-3339
20. Computer Application Seminars	(509) 963-1504
21. Cooperative Education and Internships	(509) 963-2404
22. Employee Health-Wellness Seminars	(509) 963-1911
23. Leadership Training Programs	(509) 963-1504

24.	Master Craftsmen Seminars for Maintenance Engineers	(509) 963-1504
25.	Real Estate Training Programs	(509) 963-1504
26.	Stress Management Seminars	(509) 963-2611

- Library Resources

27.	Computerized Access to Washington Research and Regional Libraries	(509) 963-1541
28.	U.S. Federal Document/Map Depository Library	(509) 963-1541
29.	Washington State Document Depository Library	(509) 963-1541

EASTERN WASHINGTON UNIVERSITY

Contact Person: George Cole (509) 458-6237

Economic Development Activity	For Information Call

- Joint University/Industry/Government Programs

1.	Business and Economic Research Center	(509) 359-2491
2.	Center for Economic Education	(509) 359-2428
3.	Human Communications-Air Force Program	(509) 359-2275
4.	Institute for International Business Development	(509) 359-2455
5.	Institute of Korean-American Affairs	(509) 359-2270
6.	Institute for Urban and Local Studies	(509) 359-6916
7.	Labor Studies Program	(509) 359-2348
8.	Spokane Incubation Center	(509) 359-6219

- Affiliate Programs

9.	Academy Business Community	(509) 458-6337
10.	Community Service Center	(509) 359-7902
11.	Conference Center	(509) 359-2406
12.	Extended Programs	(509) 359-2351
13.	EWU 2000-Planning for the Future	(509) 359-6494
14.	Information Center	(509) 359-6346
15.	Instructional Media Center	(509) 359-2265
16.	Learning Skills Center	(509) 359-2487
17.	Northwest Institute for Advanced Study	(509) 359-2201
18.	Physical Therapy Program	(509) 359-6659
19.	Student Development Program	(509) 458-6417
20.	Speech & Hearing Clinic	(509) 359-2301
21.	Thailand Exchange	(509) 359-2412

- High Tech Services

22.	Advanced Professional Training in Biotechnology	(509) 359-7082
23.	Center for Technological Development	(509) 458-6244
24.	EWU Satellite Telecommunications System	(509) 458-6401
25.	Medical Technology Program	(509) 359-2866
26.	Technical Communications Program	(509) 359-2811

- Curricular Programs

27.	Biologicals for Teaching: A Regional Supply Source	(509) 359-7082
28.	Biology Graduate Program	(509) 359-2867
29.	Biology Teacher Upgrade	(509) 359-7082
30.	Biology Undergraduate Program	(509) 359-7001
31.	Business, School of/Graduate Program	(509) 359-2455
32.	Business, School of/Undergraduate Program	(509) 359-2455
33.	Creative Writing Program	(509) 359-7064
34.	English Language Institute	(509) 359-2481
35.	Health Education Program	(509) 359-2342
36.	HPEA Graduate Program	(509) 359-2342
37.	Intensive English Language Program	(509) 359-2481
38.	Intercollegiate Center for Nursing Education	(509) 458-6107
39.	Nursing	(509) 359-6079
40.	Pre-Medical Programs	(509) 359-2868
41.	Pre-Veterinarian	(509) 359-7049
42.	Public Administration, Graduate Program	(509) 359-6164

- Continuing Education

43.	Intercollegiate Center for Nursing Education	(509) 458-6107
44.	Social Work and Human Services	(509) 359-6480

- Information Resources

45.	Business Resource Center	(509) 458-6401
46.	Career Planning & Placement	(509) 359-2221
47.	CAREERS	(509) 458-6386
48.	Center for Economic Education	(509) 359-2428
49.	Center for Extended Learning	(509) 359-2402
50.	Center for Psychological Services	(509) 359-2366
51.	College Instruction Program	(509) 359-7021
52.	Community Service Center	(509) 359-7902

- Minority Programs

53.	Black Education Program	(509) 359-2205
54.	Chicano Education Program	(509) 359-2404

55.	International Student Program	(509) 359-2331
56.	Women's Programs	(509) 359-2361

- Social Programs

57.	Alcohol/Drug Studies Program	(509) 359-6154
58.	Inland Empire School of Social Work & Human Services	(509) 359-6480

- Research Programs

59.	Behavioral Medicine Research Program	(509) 359-7907
60.	Business & Economic Research Program	(509) 359-2443
61.	Primate Research Program	(509) 359-7907
62.	Robert Reid Laboratory School	(509) 359-2429

WESTERN WASHINGTON UNIVERSITY

Contact Person: Dr. Sam Kelly (206) 676-3170

Economic Development Activity	For Information Call

- Joint University/Industry/Government Programs

1.	Institute for Watershed Studies	(206) 676-3136
2.	Northwest Washington Industry Council (PIC)	(206) 676-3617
3.	Upper Skagit Social & Economic Study	(206) 676-
4.	Wildlife Toxicology Institute	(206) 676-3547
5.	Professional Development Programs	(206) 676-3014
6.	Center for Pacific Northwest Studies	(206) 676-3284
7.	Applied Research in Technology	(206) 676-3380

- Affiliate Programs

8.	Northwest Recreation Research Center	(206) 676-3782
9.	Health/Fitness Programs: Community, Small Business and Industry	(206) 676-3055
10.	Center for Economic and Business Research	(206) 676-3909
11.	Small Business Institute	(206) 676-3899
12.	Upward Bound	(206) 676-3100
13.	DSHS Training Programs	(206) 676-3220
14.	Center for Economic Education	(206) 676-3910
15.	Undergraduate Business & Accounting & MBA Programs	(206) 676-3898

• Technology Transfer

16.	Microcomputer Earthquake Mapping Project	(206) 676-3284
17.	An Engineering/Econometric Analysis of Seasonal Energy Demand & Conservation in Pacific Northwest	(206) 676-3910
18.	Evaluation of Production Capacity for Local Processing Centers in the NW Lumber & Plywood Industries	(206) 676-3190
19.	Research in Plastics Technology	(206) 676-3380
20.	Industrial Research & Development Projects in Automotive Technology	(206) 676-3380
21.	Natural Gas Fueled Engine Research	(206) 676-3045

• Curricular Programs

22.	Map Library	(206) 676-3272
23.	Canadian-American Studies & Research	(206) 676-3728
24.	Master of Science in Counseling	(206) 676-3516
25.	Industrial/Organizational Concentration of the Undergraduate Psychology Major	(206) 676-3516
26.	Masters of Education in School Counseling Psychology	(206) 676-3516
27.	Atlas of Washington	(206) 676-3284
28.	East Asian Studies Program	(206) 676-3480

• Continuing Education

29.	Student Interns	(206) 676-3105
30.	Whatcom County Real Estate Research Report	(206) 676-3910
31.	Foreign Studies and Faculty Exchange	(206) 676-3480

THE EVERGREEN STATE COLLEGE

Contact Person: Stan Marshburn (206) 866-6000x6116

Economic Development Activities		For Information Call
1.	Washington State Institute for Public Policy	(206) 866-6000x6380
2.	Master of Public Administration Program	(206) 866-6000x6385
3.	Master of Environmental Science Program	(206) 866-6000x6774
4.	Republic Leasing Business Symposium Project	(206) 866-6000x6870

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INTERVIEWS

NAME	AFFILIATION	DATE (ALL 1986)
*Lyle Anderson	State Director, Small Business Development Center	Oct
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Spencer Blalock	Technology Transfer Officer Iowa State University Research Foundation	Aug-Sept
Henry Bredeck	Technology Transfer Officer Michigan State University	Sept
Howard Bremer	Technology Transfer Officer Wisconsin Alumni Research Foundation	Aug-Sept
David Broome	Technology Transfer Officer University of North Carolina	Aug-Sept
*Ray Davidov	Director, Small Business Institute University of Washington	July
Roger Detsell	Technology Transfer Officer University of California	Sept
*Crystal Dingler	Manager, Office of Technology Transfer University of Washington	July-Oct
*Dwight Dively	Policy Analyst, Washington State High Technology Coordinating Board	June
*Kirk Drumheller	Manager Industrial Programs, Battelle Pacific Northwest Laboratories	Sept
Jerry Ellis	Business and Government Relations Director Department of Trade and Economic Development	Aug
Fred Erbisch	Technology Transfer Officer Michigan Technological University	Oct
Wayne Fairburn	Chairman, Business Administration Central Washington University	Sept
*Richard Finholt	Director, Ohio State University's University Research Park	Sept
*Ronald Fowler	Small Business Assistance Programs Coordinator, Washington State Board for Community College Education	Oct

Becky French	Technology Transfer Officer North Carolina State University	Sept
Robert Gavin	Technology Transfer Officer University of Michigan	Sept-Oct
Robert Hester	Administrator, Small Business Institute for Seattle's Community Colleges	Sept
Sally Hinds	Technology Transfer Officer Stanford University	Aug-Sept
William Hostetler	Patent, Trademark, Copyright Officer Washington State University	Sept-Oct
Eric Johnsen	Executive Director, Central Puget Sound Economic Development District	Sept
Jack Johnson	Technology Transfer Officer University of Arizona	Sept
Megan Jones	Director, Massachusetts Centers of Excellence Corp.	June
*Lesley Larson	Acting Director, Washington Research Foundation	July
H. LeRoy Marlow	Director, Pennsylvania Technical Assistance Program	Aug-Sept
Bob McQuate	Technology Transfer Officer University of Oregon	Oct
John Moseley	Technology Transfer Officer University of Oregon	Sept-Oct
*Peter Odabashian	Director of External Affairs Washington Technology Center	Sept-Oct
John Pearson	Technology Transfer Network Director Michigan State University	Oct
Walter Plosila	Deputy Director, Pennsylvania Department of Commerce	June
John Preston	Technology Transfer Officer Massachusetts Institute of Technology	Aug
Sky Records	Assistant Regional Administrator for Business Development, U.S. Small Business Administration	Oct

Carol Riesenberg	Research Coordinator, Small Business Development Center	Sept
Robert Roseth	Director, Information Services University of Washington	Oct
Eric Rude	Dean of Research, University of Wisconsin	Oct
Kim Smith	Technology Transfer Officer Oregon State University	Sept
*Edwin Stear	Executive Director, The Washington Technology Center	Sept
Harriet Stevenson	Director, Small Business Institute Seattle University	Nov
William Stimson	Information Officer Washington State University	Oct
Roger Tollefson	Director, Pennsylvania's Ben Franklin Partnership	Sept
Bill Tompkin	Arizona Department of Commerce	July
*Robert Waldo	Executive Director Council of Presidents	Nov-Dec
Cebe Wallace	Management Assistance Officer, Seattle Office, U.S. Small Business Administration	Oct
Jim Wills	Grant and Research Development Officer Washington State University	Sept-Oct
Holly Zanville	Vice Chancellor, Oregon State System of Higher Education	Aug

*.Personal Interview; others are phone interviews.