A County Level Analysis of California's R&D Activity 1993-1999*

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April, 2002

* *Funding for this study was provided by the California Technology, Trade and Commerce Agency's Division of Science, Technology & Innovation. Additional support was provided by the San Diego Regional Technology Alliance.*
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ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support of the California Technology, Trade and Commerce Agency's Division of Science, Technology and Innovation and the San Diego Regional Technology Alliance for their financial support of this project.

The authors would also like to thank Donna Fossum of The Rand Corporation for numerous discussions and her willingness to share with us her accumulated experience, wisdom and insights about the RaDiUS database. We would also like to thank Brian Jackson of The Rand Corporation for his assistance in tracing down some technical issues with the RaDiUS database.

C.L. would like to thank Diann Swieda in the UCSD Office of Contracts and Grants for her assistance at a critical point in this project.

EXECUTIVE SUMMARY

Throughout the twentieth century, federally funded technology development has been contributing to the growth of the California economy. The early twentieth century development of the aerospace and agricultural industries was fueled by federally sponsored research. Research in physics, computer science, electrical engineering and defense related technologies in the post World War II era gave rise to whole new industries across the state. More recently, federal funding for life science and advanced computing has given rise to important industry clusters in biotech, medical devices and telecommunications. California is a leader in the size and diversity of its knowledge based industries both nationally and globally. It is the fifth largest economy in the world, and it is home to ten percent of the United States population. Because of its size and complexity, to truly to understand California, one needs to look in more detail at the distinctive regions of California. California is characterized by different topographies, different histories of migration and economic development and, as such, it represents a collection of distinct regional economies, which in combination, contribute significantly to California's national and global leadership position.

In recent decades, rapid changes in technology and global markets have given rise to an increased desire among policy makers and citizens to better understand where economies are heading, not just where they are today. One way to assess potential future scenarios is to have a more comprehensive understanding of the R&D activities, the "intellectual capital," within these distinct economic regions of the state. Because state and federal data reporting research activity tends to be at the state-wide or national level, it is very difficult to begin to aggregate this kind of data regionally. However, recently the Rand Corporation has developed a database, RaDiUS, which facilitates analyses of federally funded R&D activity on a more regional basis. This database does not include federal allocations for equipment and facilities but it does capture the lions' share of funding for R&D projects across the nation. The California funding totals in this report are based ***strictly*** on results from the RaDiUS database which is only one source of data on R&D funding to the states. The RAND Report: *Discovery and Innovation: Federal Research and Development Activities in the Fifty States, District of Columbia, and Puerto Rico* published in 2000 by Donna Fossum et al,[1] has included other databases not currently available to analysts outside Rand. The RaDiUS database reflects funds awarded directly for the conduct of research and excludes funding for infrastructure, equipment and facilities. Precise data on the latter is not currently available for regional analysis so there are some discrepancies between different reports on California's total R&D performance.

This is a first effort to examine the level and type of R&D activity within the state of California on a county-by-county basis utilizing the RaDiUS database, which is still under development by Rand. The data in this report reflects six years (1993-99) of unclassified research funding from seventeen federal agencies to all fifty-eight counties of California. Over this period, this database reports that California institutions secured $50.24 billion in unclassified federal research support. However, of the 22,665 California records for FY98 in RaDiUS that were analyzed in this study, approximately 3,600 records were blank and this prevented a full

[1] Donna Fossum, Lawrence S. Painter, Valerie Williams, Allison Yezril, Elaine Newton, and David Trinkle, *Discovery and Innovation: Federal Research and Development Activities in the Fifty States, District of Columbia, and Puerto Rico*, c2000, Rand Corporation.

reporting of R&D funding to California. The missing records are distributed approximately equally between the Departments of Defense, Veteran's Affairs and Agriculture. While our analysis for FY98 revealed over $7 billion in R&D funding, if this missing data were taken into account, it is likely that the total R&D funding for California would be in the neighbourhood of $13 to $13.5 Billion for FY98, according to recent conversations with Dr. Donna Fossum, the developer of the RaDiUS database.

A county-by-county data analysis reveals some very interesting characteristics of the R&D landscape of California in the 1990's. Fifty eight percent of the federally funded research in California was conducted by individual businesses and forty one percent was conducted by universities and independent research institutes. Eight counties of the fifty-eight in California received ninety four percent of the federal funding with Los Angeles County having the largest share. San Diego County ranked second, Santa Clara third, Orange County fourth, Alameda fifth, San Francisco sixth, San Mateo seventh and Santa Barbara eighth.

Counties also varied by the federal agencies from which they secured the majority of their funds. For example, analysis reveals that the majority of federal funds coming to Los Angeles for R&D 1993-1999 were from DOD and NASA. San Diego county secured the majority of its funding from DOD and HHS. The majority of San Francisco funding came from HHS and in Alameda County it was from DOE. Who performs the research also varies significantly by county. In Los Angeles County for example, approximately two thirds of the research is conducted by business entities even though the county has a very large number of higher education institutions. In contrast, San Diego county with far fewer educational institutions conducts a little more than half of its R&D in university and research institute settings. In Orange County and Santa Barbara County seventy-five percent of the R&D activity is conducted by businesses.

It is very difficult to classify specific technologies which are being funded by the federal government based on the way the data is reported in RaDiUS. However, this report attempts to group and categorize technology sector funding based on program titles. Based on this very preliminary (and potentially error prone approach), it appears that thirty nine percent of the Federal R&D coming to California is for defense related research projects; twenty eight percent for aerospace technology and twenty one percent for the life sciences. It is also the case that counties tend to concentrate in specific technology areas in terms of their research activities. For example, Alameda County is very high in energy research, Los Angeles in aerospace and defense, Santa Clara in electronics and San Diego in the life sciences.

This report also describes the level and type of SBIR funding coming to the state and each county. SBIR funds are interesting because they are one indicator of the commercializability of technologies being developed in research labs. $579 million dollars in SBIR funding came to the State of California over the six-year period studied (1993-99). This represents only about one percent of the total R&D funds won by the state. Federal agencies typically allocate two percent of their funding to SBIR activities and thus it is an interesting question why California is securing less of this money than is available. The data reveal that SBIR funds mirror the R&D activities funded in each county. Overall the largest source of SBIR funds is HHS and the lowest is NSF. Exact amounts of DOD SBIR funding are not available but may be significant. There have been significant increases in SBIR funding in San Diego County for example, where there

is a lot of entrepreneurial activity. Finally, the report describes NIST-ATP funds which have amounted to about $325 million dollars to eleven counties over the last six years. Santa Clara and San Diego county secured the largest percentages of these funds. NIST-ATP funds also focus on commercializable technologies and, in combination with SBIR, can be very good indicators of potential new industry developments.

This report does not attempt to make interpretations from these data. It simply provides a description of the diversity of research activities and performers across the counties of California. However, it does suggest the importance of major research centers such as universities or independent research institutes as well as large technology based companies as magnets for federal research and development dollars. What the exact relationship is between the research centers, the private companies and the industrial clusters which create wealth and jobs for each county is not clear. The nature of this relationship certainly merits further analysis.

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I. Introduction

California has had a long history of science and technology based economic development. The agricultural and aerospace sectors were fueled by research and development; the electronics and semi-conductor industries grew up next to a great research university in the Silicon Valley and today California's research institutions and medical centers are at the forefront of the revolutionary development of life science companies and products.

California's R&D budget is the largest in the nation. As a state, we garner close to 20% of the federal R&D budget and this share continues to increase with each passing year. As the fifth largest economy in the world, California is both large and diverse, with regions varying both in terms of their R&D activities and industrial cluster developments. Furthermore, these distinctive regional differences are not well understood as most federal analyses of R&D funding do not address the regional breakdown of funding. While it may be useful for federal policymakers to compare California to the other 49 states, this is not a useful benchmark for regional policymakers.

Presenting county by county comparisons is a first step towards a more regional perspective. In order to understand R&D activities on a regional level, it is necessary to build new indicators that can drill down to this regional level. This way, state legislators, policymakers and regional government officials can gain a better understanding of the research activities happening in their local jurisdictions and use this information to inform economic development strategies and public policies.

Most available federal reports on science indicators aggregate R&D funding at the state level.[2] While these reports may adequately describe research at the regional level for small states, they fail to properly describe California, one of the most diverse and largest states in the United States. California is home to 58 counties, some of which are equivalent to the size of small states. In order to build data sets that can describe regional trends, one has to begin with data that has been disaggregated down to the award or grant level and then re-aggregate back to the county level. Rand's RaDiUS database[3] is one of the few databases that is amenable to this approach, although it does not include funding for infrastructure, equipment and facilities. Nonetheless, this is a database that organizes R&D grants data across 17 agencies and delivers this content in a uniform format. This makes RaDiUS data amenable for cross-agency, regional analyses of research funding and a very useful preliminary tool for descriptive and comparative purposes.

The California funding totals in this report are based ***strictly*** on results from the RaDiUS database which is only one source of data on R&D funding to the states. The RAND Report: *Discovery and Innovation: Federal Research and Development Activities in the Fifty States,*

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[2] National Science Foundation's Annual Science & Engineering Indicators, 2000.

[3] RaDiUS stands for "Research and Development in the United States". RaDiUS was created by RAND, in cooperation with the National Science Foundation (NSF), to assist its Science and Technology Policy Institute in providing analytical support to the White House Office of Science and Technology Policy (OSTP) and the National Science and Technology Council (NSTC).

District of Columbia, and Puerto Rico published in 2000 by Donna Fossum et al,[4] has included other databases not currently available to analysts outside Rand. The RaDiUS database reflects funds awarded directly for the conduct of research and excludes funding for infrastructure, equipment and facilities. Precise data on the latter is not currently available for regional analysis so there are some discrepancies between different reports on California's total R&D performance.

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This study provides a county-by-county picture of California's R&D funding landscape, using RaDiUS data as a basis for comparison across the 58 counties of the state. Section II provides a state-wide summary of this data with accompanying charts and graphs. Section III describes which federal agencies fund R&D in each county and the R&D funding trends between 1993 and 1999. Section IV analyzes R&D funding by the type of performer for each county and these trends over time (1993-99). Section V suggests a new methodology for analyzing R&D funding, by technology sectors. County level results of this technology sector analysis is then presented. R&D funding by itself will not give rise to industrial clusters. There also need to be resources devoted to commercialization activities. Hence, Section VI describes Small Business Innovation Research (SBIR) funding trends to each county of the state. Section VII breaks out funding from the Advanced Technology Program (ATP) administered by the Department of Commerce's National Institute for Standards and Technology (NIST). Throughout this report, the analysis emphasizes the top eight counties receiving funding, as these top counties share characteristics that set them apart from the other 58 counties. In addition, a full set of summary data is included as a separate set of Appendices.

While this data is preliminary, it does provide a broad overview of the rich and complex research activities that occur in every corner of the state. Although R&D activities are, for the most part, concentrated in a few large, metropolitan counties, one can truly say that few counties are unaffected by research activities that add to the innovation capacity of the state. Fully 51 of the 58 counties in California have received some form of federal R&D funding from the 17 agencies tracked by RaDiUS.

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[4] Donna Fossum, Lawrence S. Painter, Valerie Williams, Allison Yezril, Elaine Newton, and David Trinkle, *Discovery and Innovation: Federal Research and Development Activities in the Fifty States, District of Columbia, and Puerto Rico*, c2000, Rand Corporation.

Finally, this report can only begin to give the reader a glimpse of the richness and the complexity of all the data available in RaDiUS. Since project time and scope limited this analysis to a broad survey of the top eight counties that perform the majority of the research in the state, an extensive set of appendices is provided that details research activities in each of the 58 counties that have received federal R&D funding during the time period studied (1993-99). For the first time, state legislators, policymakers, regional government officials and economic development professionals have a tool that describes the extent and character of R&D funding for their local regions.

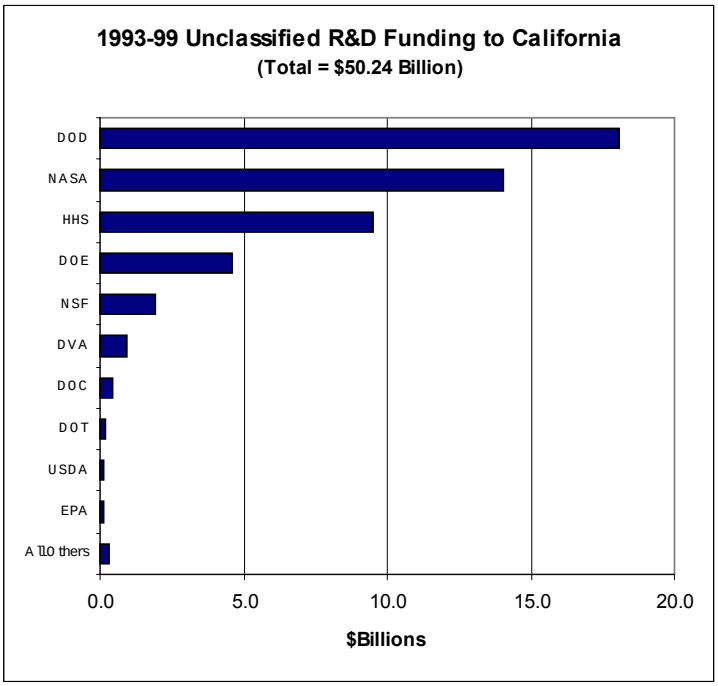
II. The Lay of the Land: State Level Data from RaDiUS

According to RaDiUS, in the period between the federal fiscal years 1993-99 inclusive, California received a total of $50.24 billion dollars for unclassified R&D activities from the Federal Government.[5] California is the largest recipient of Federal R&D funding among the 50 states. According to Rand, California receives approximately 20% of all Federal dollars spent on R&D activities.[6,7]

A. Unclassified R&D Funding

The agencies awarding the largest amount of R&D funding to the state include the Department of Defense, National Aeronautical & Space Administration, the Department of Health and Human Services (primarily through the National Institutes of Health), the Department of Energy and the National Science Foundation. A breakdown is shown in Figure II-A and Table II-A.

Figure II-A 1993-99 Unclassified Federal R&D Funding to the State of California, by Agency *(Source: RaDiUS)*



[5] Throughout this study, only unclassified R&D funding data is reported.
[6] Donna Fossum, Lawrence S. Painter, Valerie Williams, Allison Yezril, Elaine Newton, and David Trinkle, *Discovery and Innovation: Federal Research and Development Activities in the Fifty States, District of Columbia, and Puerto Rico*, c2000, Rand Corporation.
[7] The California funding totals in this report are based *strictly* on results from the RaDiUS database which is only one source of data on R&D funding to the states. Fossum et al have included other databases not currently available to other analysts in their report, Discovery and Innovation. The RaDiUS database reflects funds awarded directly for the conduct of research and excludes funding for infrastructure, equipment and facilities. Precise data on the latter is not currently available for our regional analyses so there are some discrepancies between various reports on California's total R&D performance.

Table II-A 1993-99 Unclassified Federal R&D Funding to the State of California, by Agency *(Source: RaDiUS)*

Agency[8]	1993-99 Unclassified R&D Funding ($Billion)
DOD	18.0519
NASA	14.0664
HHS	9.5038
DOE	4.5919
NSF	1.9000
DVA	0.9549
DOC	0.4213
DED	0.2065
DOT	0.1983
USDA	0.1491
EPA	0.1218
DOI	0.0518
DOJ	0.0080
DOL	0.0066
NRC	0.0052
SSA	0.0017
HUD	0.0008
Total	**50.2397**

B. Performer Type

The federal government awards grants and contracts to a wide range of performers, from individual businesses to universities, as well as to a variety of other entities, such as consulting practices and private individuals. These performer types and the aggregated funding awarded to each category are listed in Figure II-B and Table II-B.

As is shown in Figure II-B and Table II-B, individual businesses received the largest fraction of the total funding awarded to California (58.2%), over the time period studied, 1993-99. Examples of businesses receiving significant amounts of funding include aerospace and defense companies such as Boeing and TRW. Substantial funding is also awarded to public and private educational institutions such as universities (25.4%), federal government labs (10%) and non-profit/non-educational research institutes (5%). As the RaDiUS database does not include funding for equipment and facilities, the funding may be somewhat understated.

[8] Full names for all agencies are given in Section I of the Appendices. A listing of all relevant RaDiUS terms are detailed in a Glossary (Section II of the Appendices).

Figure II-B 1993-99 Unclassified R&D Funding to California, by Performer Type ***(Source: RaDiUS)***

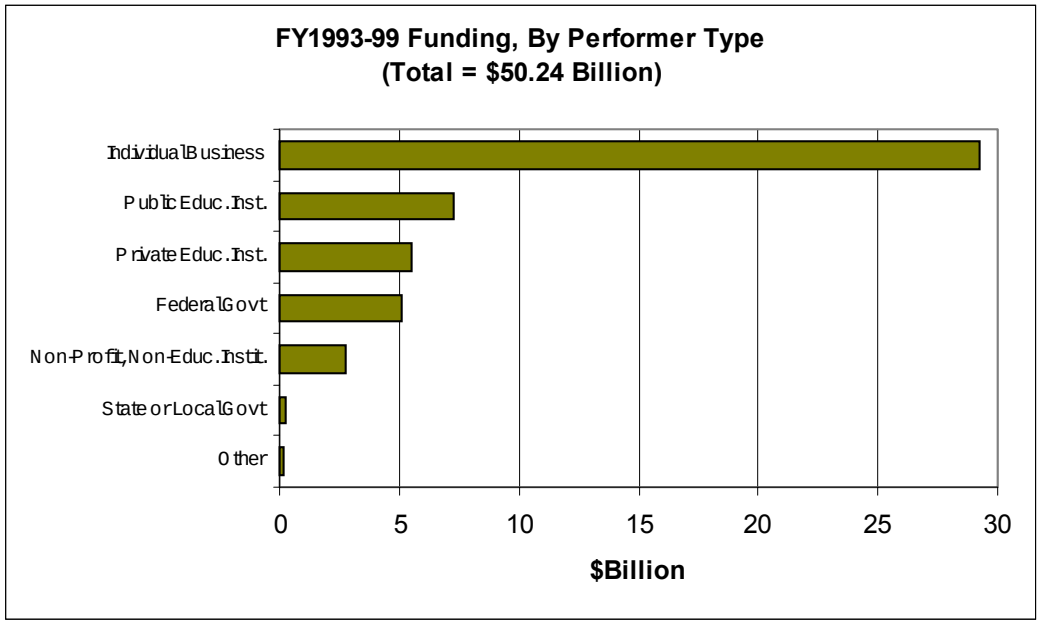
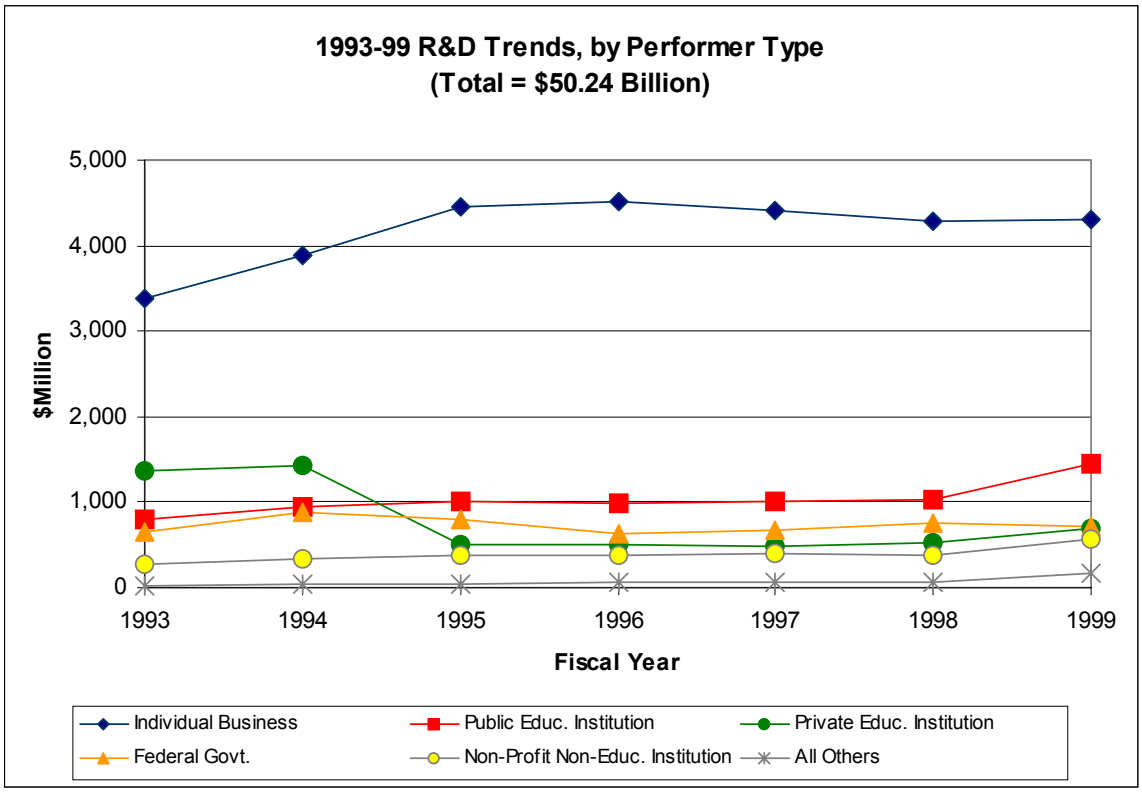


Table II-B 1993-99 Unclassified Federal R&D Funding to California, by Performer Type ***(Source: RaDiUS)***

Performer Type	FY1993-99 Funding ($Mil)	% of Funding
Individual Business	29.225	58.17%
Public Educational Institutions	7.233	14.40%
Private Educational Institutions	5.531	11.01%
Federal Government	5.080	10.11%
Non-Profit, Non-Educational Institutions	2.727	5.43%
State or Local Governments	0.282	0.56%
Not Specified	0.071	0.14%
Other Government Entities	0.065	0.13%
Other	0.018	0.04%
Private Individuals	0.008	0.02%
Total:	**50.240**	**100.00%**

In general, funding trends by performer type have been relatively stable over time. See Figure II-C. Funding to individual businesses rose in the early 1990s and remained stable for the rest of the decade. Slight decreases in funding to private educational institutions were offset by slight increases to public educational institutions.

Figure II-C 1993-99 Unclassified Funding to California, by Performer Type



C. Unclassified SBIR Funding

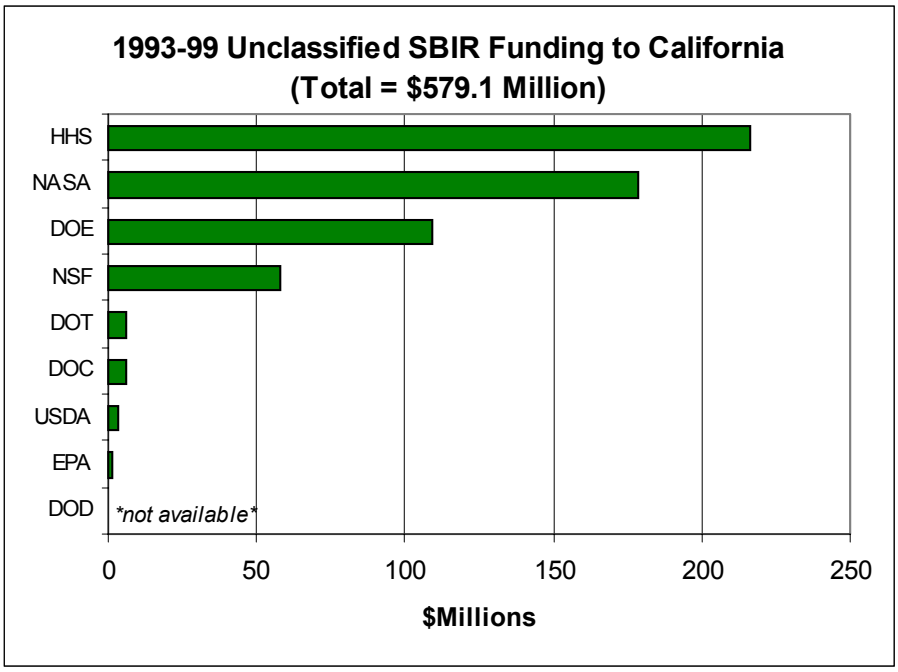
The total funding to California from the Small Business Innovation Research (SBIR) program is considerably smaller when compared to the R&D funding totals. Between 1993 and 1999, the aggregated unclassified SBIR funding to California totaled $579.1 million. This is equivalent to 1.1% of R&D funding to the state. Nevertheless, this small grant program is a useful indicator of innovation activity in a region. SBIR grants are awarded for extremely high risk commercialization activities that are not funded by any other means. In other words, one can view it as a source of government "venture capital" during an early critical stage of the technology commercialization/product development cycle. All major agencies that contribute R&D funding to the state participate in the SBIR program, typically at 2% of all funds awarded annually. It is possible that, with SBIR funding at a level of 1.1% of R&D funding to the state, California is receiving a lower amount than it is eligible for. However, compared to the rest of the US, California is also blessed with a disproportionate share of angel investment and venture capital funds to support commercialization related R&D. Hence, private capital may compensate for the discrepancies in obtaining public venture capital. The agency breakdown of SBIR funding is shown in Figure II-D and Table II-D.

Unclassified SBIR funding data for the Department of Defense is incomplete and mostly unavailable at this time. While RaDiUS reports the number of SBIR grants given out by DOD, there is no reporting of funding amounts. For the purpose of this analysis, a designation of NA

in any table or figure indicates that a particular county or region is receiving some amount of funding from DOD but specific data is unavailable at this time.[9] It may be that if the classified SBIR funding were to be added to the unclassified funding, California's total intake of SBIR funding may come closer to the 2% average expected.

The agencies awarding the highest amount of unclassified SBIR funding include HHS, NASA, DOE and NSF. DOD is also suspected to be a significant but possibly minor component of California's SBIR funding, as evidenced by the number of grants given out. Of the 6,308 SBIR grants received by California between 1993 and 1999, only 260 are DOD grants.

Figure II-D 1993-99 Unclassified SBIR Funding by Federal Agency to the State of California *(Source: RaDiUS)*



[9] Throughout this report, the use of "NA", "0.0" and "blank" are standardized for all tables and figures. These definitions are included here for completeness. NA indicates a non-zero amount of funding but that amount is not available. A value of 0.0 indicates a small, finite non-zero amount that has been rounded to zero. Blanks indicate no funding for that particular category.

Table II-D 1993-99 Unclassified SBIR Funding by Federal Agency to the State of California ***(Source: RaDiUS)***

Agency	1993-99 Unclassified SBIR Funding ($Millions)
DOD	NA
HHS	216.384
NASA	178.484
DOE	109.291
NSF	57.839
DOT	6.309
DOC	5.943
USDA	3.431
EPA	1.414
Total:	**579.096**

III. County Level Analysis of Unclassified Federal R&D Funding

The following is a summary of unclassified federal R&D funding derived from RaDiUS, by county. The discussion will be on a very general level, just to give the reader a broad lay of the land. For full tables with data for all counties,the reader is referred to Sections III and IV of the Appendices.

A. Unclassified R&D funding to Each County

The top counties receiving Federal R&D Funding are shown in Figure III-A and Table III-A. Eight counties were distinguished by having aggregated 1993-99 funding of approximately $1 billion or more. Taken together, these top eight counties in the state account for 96% of the R&D funding, or $48.4 billion of the total $50.24 billion cumulative R&D funding to California, for the period between 1993-99. Number 1 ranked Los Angeles County received the lions' share of R&D funding, $23.1 billion or 46% of the state total. Below these top eight counties are seven more counties where each county's funding (1993-99, aggregated) totaled between $100 Million and $1 Billion. Together, these middle-ranking counties only account for an additional 3% of the total R&D funding to the state. The rest of the 58 counties all received substantially less than $100 Million over the time period studies (1993-99). The dropoff in funding between top-ranked, middle-ranked and bottom-ranked funding is stark.

Table III-A includes the names of major public and private universities in each county (i.e. all University of California campuses, all CSU campuses, Stanford, USC and CalTech). While the R&D funding data includes funding to individual businesses and other entities besides universities, there is a strong correlation between research universities and a county's ranking. Of the 50 counties in California receiving federal R&D funding, eight of the top ten counties receiving have *at least one* major research university (UC or private equivalent) located within that county. Top-ranked Los Angeles, with eight universities, receives a disproportionately large share of R&D funding, even compared to other counties in the state. While Santa Cruz and Riverside counties are not in the top ten list, they are not far behind, at rankings of 12 and 13. Each has a young and rising UC campus located in the county.

Figure III-A Top 8 Counties Receiving Unclassified Federal R&D Funding, 1993-99 Aggregated. ***(Source: RaDiUS)***

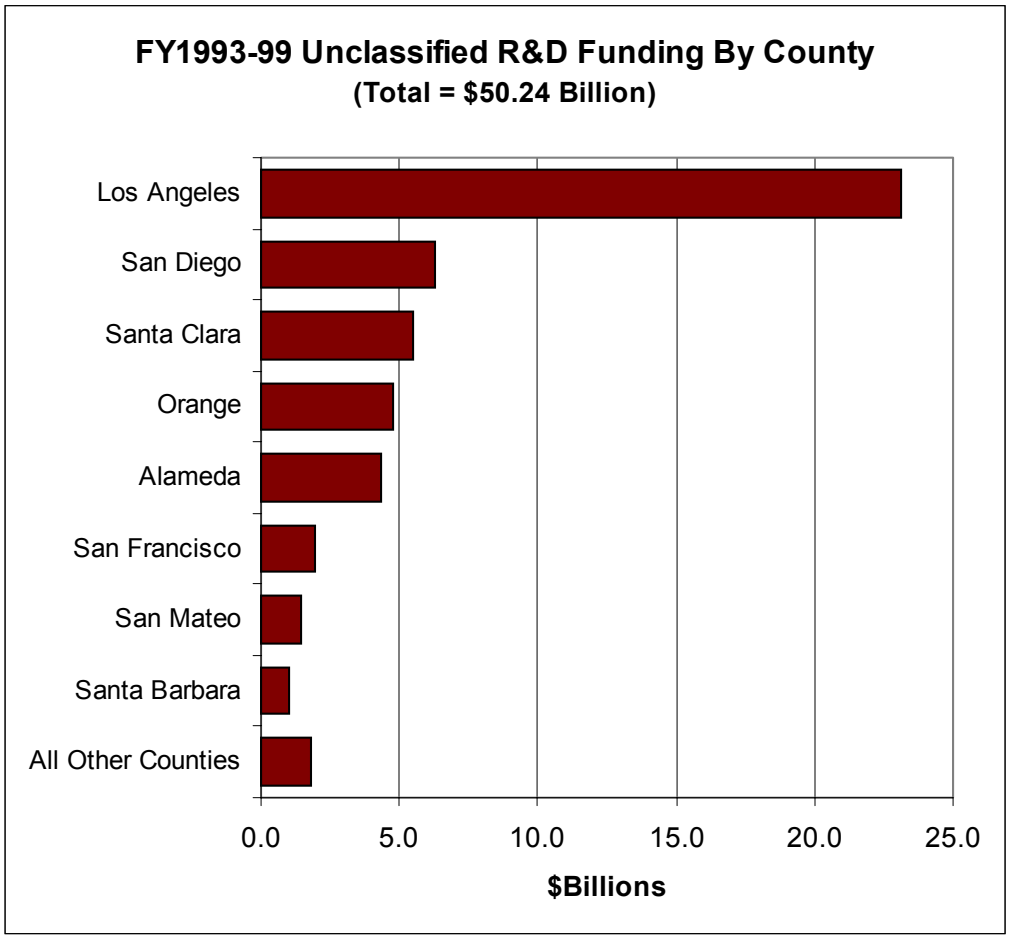


Table III-A County Rankings for 1993-99 Aggregated Unclassified Federal R&D Funding *(Source: RaDiUS)*

Ranking	County Name	1993-99 Unclassified Federal R&D Funding ($Million)	Research Universities in County
1	Los Angeles	23,124.521	CalTech, UC Los Angeles, USC, Cal Poly Pomona, CSU Dominguez Hills, CSU Los Angeles, CSU Long Beach, CSU Northridge
2	San Diego	6,289.445	UC San Diego, San Diego State, CSU San Marcos
3	Santa Clara	5,527.435	Stanford, San Jose State
4	Orange	4,735.830	UC Irvine, CSU Fullerton
5	Alameda	4,344.204	UC Berkeley
6	San Francisco	1,984.877	UC San Francisco, San Francisco State
7	San Mateo	1,415.110	
8	Santa Barbara	986.489	UC Santa Barbara, CSU Channel Islands
9	Yolo	676.358	UC Davis
10	Sacramento	219.334	CSU Sacramento
11	Ventura	208.004	
12	Santa Cruz	166.152	UC Santa Cruz
13	Riverside	143.999	UC Riverside
14	San Bernardino	102.112	CSU San Bernardino
15	Contra Costa	100.898	CSU Hayward
16	Kern	85.289	CSU Bakersfield
17	Sonoma	35.643	Sonoma State
18	Monterey	27.751	CSU Monterey Bay
19	Marin	9.743	
20	San Joaquin	9.625	
21	San Luis Obispo	8.862	CSU San Luis Obispo
22	Fresno	8.603	CSU Fresno
23	Lake	8.479	
24	Humboldt	5.786	Humboldt State
25	Butte	2.663	CSU Chico
26	Napa	1.668	
27	Solano	1.578	California Maritime Academy
28	Placer	1.404	
29	Inyo	1.171	
30	Kings	1.059	
31	Modoc	0.656	
32	Imperial	0.631	
33	Stanislaus	0.606	CSU Stanislaus
34	Tulare	0.493	
35	Shasta	0.445	
36	Trinity	0.358	
37	Mendocino	0.347	
38	Tuolumne	0.343	
39	Plumas	0.250	
40	San Benito	0.237	
41	El Dorado	0.231	
42	Siskiyou	0.205	

Ranking	County Name	1993-99 Unclassified Federal R&D Funding ($Million)	Research Universities in County
43	Glenn	0.160	
44	Yuba	0.099	
45	Tehama	0.051	
46	Calaveras	0.050	
47	Colusa	0.050	
48	Del Norte	0.050	
49	Mariposa	0.032	
50	Lassen	0.030	
	Not Specified	*0.264*	
	Total ($Millions):	**50,239.679**	

B. Agency Breakdown of Unclassified R&D Funding to Each County

Unclassified R&D funding is heavily concentrated within certain counties of the state with the mix of funding differing sharply between counties. Among the top eight counties, Los Angeles received over 80% of its funding from a combination of NASA and DOD. On the other hand, over 80% of the funding to San Diego County derives from DOD and HHS. In contrast, Alameda County received 62% of its funding from DOE. These results are shown in a series of pie charts, in Figures III-B to I. A full agency breakdown for all 50 counties receiving federal R&D funding is available in Section III of the Appendices.

Please note that the following pie charts are uniformly color coded by agency (i.e. NASA = dark blue, DOD = dark green, HHS = yellow, NSF = orange, DOE = red, DVA = brown, DOC = mauve, and Others = gray).[10]

[10] Color codes refer to the appearance of screen colors only. Colors in printed copies of this report may differ slightly due to a particular color printer's ability to translate screen colors into ink renderings. If there is any doubt about coloration, please refer to the agency abbreviation corresponding to that particular section of the pie chart.

Figure III-B 1993-99 Unclassified Federal R&D Funding to Los Angeles County, Total = $23.124 Billion ***(Source: RaDiUS)***

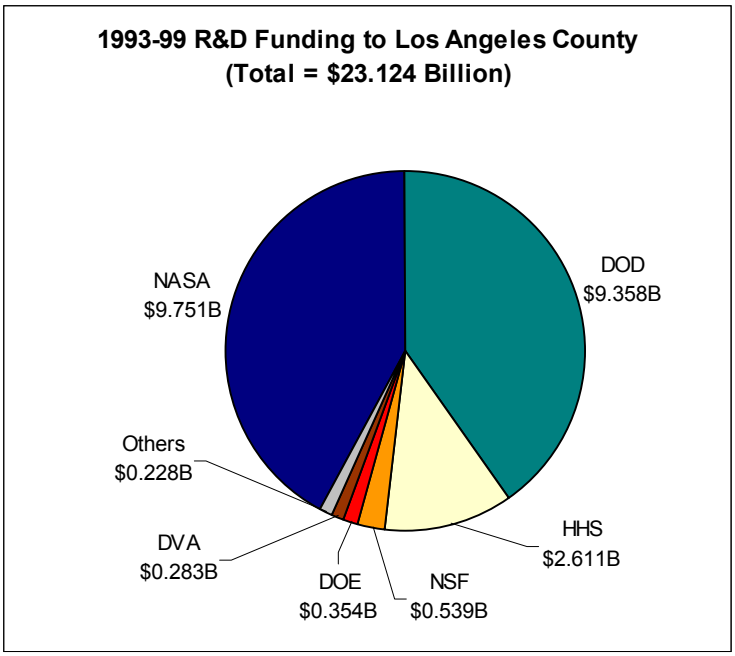


Figure III-C 1993-99 Unclassified Federal R&D Funding to San Diego County, Total = $6.289 Billion ***(Source: RaDiUS)***

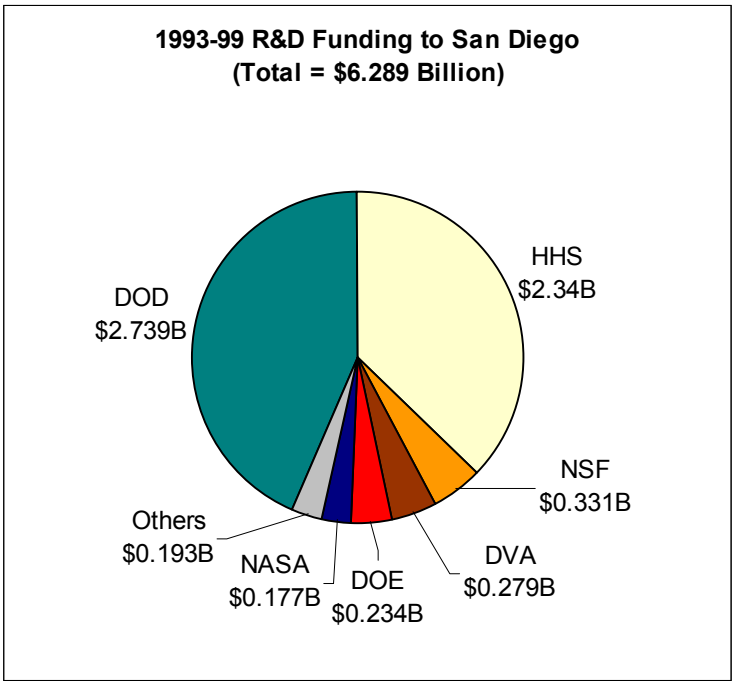


Figure III-D 1993-99 Unclassified Federal R&D Funding to Santa Clara County, Total = $5.527 Billion ***(Source: RaDiUS)***

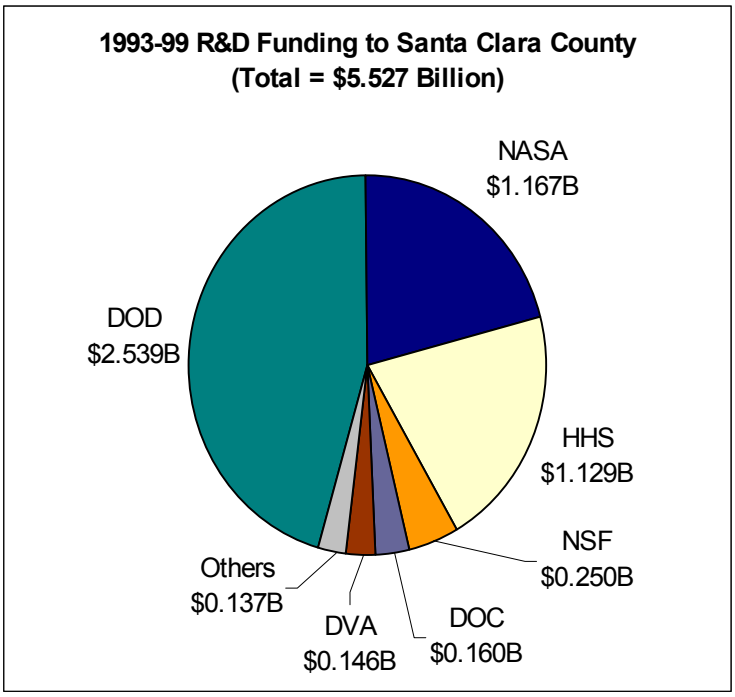


Figure III-E 1993-1999 Unclassified Federal R&D Funding to Orange County, Total = 4.736 Billion ***(Source: RaDiUS)***

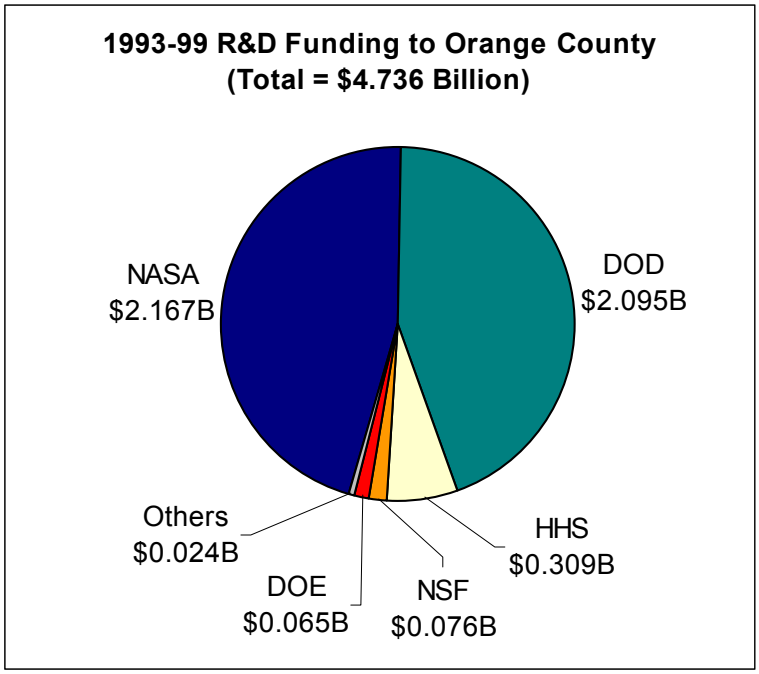


Figure III-F 1993-99 Unclassified Federal R&D Funding to Alameda County, Total = $4.344 Billion ***(Source: RaDiUS)***

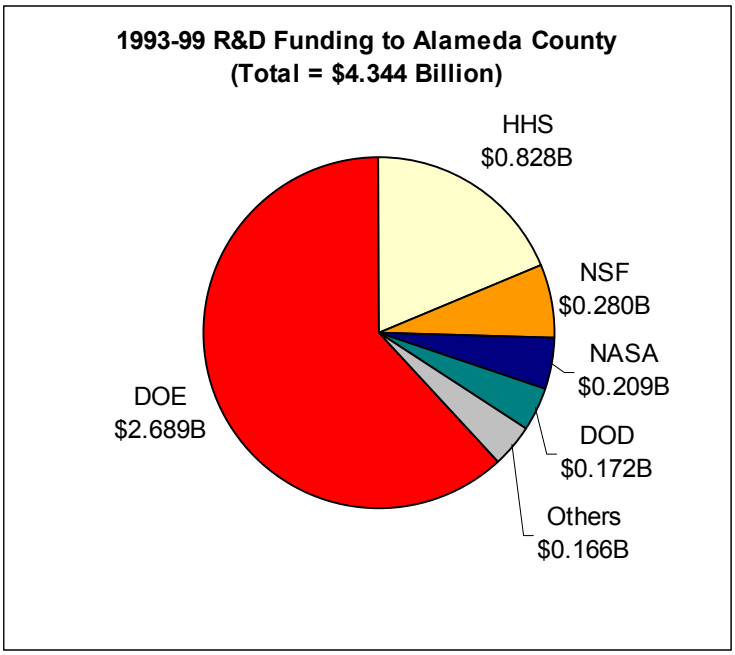


Figure III-G 1993-99 Unclassified Federal R&D Funding to San Francisco County, Total = $1.985 Billion ***(Source: RaDiUS)***

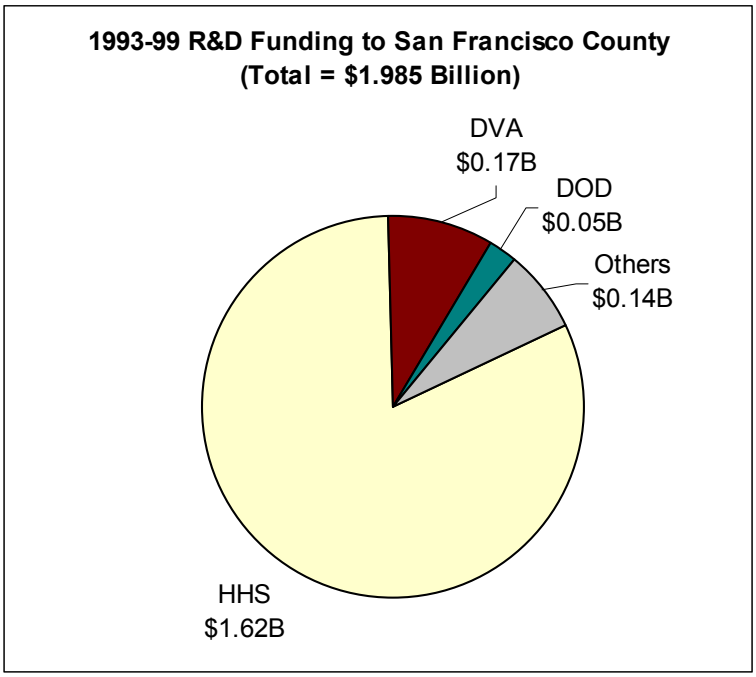


Figure III-H 1993-99 Unclassified Federal R&D Funding to San Mateo County, Total = $1.415 Billion ***(Source: RaDiUS)***

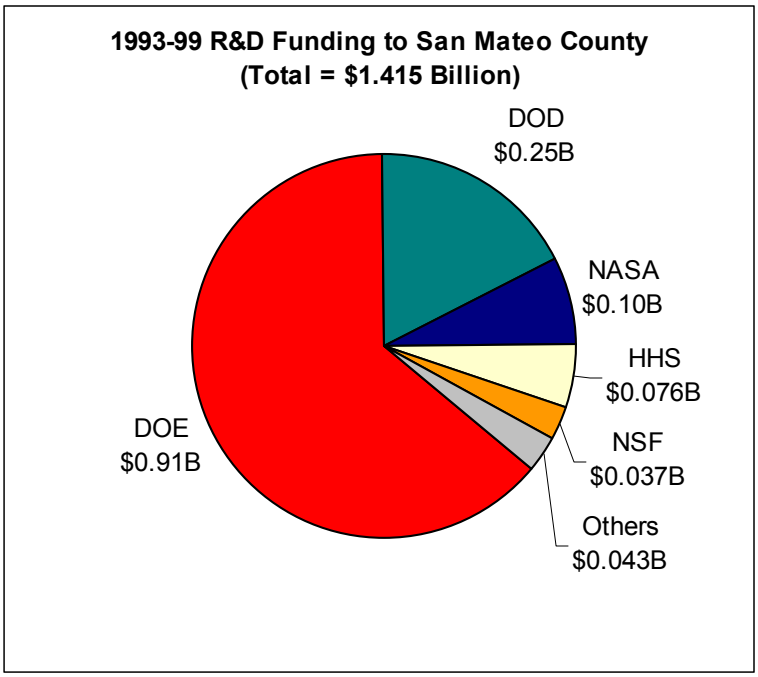
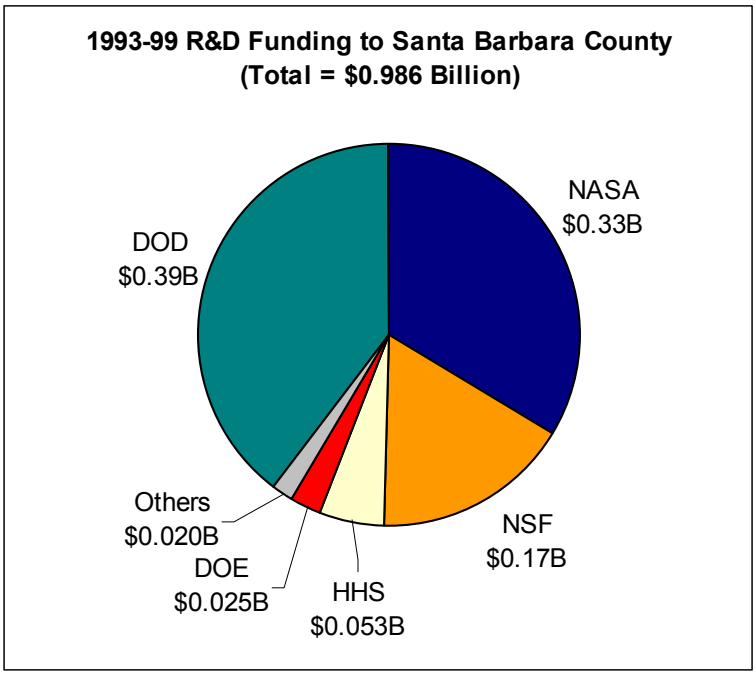


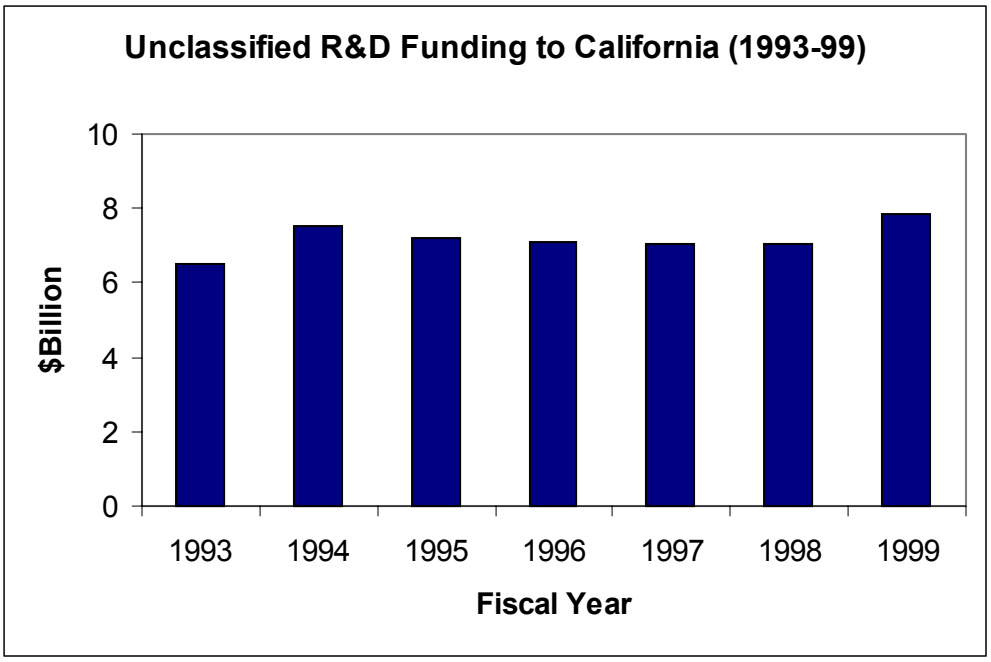
Figure III-I 1993-99 Unclassified Federal R&D Funding to Santa Barbara County, Total = $0.986 Billion ***(Source: RaDiUS)***



C. 1993-99 Unclassified R&D Funding Trends

Finally, Federal support of unclassified R&D activities in California has been rising steadily over the past decade. Between 1993 and 1999 inclusive, funding rose approximately 21%. See Figure III-J.

Figure III-J. 1993-99 Unclassified Federal R&D Funding to the State of California ***(Source: RaDiUS)***



However, at the agency level, unclassified R&D funding trends did not uniformly rise. Figure III-K and Table III-B represent a time trend analysis of unclassified R&D funding to California. NASA funding has been decreasing over most of the decade as have DOD unclassified research activities. By contrast, HHS funding has been increasing.

The reader is cautioned to treat these HHS results as an *extremely* preliminary indicator of trends. Beginning in FY1999, Congress committed to double NIH's budget by 2003. As a result, NIH funding has been increasing significantly since FY1999 to reflect this change in budget priorities.[11] Because of the high levels of research activity in the state of California, it is reasonable that there would have been a significant increases in funding from NIH between FY1998 and FY1999. However, a doubling of activity from one fiscal year to another would appear to be an increase that merits further examination.

[11] FY2000 data for HHS is unavailable at this time, due to a systematic error in the RaDiUS database. Rand is aware of this error and is working on fixing the data but this error was not corrected at the time for the final report. Hence, throughout this report, all aggregated data that includes HHS funding is reported for the period 1993-99 only. FY2000 data will be presented where it is possible to break out the data by agency and HHS is not included.

The rise in HHS funding in the recent past tended to offset the drop in R&D funding from DOD and NASA. Hence, while the overall levels of funding to the State of California didn't change substantially, the mix of R&D activities funded did.

Figure III-K. 1993-99 Agency Trends in Unclassified R&D Funding to the State of California ***(Source: RaDiUS)***

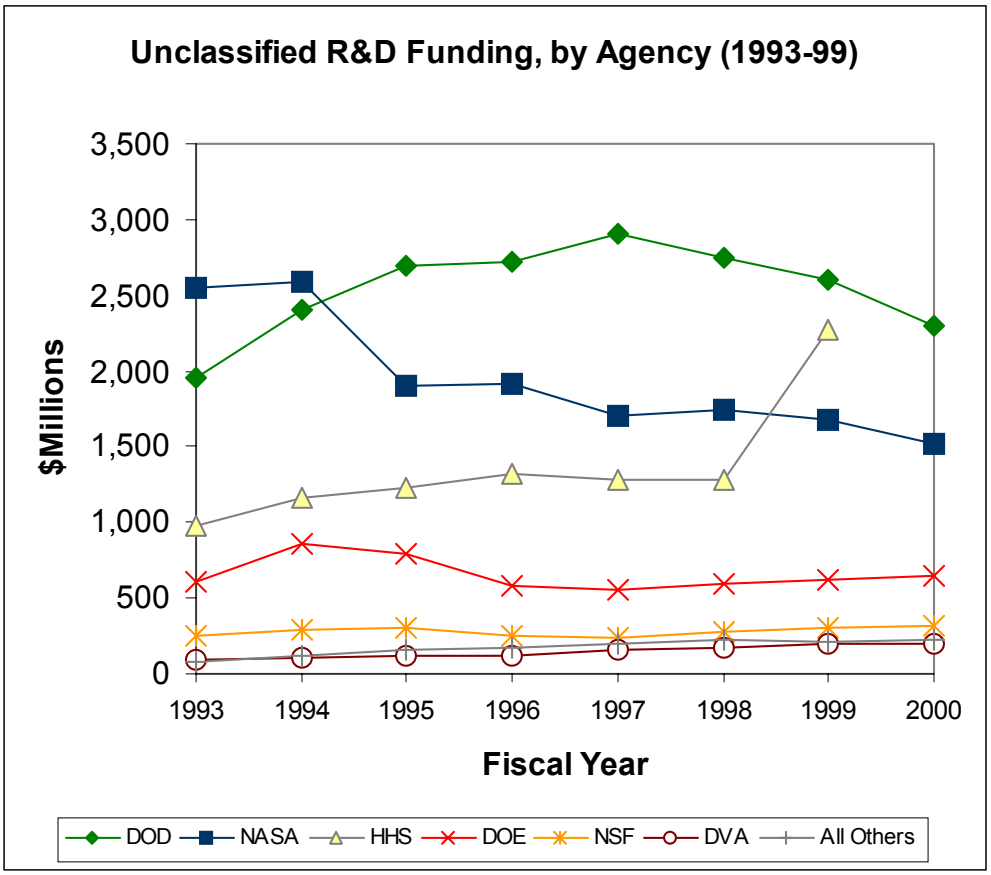


Table III-B 1993-2000 Agency Trends in Unclassified R&D Funding to the State of California *(Source: RaDiUS)*

Agency Abbrev.	1993	1994	1995	1996	1997	1998	1999	2000	1993-2000 Total
DED	15.109	19.769	26.732	34.681	36.563	39.564	34.071	32.341	**238.831**
DOC	17.813	29.885	56.802	57.747	75.077	98.411	85.544	80.704	**501.984**
DOD	1,960.704	2,410.137	2,699.111	2,722.544	2,908.973	2,747.721	2,602.759	2,303.152	**20,355.101**
DOE	606.911	857.492	787.676	577.218	555.318	590.117	617.119	651.456	**5,243.308**
DOI	4.709	6.059	7.263	6.380	9.121	10.003	8.231	6.985	**58.751**
DOJ	0.300	0.451	0.900	1.353	1.723	1.790	1.444	1.108	**9.069**
DOL	0.568	1.046	1.426	1.842	1.292	0.364	0.038	0.053	**6.627**
DOT	9.011	22.965	26.133	24.628	31.918	40.159	43.439	65.052	**263.305**
DVA	88.274	102.995	113.097	123.960	152.577	177.160	196.829	193.993	**1,148.885**
EPA	14.222	18.850	20.512	18.567	19.780	16.552	13.269	15.503	**137.255**
HHS	972.811	1,155.983	1,229.079	1,314.992	1,275.271	1,285.627	2,269.995	--	**9,503.758***
HUD		0.109	0.155	0.064	0.066	0.214	0.179	0.295	**1.083**
NASA	2,550.259	2,586.944	1,897.205	1,918.293	1,698.097	1,739.894	1,675.704	1,513.839	**15,580.234**
NRC	0.162	0.408	0.707	1.278	1.301	0.797	0.555	0.519	**5.728**
NSF	248.379	284.875	300.158	248.608	243.409	274.432	300.136	319.551	**2,219.546**
SSA			1.134	0.349	0.089	0.089			**1.661**
USDA	14.258	18.287	20.433	25.863	23.550	22.476	24.237	26.066	**175.170**
FY Total:	**6,503.490**	**7,516.254**	**7,188.521**	**7,078.366**	**7,034.127**	**7,045.371**	**7,873.550**	**5,210.617**	**--**

**1993-99 Total only because FY2000 HHS data is unavailable at this time.*

D. Unclassified Federal R&D Funding Trends to the Top 8 Counties

At the county level, unclassified federal R&D funding trends do not mirror the state trend. The pie charts in Section III-C indicate that the mix of agencies funding R&D activities in each county varied significantly. Therefore, one would expect that county level time trends should also vary, as a reflection of the various federal agencies' funding appropriations and priorities over time. This is indeed the case and the results are shown in Figure III-La,b.

To determine which counties have sustained the largest increases over time, two separate analyses were performed. Since 96% of all R&D funding to the state goes to eight counties, these counties were considered separately. Table III-C shows the percentage change in funding between 1993 and 1999. Of the top eight counties, San Francisco sustained the largest percentage increase and San Diego sustained the largest absolute funding increase. Both of these counties receive a substantial portion of their funding from HHS and the increase in HHS funding probably is driving these results.

In the second analysis, all counties that maintained sustained funding (i.e. non-zero funding for each year between 1993 and 1999) were also analyzed. Of the 51 counties receiving funding, only 30 met this criterion. These results are shown in Table III-D. The top three counties with the highest sustained increases in funding are Placer, Sonoma and Butte counties at 1,247%,

1,220% and 581% respectively. Of these three counties, Sonoma County has the largest absolute level of funding, ending up at $7.13 million by 1999.

All of these increases occur from an extremely small base level of funding so the question is whether or not this growth can be sustained over the long run. To answer this question, one needs to probe further about the number and size of the grants being awarded. If the total annual funding for a county is on the order of $25-50,000, this is a good indication that this county received only one grant for that year.[12] For a county with a five to ten-fold increase in funding from this base, was the result based on a ten-fold rise in the number of grants or on the awarding of one large grant? One could argue that for a county with a small base of funding, increases in the number of awards sustained over a certain time period may be a better indicator of innovation than the awarding of one large grant that is not sustained from one year to the next.

In the case of Placer county, the data indicates that it has sustained 1-3 grants per year, between 1993-99. The funding amounts have varied with some grants receiving considerably more funding than others. Butte County saw a similar fluctuation with the amount of funding increasing but with no substantial change in the number of grants. On the other hand, Sonoma county has sustained a steady rise in the number of grants from 19 in 1993 to 30 in 1999. The question for all these counties is whether or not the growth in funding can be sustained over time, given that none of these counties has a research university (or equivalent), as a regional anchor for innovation.

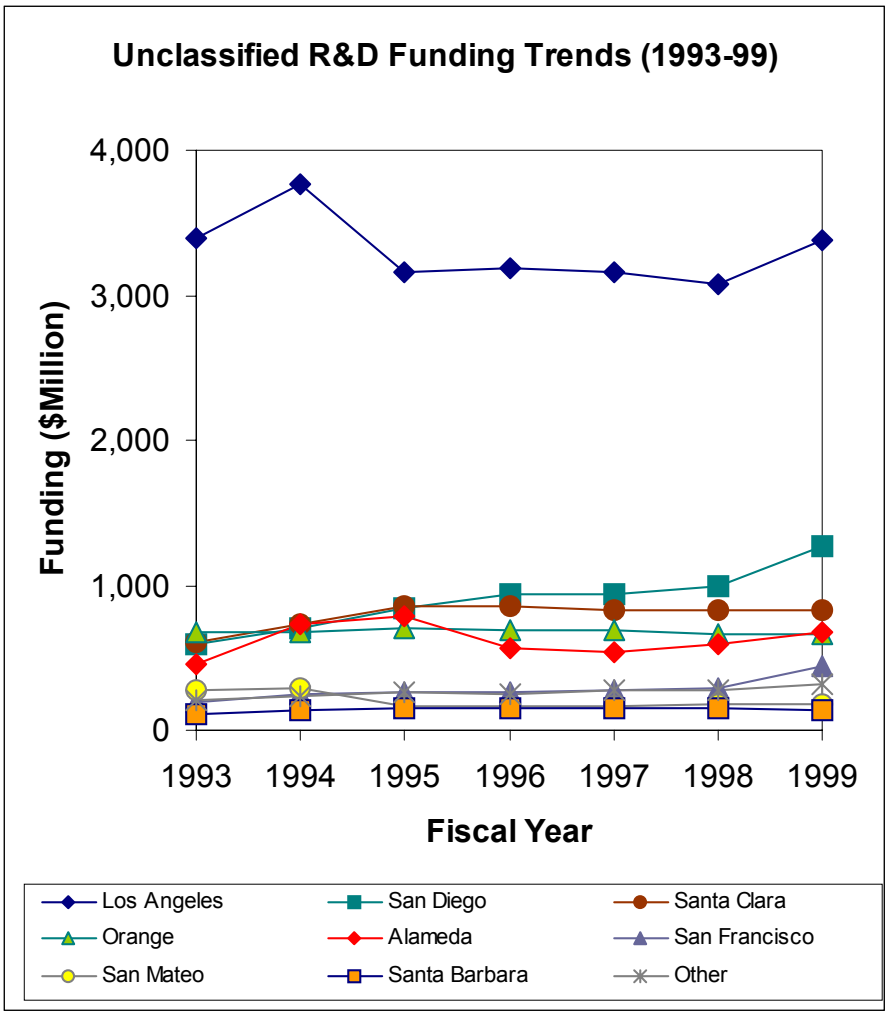
Table III-C. 1993-99 Unclassified R&D Funding Changes for the Top 8 Counties Receiving Federal Funding *(Source: RaDiUS)*

Ranking[13]	County Name	1993 Funding	1999 Funding	Difference	% Difference
1	Los Angeles	3,389.693	3,373.516	-16.177	-0.5%
2	San Diego	594.150	1,266.566	672.416	113.2%
3	Santa Clara	609.619	824.144	214.525	35.2%
4	Orange	669.345	655.515	-13.830	-2.1%
5	Alameda	450.578	681.330	230.752	51.2%
6	San Francisco	197.352	448.098	250.746	127.1%
7	San Mateo	269.319	178.775	-90.545	-33.6%
8	Santa Barbara	115.515	134.443	18.927	16.4%
		6,295.571	**7,562.386**	**1,266.815**	**20.1%**

[12] This is based on a calculation of the average grant size in the database. Examining all records in the database, California received 154,985 grants totaling $56.8 billion. This results in an average grant size of $36,655.
[13] Ranking is determined by aggregated funding from 1993-99 inclusive.

Figure III-L 1993-99 Unclassified R&D Funding Trends to the Top 8 Counties ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Scale (Minus Los Angeles County)

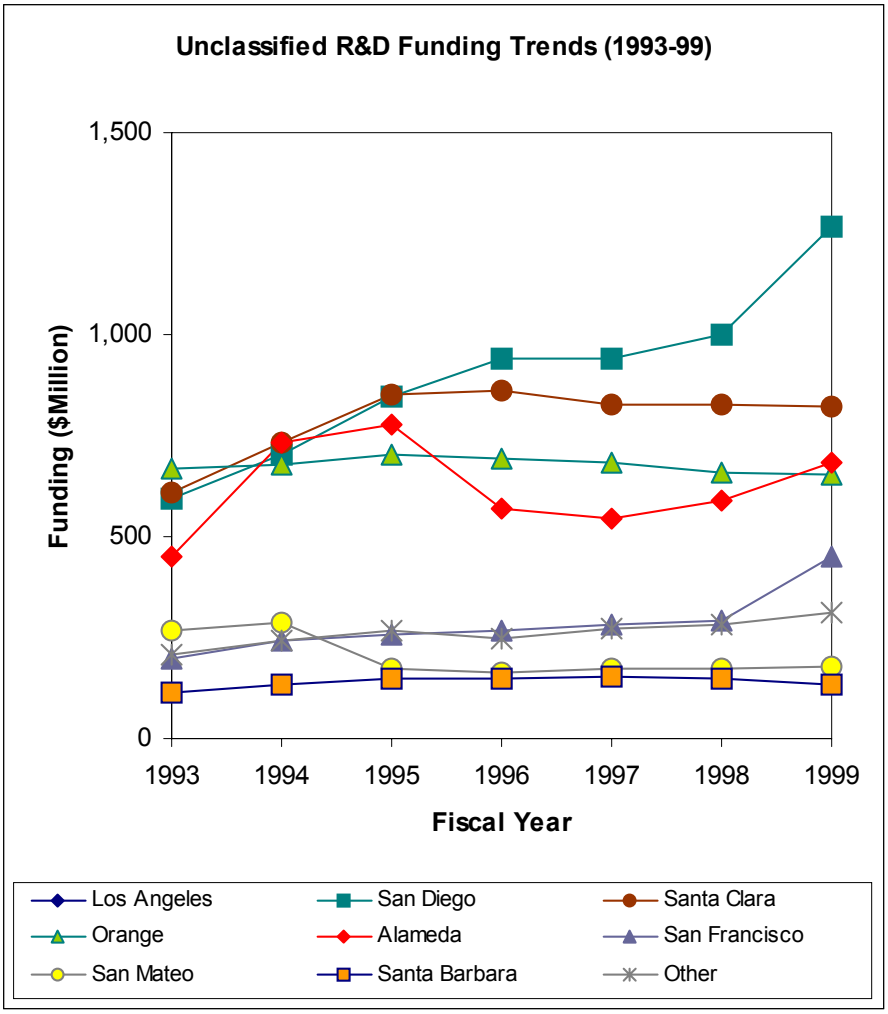


Table III-D. 1993-99 Unclassified R&D Funding Changes for the Top 30 Counties Receiving Federal R&D Funding ***(Source: RaDiUS)***

R&D Ranking[14]	County Name	1993 Unclassified R&D Funding ($Millions)	1999 Unclassified R&D Funding ($Millions)	Difference ($Millions)	% Difference
27	Placer	0.024	0.323	0.299	1247.2%
17	Sonoma	0.540	7.131	6.591	1220.0%
25	Butte	0.063	0.427	0.364	581.4%
20	Fresno	0.282	1.776	1.494	529.1%
24	Humboldt	0.288	1.090	0.801	277.8%
21	San Luis Obispo	0.519	1.857	1.337	257.7%
18	Monterey	1.641	4.841	3.200	195.0%
16	Contra Costa	8.006	19.163	11.157	139.4%
6	San Francisco	197.352	448.098	250.746	127.1%
2	San Diego	594.150	1,266.566	672.416	113.2%
15	San Bernardino	11.127	22.729	11.602	104.3%
26	Napa	0.169	0.331	0.163	96.7%
12	Santa Cruz	16.652	30.365	13.713	82.4%
13	Riverside	14.651	25.584	10.933	74.6%
9	Yolo	79.545	129.705	50.161	63.1%
10	Sacramento	19.151	30.890	11.739	61.3%
5	Alameda	450.578	681.330	230.752	51.2%
3	Santa Clara	609.619	824.144	214.525	35.2%
19	Marin	2.357	2.900	0.543	23.0%
8	Santa Barbara	115.515	134.443	18.927	16.4%
1	Los Angeles	3,389.693	3,373.516	-16.177	-0.5%
4	Orange	669.345	655.515	-13.830	-2.1%
11	Ventura	25.351	24.432	-0.920	-3.6%
29	Inyo	0.060	0.054	-0.006	-10.2%
7	San Mateo	269.319	178.775	-90.545	-33.6%
23	Lake	0.738	0.403	-0.336	-45.5%
30	Kings	0.133	0.045	-0.089	-66.4%
22	San Joaquin	2.194	0.650	-1.544	-70.4%
28	Solano	0.414	0.115	-0.299	-72.3%
14	Kern	23.422	4.715	-18.708	-79.9%
		6,502.899	**7,871.912**	**1,369.012**	**21.1%**

[14] Ranking is determined by aggregated funding from 1993-99 inclusive.

IV. County Level Analysis of Performer Type

The state's R&D activities are conducted by a variety of performers, from individual businesses to research universities to private individuals, in some cases. This section analyzes county level data, by performer type. Project constraints will limit this analysis to performers of R&D activities in the top eight counties only. However, full performer type breakdown data has been provided for all counties in Sections V and VI of the Appendices.

A. Who Performs R&D Activities in Each County?

State level data reveals that over half of California's total R&D funding was awarded to individual businesses. However, at the regional (county) level, a more complex picture emerges. The mix of entities that perform R&D changes as one moves from one county to another. Figure IV-A through H breakdown R&D funding by performer type for the top eight counties receiving federal R&D funding. These top eight counties account for 96% of all R&D funding to the state.

While individual businesses account for 58.2% of total R&D funding at the state level, the percent of R&D performed by individual businesses can range from a low of 5% (Alameda County) to a high of 90% (Orange County), depending on the county. In five of the top eight counties, individual businesses receive more unclassified R&D funding than any other type of entity in their county, including universities, which typically represent the next highest type of awardee. Of the rest, there is a site-specific reason why other performers predominate. Fifth ranked Alameda County is the site of two DOE funded labs (Lawrence Berkeley National Labs and Lawrence Livermore National Labs), hence the predominant R&D performer in that county is the federal government. In sixth ranked San Francisco County, land scarcity probably prevents the siting of major technology industries hence the major performer of R&D is UCSF, a public university. Finally, seventh ranked San Mateo County is the site of the Stanford Linear Accelerator Center (SLAC), another DOE funded National Lab, hence the major R&D performer in that county is the federal government.

Please note that the pie charts below are uniformly coded by performer type (i.e. Individual Businesses = dark blue; Private Educational Institutions = dark green; Public Educational Institutions = red; Federal Government = orange; Non-Profit/Non-Educational Research Institutes = yellow; State or Local Government = mauve; and All Others = gray).[15]

[15] Color codes refer to the appearance of screen colors only. Colors in printed copies of this report may differ slightly due to a particular color printer's ability to translate screen colors into ink renderings. If there is any doubt about coloration, please refer to the agency abbreviation corresponding to that particular section of the pie chart.

Figure IV-A 1993-99 Unclassified R&D Funding to Los Angeles County, By Performer Type, Total = $23.124 Billion ***(Source: RaDiUS)***

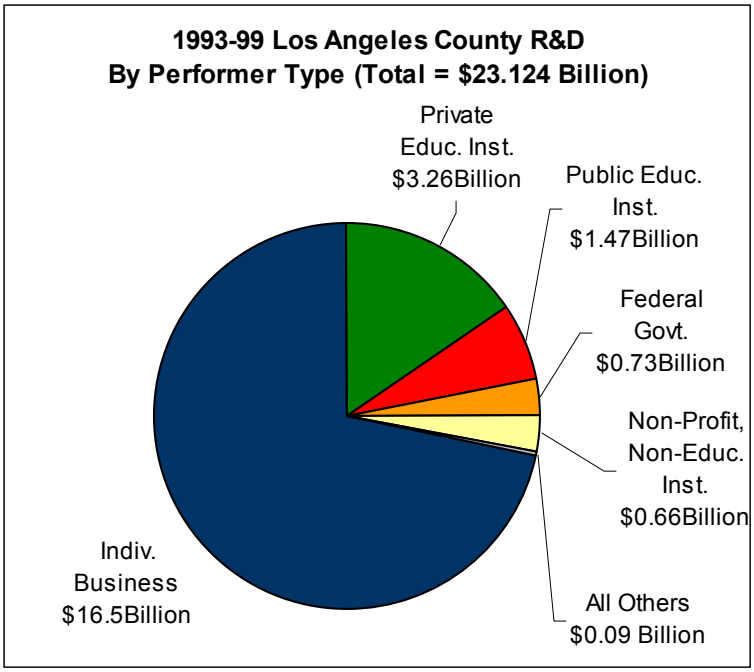


Figure IV-B 1993-99 Unclassified R&D Funding to San Diego County, By Performer Type, Total = $6.289 Billion ***(Source: RaDiUS)***

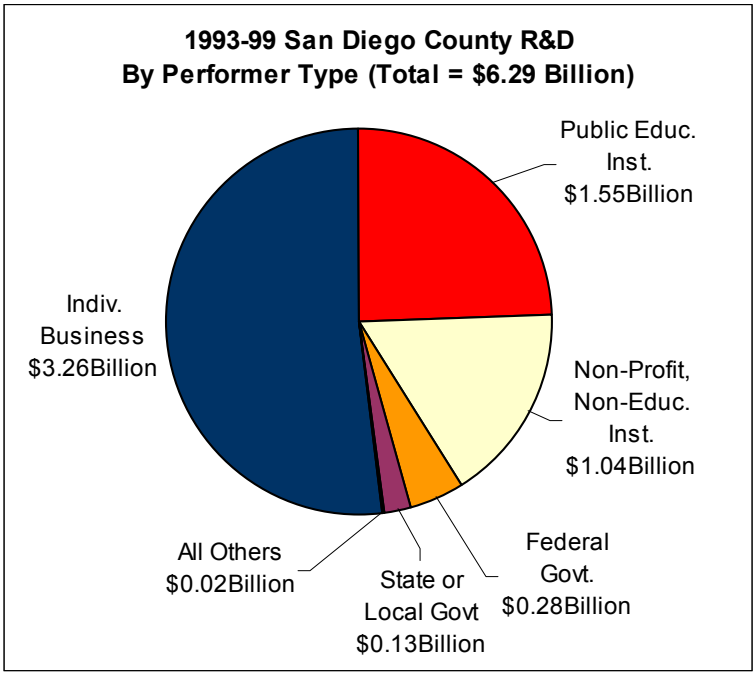


Figure IV-C 1993-99 Unclassified R&D Funding to Santa Clara County, By Performer Type, Total = $5.527 Billion ***(Source: RaDiUS)***

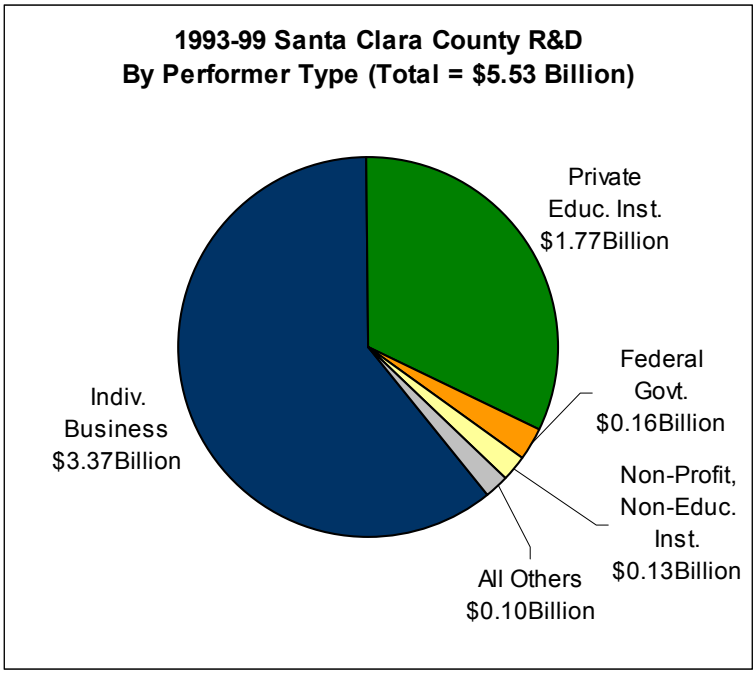


Figure IV-D 1993-99 Unclassified R&D Funding to Orange County, By Performer Type, Total = $4.735 Billion ***(Source: RaDiUS)***

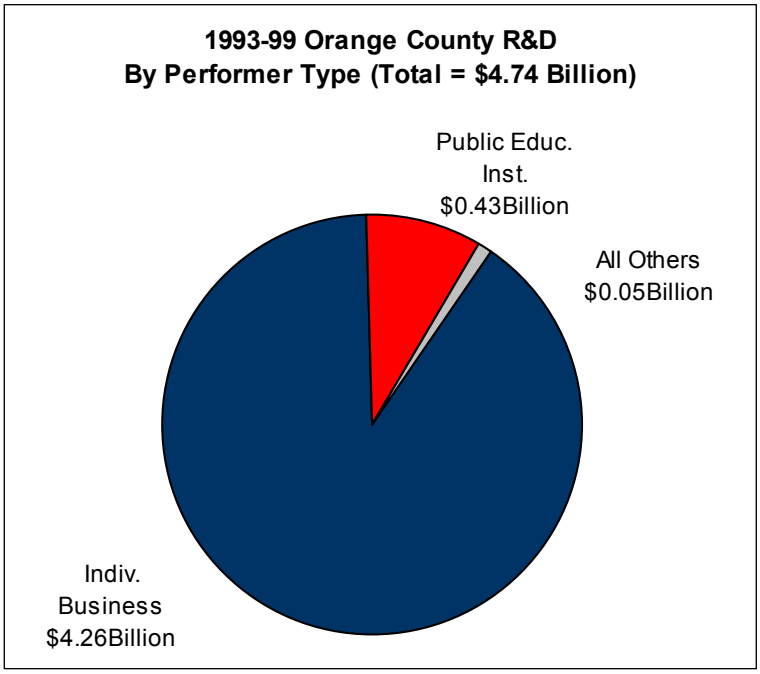


Figure IV-E 1993-99 Unclassified R&D Funding to Alameda County, By Performer Type, Total = $4.344 Billion ***(Source: RaDiUS)***

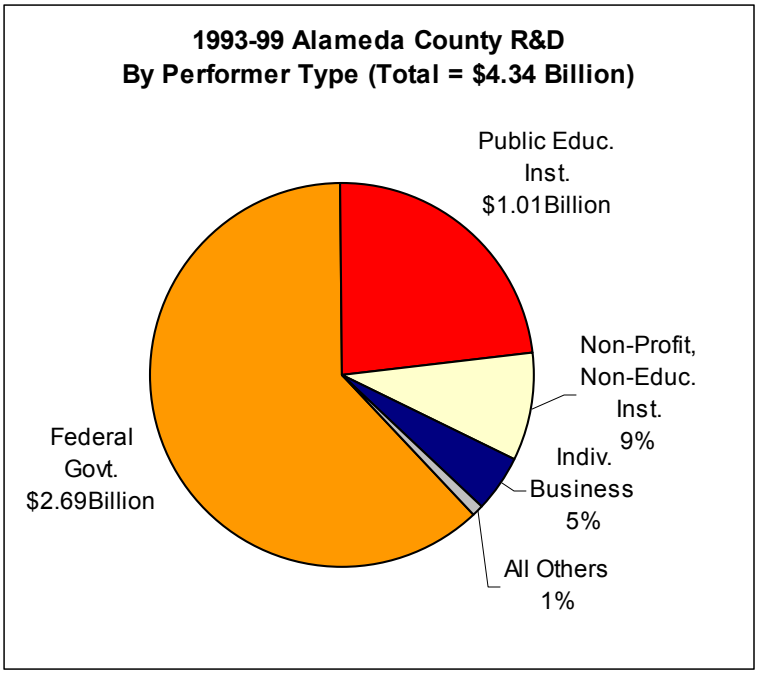


Figure IV-F 1993-99 Unclassified R&D Funding to San Francisco County, By Performer Type, Total = $1.985 Billion ***(Source: RaDiUS)***

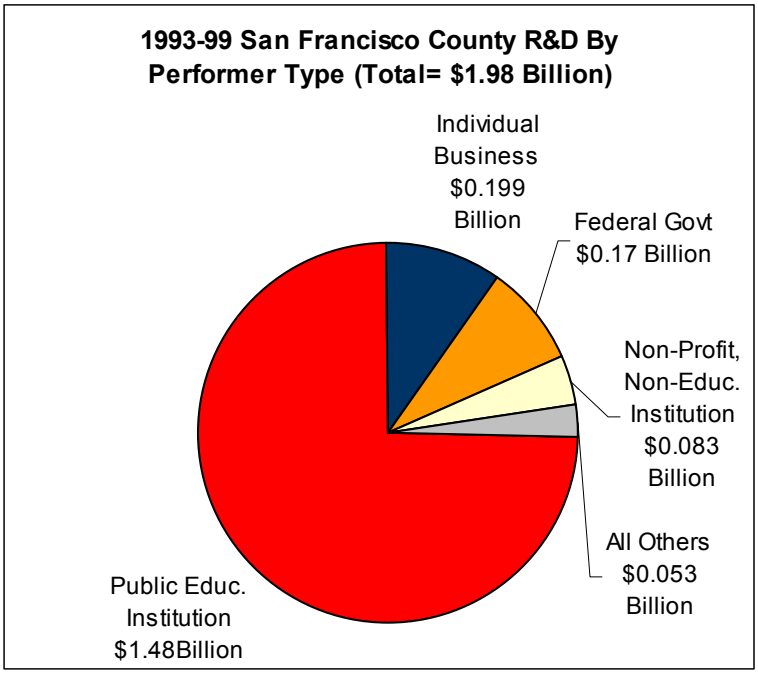


Figure IV-G 1993-99 Unclassified R&D Funding to San Mateo County, By Performer Type, Total = $1.415 Billion ***(Source: RaDiUS)***

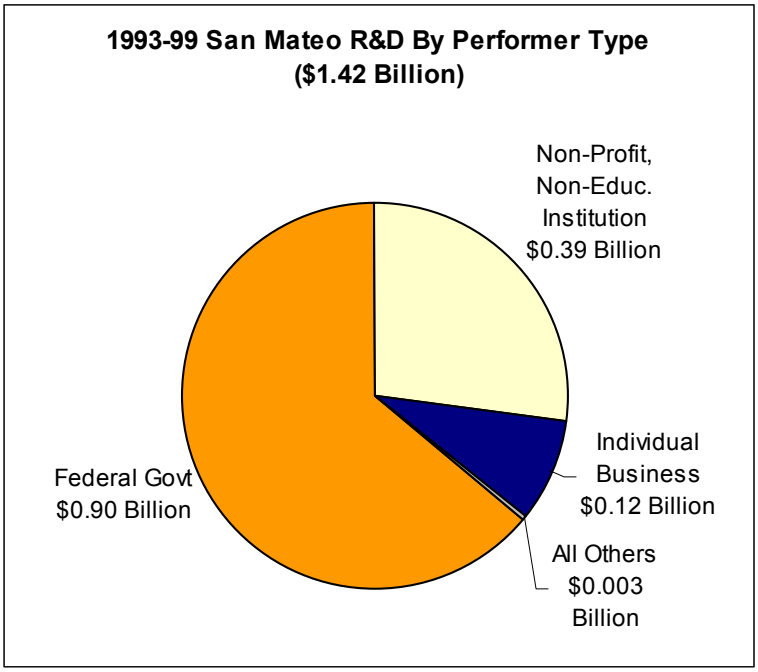
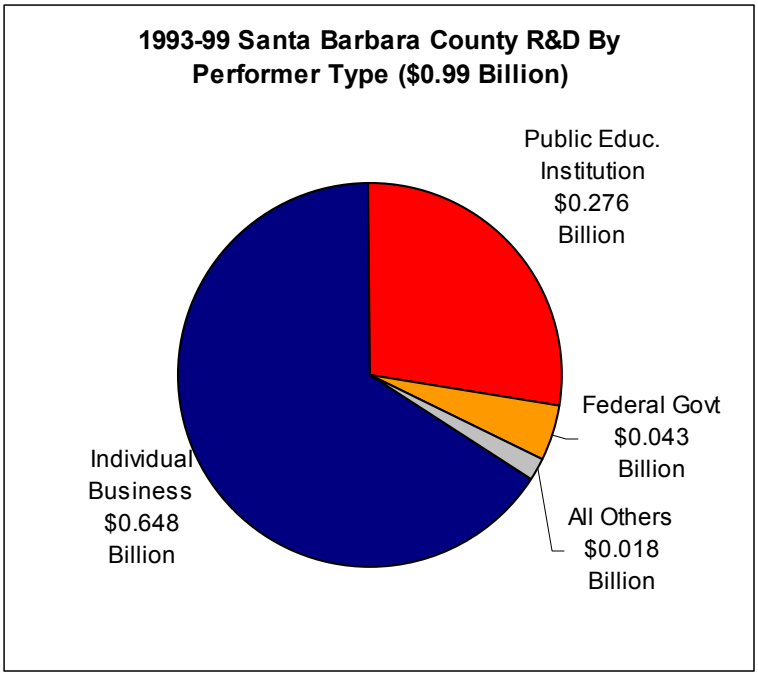


Figure IV-H 1993-99 Unclassified R&D Funding to Santa Barbara County, By Performer Type, Total = $0.986 Billion ***(Source: RaDiUS)***



B. 1993-99 Trends in Funding by Performer Type

At the state level, trends in funding to each performer type were relatively stable over the seven-year period (1993-99) studied. On the county level, trends were also fairly stable, with a few notable exceptions. Funding to private educational institutions in Los Angeles County dropped noticeably between FY1994 and FY1995. Funding to San Diego County businesses rose steadily over the first half of the 1990s. There were notable swings in funding to federal government labs in Alameda County between FY1993 and 1996. Funding to public educational institutions jumped in San Francisco County in FY1999. Finally there was a decrease in funding to federal government labs in San Mateo County between FY1994 and FY1995.

Are these effects significant or are they data anomalies? In general, one should be suspicious of large changes in funding from one year to the next. They can be a) signals of major programs being added or cut; *OR* b) merely "apparent" changes due to missing or incomplete data. Steady increases in funding over the course of several years are more likely to represent actual shifts rather than incomplete or missing data. On the other hand, large decreases in funding could be real if major program initiatives were being cut as funding priorities changed. Thus, at a first-glance, it is *likely* that the trends seen in most counties are real, but one should be extremely cautious when receiving the overview data presented for Los Angeles, San Francisco and San Mateo counties, absent other data that may shed light on significant events taking place that could have affected their numbers. As the RaDiUS database becomes more comprehensive, it will be easier to evaluate the reason for these shifts.

Figures IV-I through IV-P displays the performer type breakdown of unclassified R&D funding trends for each of the top 8 counties. All other counties are aggregated into Figure IV-Q.

Figure IV-I 1993-99 Unclassified R&D Funding Trends to Los Angeles County, By Performer Type, Aggregated Total Funding = $20.124 Billion ***(Source: RaDiUS)***

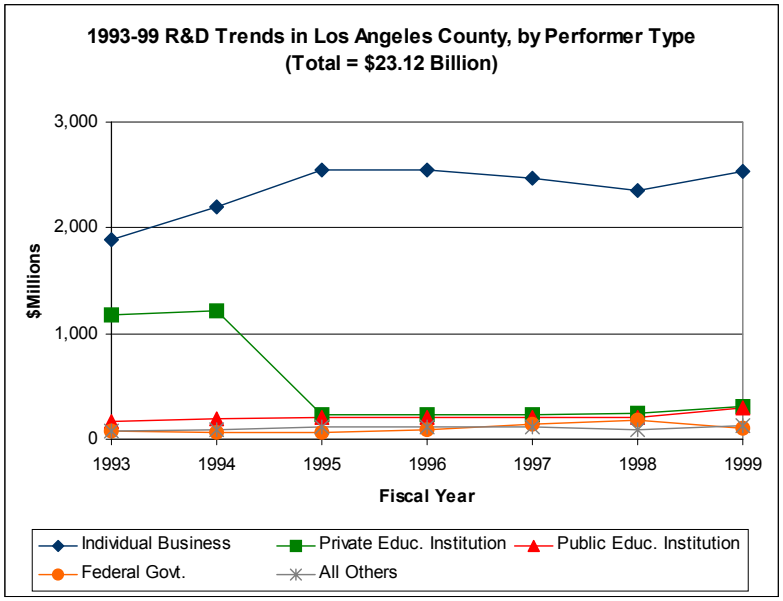


Figure IV-J 1993-99 Unclassified R&D Funding Trends to San Diego County, By Performer Type, Aggregated Total Funding = $6.289 Billion ***(Source: RaDiUS)***

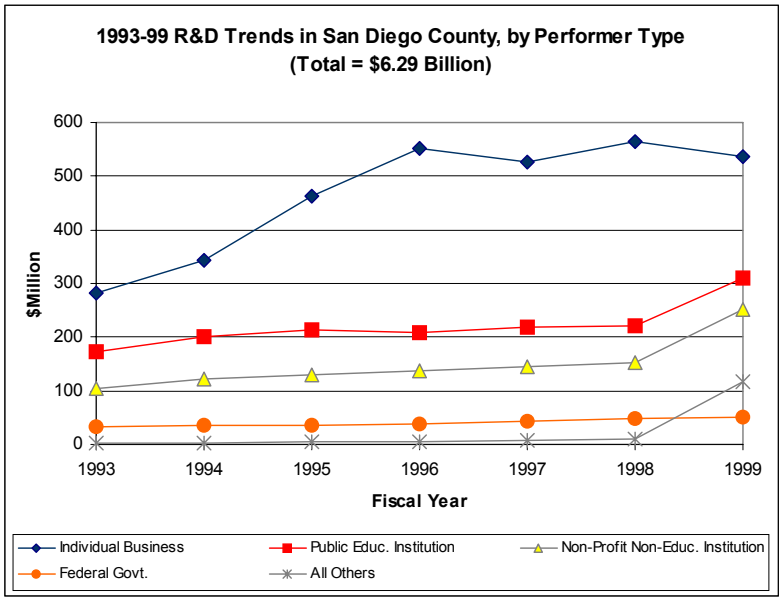


Figure IV-K 1993-99 Unclassified R&D Funding Trends to Santa Clara County, By Performer Type, Aggregated Total Funding = $5.527 Billion
(Source: RaDiUS)

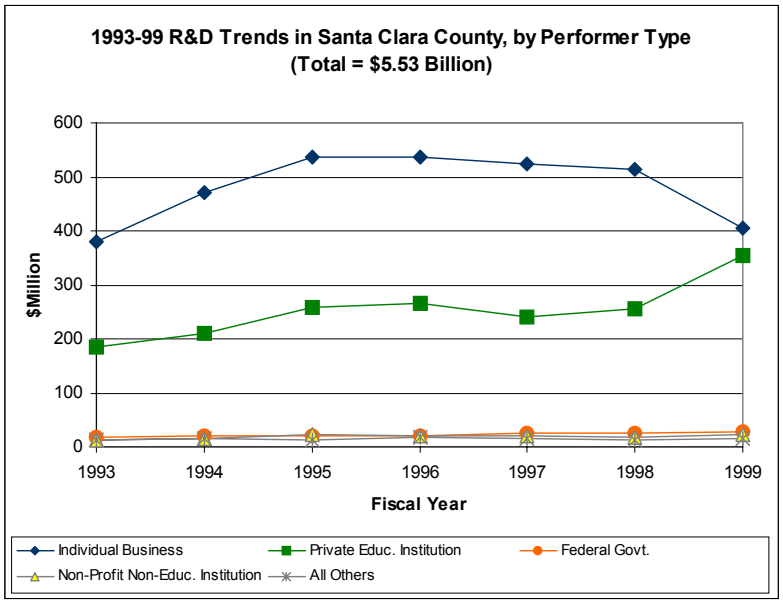


Figure IV-L 1993-99 Unclassified R&D Funding Trends to Orange County, By Performer Type, Aggregated Total Funding = $4.736 Billion
(Source: RaDiUS)

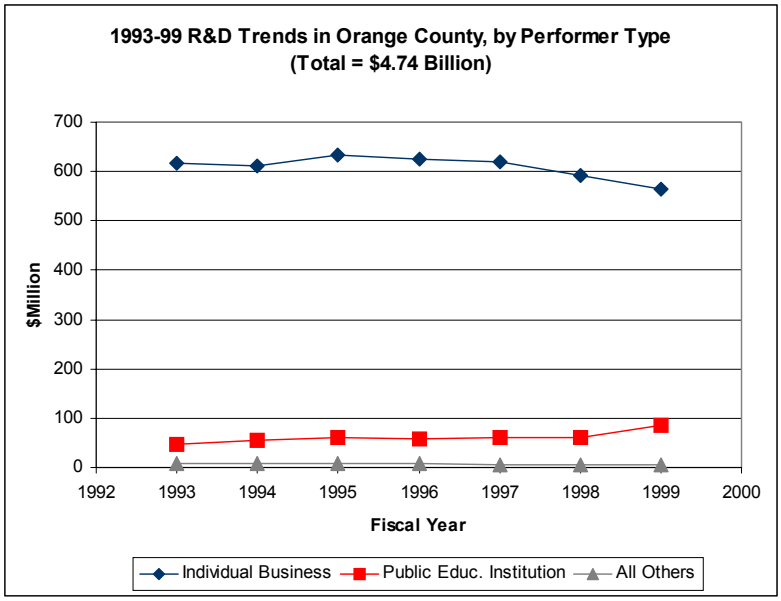


Figure IV-M 1993-99 Unclassified R&D Funding Trends to Alameda County, By Performer Type, Aggregated Total Funding = $4.344 Billion
(Source: RaDiUS)

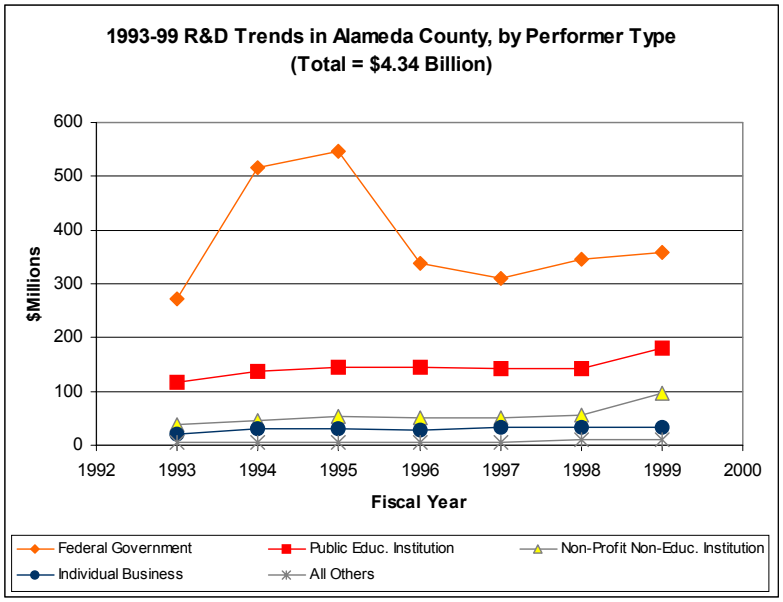


Figure IV-N 1993-99 Unclassified R&D Funding Trends to San Francisco County, By Performer Type, Aggregated Total Funding = $1.985 Billion
(Source: RaDiUS)

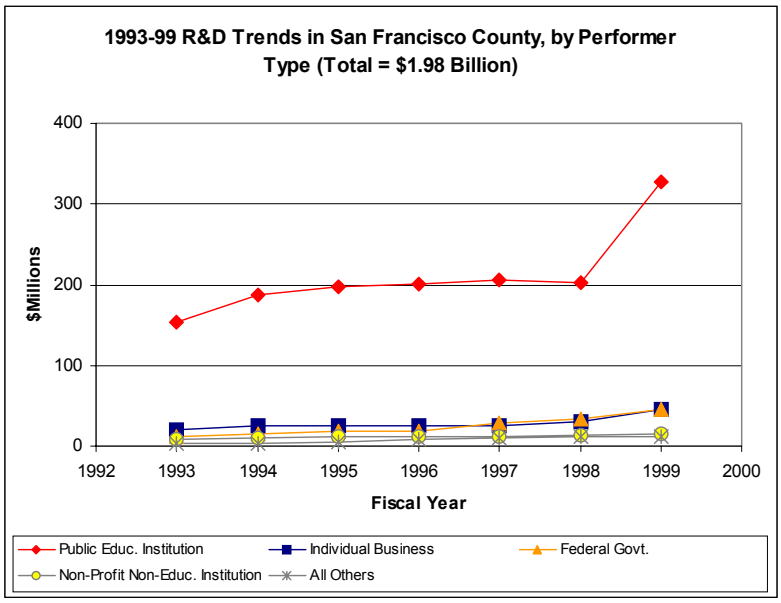


Figure IV-O 1993-99 Unclassified R&D Funding Trends to San Mateo County, By Performer Type, Aggregated Total Funding = $1.415 Billion
(Source: RaDiUS)

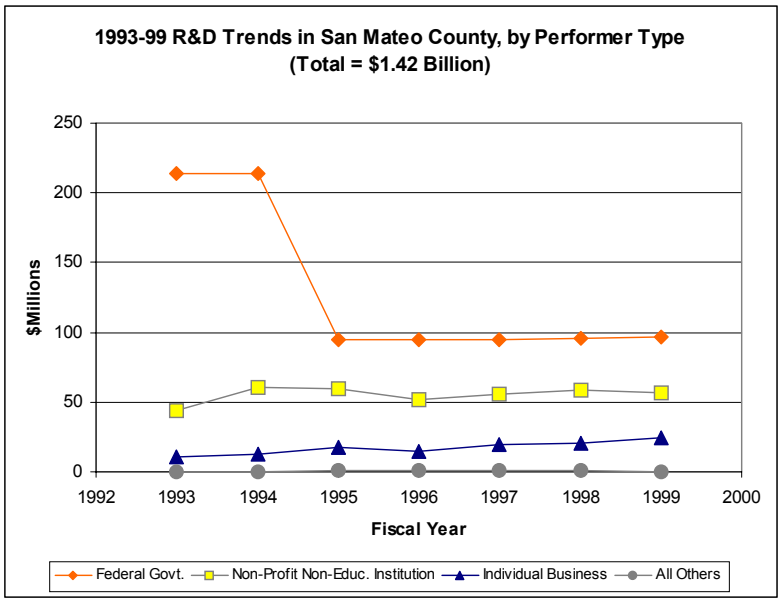


Figure IV-P 1993-99 Unclassified R&D Funding Trends to Santa Barbara County, By Performer Type, Aggregated Total Funding = $0.986 Billion
(Source: RaDiUS)

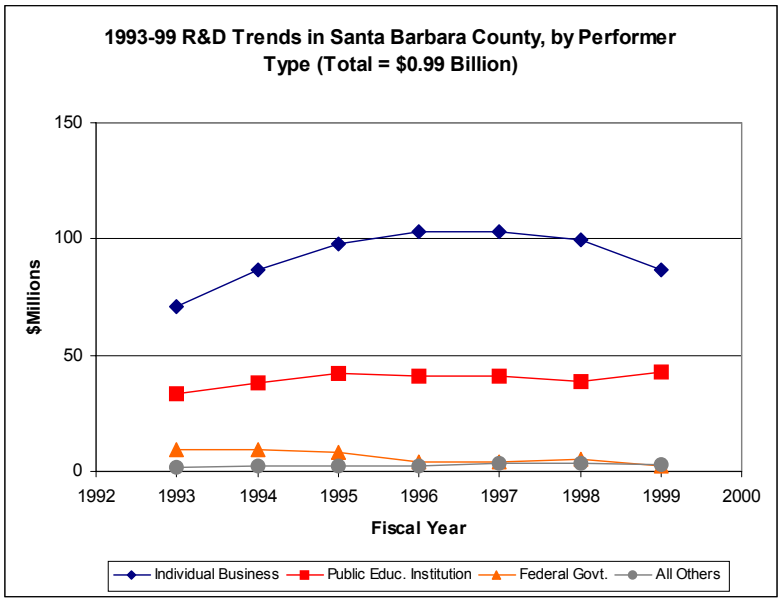
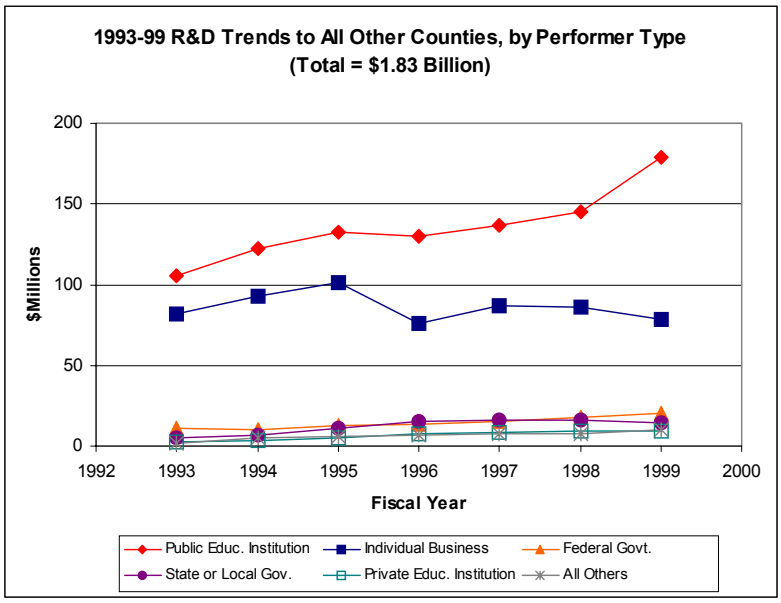


Figure IV-Q 1993-99 Unclassified R&D Funding Trends to All Other Counties, By Performer Type, Aggregated Total Funding = $1.382 Billion
(Source: RaDiUS)



V. Technology Sector Analysis of 1993-99 Aggregated R&D Funding

If R&D funding is an important driver of innovation in knowledge intensive industry sectors, then understanding how R&D funding supports the development of distinct technologies may be a useful indicator of research and innovation capacity for the State of California. As there is no separate field in RaDiUS titled "technology sector," it is difficult to represent such trends accurately. Furthermore, while there is an award description field associated with each record in RaDiUS, the content of this field derives from research abstracts. The technical language in the description often does not include general terms such as "biotechnology." Querying this field for terms corresponding to general technology terms such as "biotechnology" or "advanced computing" can lead to severe undercounts of research activity in all technology sectors of interest to this study.

On the other hand, RaDiUS data records are clearly identified by funding agency and most of these agencies have names that are clearly identifiable with certain technology sectors such as Energy, Defense, Health, and Transportation, among others. Yet, associating agencies with technology sectors is not a perfect solution either, as there are enabling technologies such as electronics and advanced computing that may be funded by a broad array of agencies.

To ***partially*** overcome these difficulties, an exploratory identification and categorization of R&D funding to technology sectors based on the assigned name of the program element was developed.[16] This section describes the methodology used and summarizes results from such an analysis.

However, the reader is cautioned to treat these results as <u>extremely</u> preliminary, rather than as definitive answers to an issue that is not easily handled by the RaDiUS data set.

Furthermore, this method does not guarantee that the results obtained will be completely accurate. On the one hand, this approach over-estimates the contribution from particular program elements because it may be attribute ***ALL*** of the funding for this program element to a particular technology sector when, in fact, only part of the total funding to that program element is relevant. For instance, NIST's Advanced Technology Program funds research applicable to many different technology sectors but this program element cannot be broken out, hence this funding has been included in all relevant technology sectors leading to an overcount. In other cases, this approach may under-estimate the actual funding to certain technology sectors that are not strictly identified by name. For instance, many NASA programs have mission specific names with no hint of the technologies being funded, e.g., a program titled "Mission to Planet Earth--Earth Probes Development" may be relevant to the Electronics sector but the uncertainty in the name precludes attributing this funding to Electronics.

[16] Program elements are individual programs administered within a particular agency or sub-agency. This is the most detailed level for drilling down into RaDiUS data. For example, "Neuroscience" is a program element within NSF's Directorate of Biological Sciences' Division of Molecular & Cellular Biosciences.

Therefore, the reader is cautioned against summing up the funding sub-totals obtained by this method of analysis. <u>There is NO one-to-one correspondence possible at this time.</u>

A. Categorizing RaDiUS Data into Technology Sectors

One method for creating technology sector counts from RaDiUS data begins by assigning technology sectors to the specific agency program that funds and oversees each award or task. RaDiUS data is amenable to this type of analysis because there are a series of fields (titled "Level 1" through "Level 4") that specify the agency, sub-agency, program and/or division associated with each grant or award. For the most part, these program descriptions provide enough detail that each can be assigned to a particular technology sector (e.g., a NSF program titled "Advanced Computing Research" can be assigned to the Advanced Computing technology sector). However, there are instances where either a) the agency or program hierarchy is missing or not available; *OR* b) the agency or program hierarchy is available but the funding is classified; *OR* c) the agency or program hierarchy is not available but the funding data is available. (See Table V-A for a full explanation of program hierarchies and sample listings.) Finally, if a program element may be relevant to more than one technology sector, its funding has been included in ***all*** relevant sectors.

Hence, the reader is cautioned against comparing these R&D funding totals with funding totals from other sections of this report. The totals reported here will NOT sum up to totals reported in the other sections! Nonetheless, they provide an overview of likely trends in funding.

Pleased see Section VIII of the Appendices for a full list of the agencies and program elements assigned to each particular technology sector. Please note that some program elements have been used for more than one technology sector. In other cases, some program elements have not been included in *any* technology sector because a) they were irrelevant to the technology sectors studied; *OR* b) there was extreme ambiguity in categorizing the research and matching it against any of the technology sectors of interest.

Table V-A An Explanation of Program Descriptions in the RaDiUS Database

RaDiUS Field Name	Agency/Program Hierarchy Associated with This Field[17]	Example 1: Full Hierarchy Available	Example 2: Hierarchy Unavailable	Example 3: Hierarchy Available but Funding is Classified	Example 4: Hierarchy is Partially Missing
Level 1	Agency Name	Department of Health & Human Services	Environmental Protection Agency	Department of Defense	Department of Defense
Level 2	Sub-Agency Name, if this exists	National Institutes of Health	R&D Contracts	Defense Advanced Research Projects Agency (DARPA)	Defense Advanced Research Projects Agency (DARPA)
Level 3	Division within a Subagency, if this exists	National Institute of General Medical Sciences	(blank)	0602712E - Materials & Electronics Technology	R&D Contracts Not Linked to Specific Program Elements
Level 4	Program Title	AIDS Research	(blank)	Project Number Unspecified	(blank)
Funding Data Available?		*Yes*	*Yes*	*Not available (classified)*	*Yes*

B. 1993-99 State-wide R&D Funding by Technology Sector

Using the methodology detailed above, the unclassified R&D funding for California was reorganized into a series of 11 technology sectors. These include:

- advanced computing
- advanced materials
- aerospace
- defense
- electronics
- energy
- environmental technologies
- life sciences/biotechnology
- telecommunications
- transportation
- other

[17] If there is no sub-agency or division involved, then the highest level populated is given to the program title. Hence, if EPA funding is not associated with a particular division or sub-agency, then Level 2 will be used for the program title. Likewise, DARPA funding is not subdivided into divisions so Level 3 is used for the program title and Level 4 is unused (blank).

Table V-B detail the sectors chosen and the overall funding attributed to each sector. Figures V-A through K consist of a series of pie charts outlining which agencies are major contributors to R&D activities for each technology sector. Some technology sectors are almost wholly funded by one agency, e.g., Defense, Energy and Aerospace sectors. In contrast, other technologies such as Advanced Computing, Advanced Materials, and Environmental Technologies are funded by a number of agencies. In most cases, even if several agencies fund research activities in a particular technology sector, there is usually one lead agency that provides the bulk of the funding in that area. The agencies that fund each particular technology sector are quite predictable. In other words, one should not be surprised that the Department of Energy funds R&D in the Energy sector, or that the Department of Transportation provides the bulk of the funding for Transportation R&D. Finally, the category marked "Other" consists of all program elements that do not fit into the ten categories above. These include agencies such as the Department of Education as well as program elements from agencies such as NSF that do not fit other technology categories. For a full breakdown of program elements, please see Sections VII and VIII of the Appendices.

As noted previously, one should view these results as ***extremely*** preliminary. For example, these pie charts do not fully reflect DOD activities in each of these technology sectors. The United States Army funds a large number of research programs that can be clearly identified as life sciences/biotechnology related but there are no funding data associated with these program elements, hence the pie chart for the life sciences/biotechnology sector is incomplete because the DOD component is missing.

Because of the difficulties in classifying DOD research activities by technology sectors, an extra effort was made to probe all DOD grant records with non-zero funding amounts listed under "R&D Contracts Not Specifically Tied to Program Elements". In particular, the content of the award description field associated with these grants was examined to see if this field might yield additional complementary information that would assist in technology sector classification. Unfortunately, while some agencies include extensive descriptive abstracts with each award or task, DOD was the one exception to the rule. There is ***no*** currently useful information listed in the award description field for any DOD awards and tasks in the database.[18]

In order to make up for these shortfalls, a separate technology category called "Defense" was created. Thus, while it is impossible to determine what fraction of DOD funding goes towards each technology category, it is possible to assign an overall number to unclassified defense research. This arises because unclassified defense R&D activities are listed under a catch-all category called "R&D Contracts Not Specifically Tied to Program Elements".

Finally, please note that these technology sector totals ***will not*** add up to the $50.24 billion, the aggregated total R&D funding to the state of California between 1993 and 1999 listed in other sections of this report. The reasons include:

a) certain programs may fund a particular research activity that forms the basis of enabling technology for relevant for more than one technology sector; *OR*

[18] From private communications with Rand, it is not clear if this data is currently unavailable due to security reasons or if it's not available from the source because DOD does not choose to track this information.

b) certain general programs such as NIST's Advanced Technology Programs fund activities in more than one technology area.

It is impossible to break out funding from NIST to each technology area from this method of analysis, hence full funding from this NIST has been attributed to each technology sector, leading to a natural multiple overcount of NIST's contributions. This is reflected in Table V-B as a percentage total that does not equal 100%. Please see Section VIII of the Appendices for the full list of all program elements that contributed to each technology sector.

The missing DOD data also distorts the total funding in Table V-B that is attributed to each technology sector. From the detailed data listed in Section VII of the Appendices, it is clear that DOD funds a significant amount of R&D activities in Advanced Computing, Advanced Materials, Electronics, Telecommunication and even Transportation (Logistics) but because these results are classified and/or unavailable, we have no indications of funding amounts to each individual technology sector. Hence, reportedfunding to these technology sectors are very likely underestimates of the true, complete picture.

Table V-B 1993-99 CA Unclassified R&D Funding to Each Technology Sector *(Source: RaDiUS)*

Technology Sector	1993-99 Funding ($Billions)	% of Funding[19]
Defense	**19.770**	**39.4%**
Aerospace	**14.178**	**28.2%**
Life Sciences/Biotech	**10.629**	**21.2%**
Energy	**2.884**	**5.7%**
Environmental Technologies	**2.480**	**4.9%**
Advanced Computing	**1.221**	**2.4%**
Advanced Materials	**1.184**	**2.4%**
Electronics	**0.351**	**0.7%**
Telecommunications	**0.263**	**0.5%**
Transportation	**0.152**	**0.3%**
Other[20]	***0.992***	***2.0%***
Agency Totals:	**54.104**[21]	**107.7%**

Please note that the following pie charts are uniformly coded by agency (i.e. NASA = dark blue, DOD = dark green, HHS = yellow, NSF = orange, DOE = red, DOC = olive, DVA = brown, DED = white, USDA = mauve, and All Other = gray).[22]

[19] These percentages are calculated based on the 1993-99 total funding to the state of California, which equals $50.24 billion.

[20] This category includes program elements that are not technology sector related, e.g. social science research. See Section VIII-K of the Appendices for a full breakdown of the program elements that constitute this category.

[21] This total does NOT correspond to the $50.24 Billion listed in other sections of this report!

[22] Color codes refer to the appearance of screen colors only. Colors in printed copies of this report may differ slightly due to a particular color printer's ability to translate screen colors into ink renderings. If there is any doubt about coloration, please refer to the agency abbreviation corresponding to that particular section of the pie chart.

Figure V-A **1993-99 Agency Breakdown of R&D Funding to the Advanced Computing Sector, Total = $1.221 Billion** ***(Source: RaDiUS)***

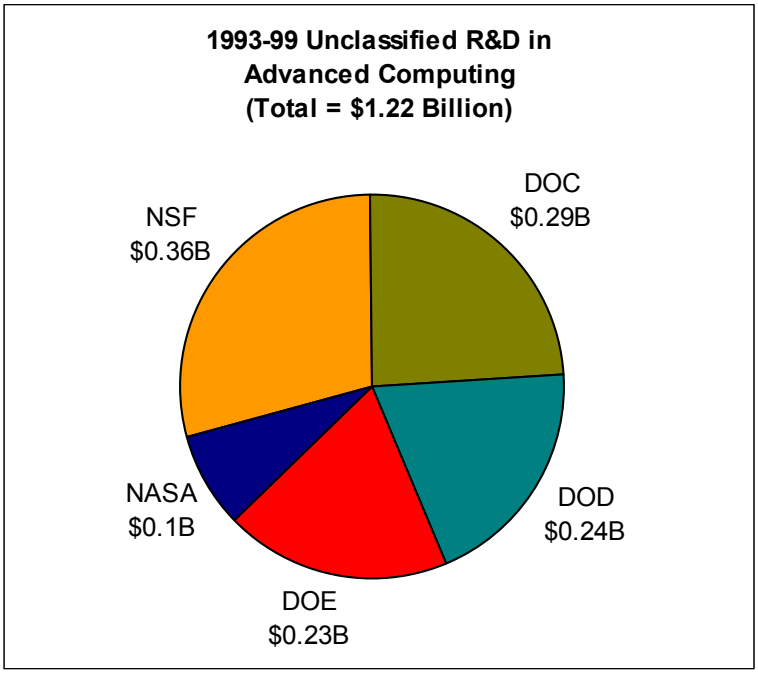


Figure V-B **1993-99 Agency Breakdown of R&D Funding to the Advanced Materials Sector, Total = $1.183 Billion** ***(Source: RaDiUS)***

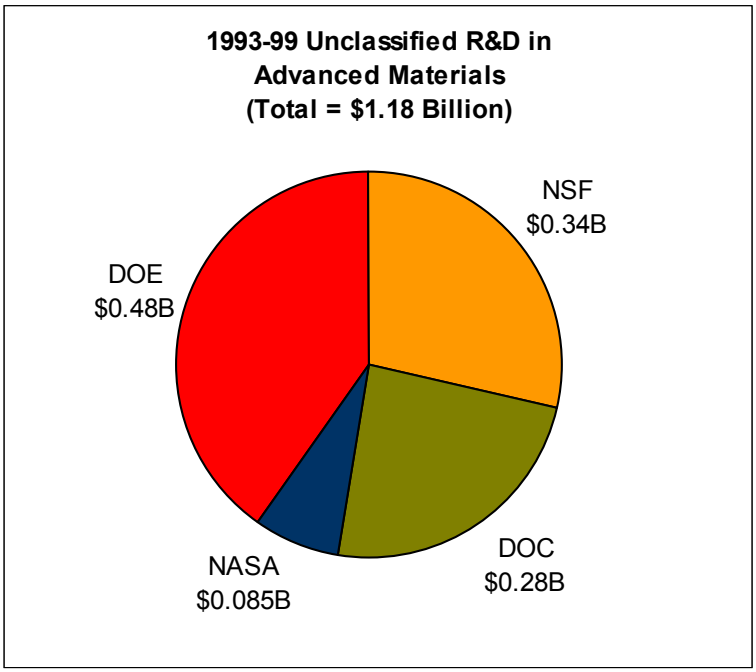


Figure V-C **1993-99 Agency Breakdown of R&D Funding to the Aerospace Sector, Total = $14.178 Billion** ***(Source: RaDiUS)***

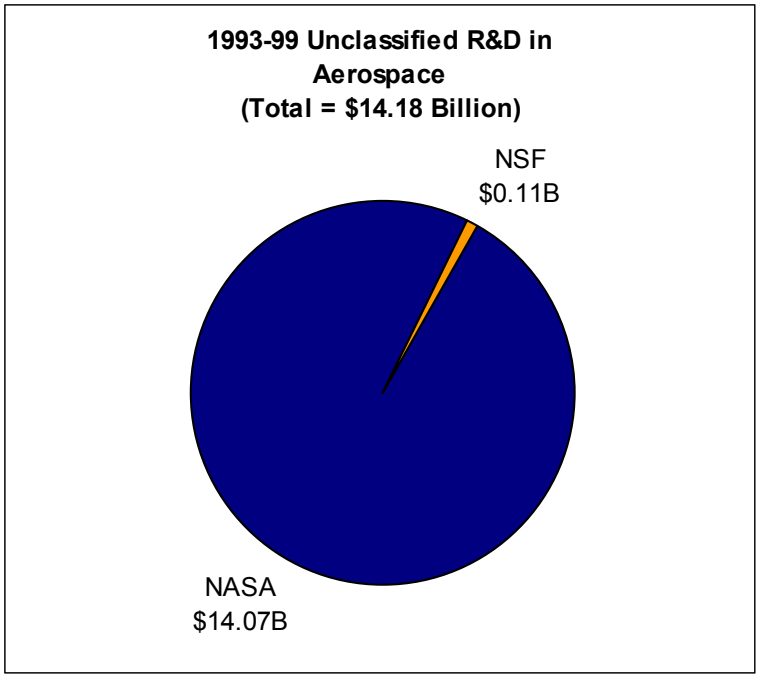


Figure V-D **1993-99 Agency Breakdown of R&D Funding to the Defense Sector, Total = $19.771 Billion** ***(Source: RaDiUS)***

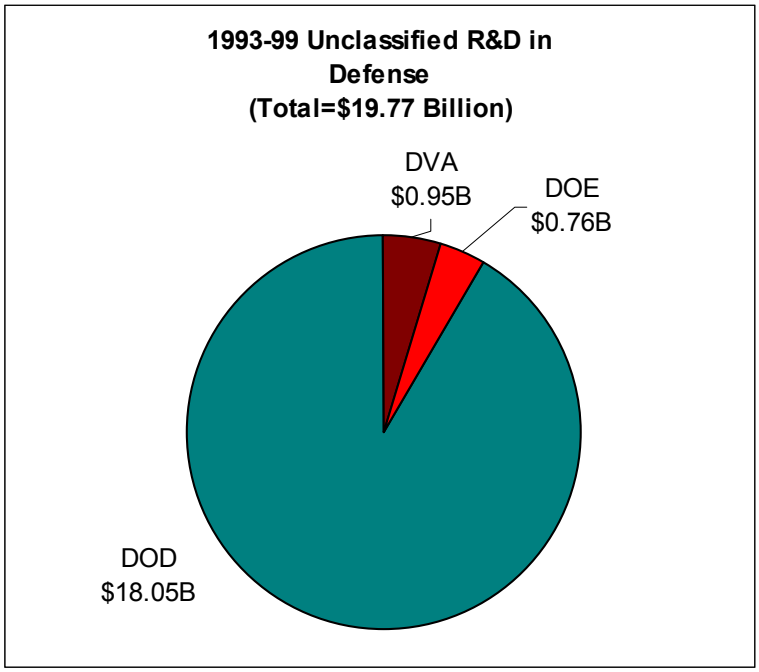


Figure V-E **1993-99 Agency Breakdown of R&D Funding to the Electronics Sector, Total = $0.351 Billion** ***(Source: RaDiUS)***

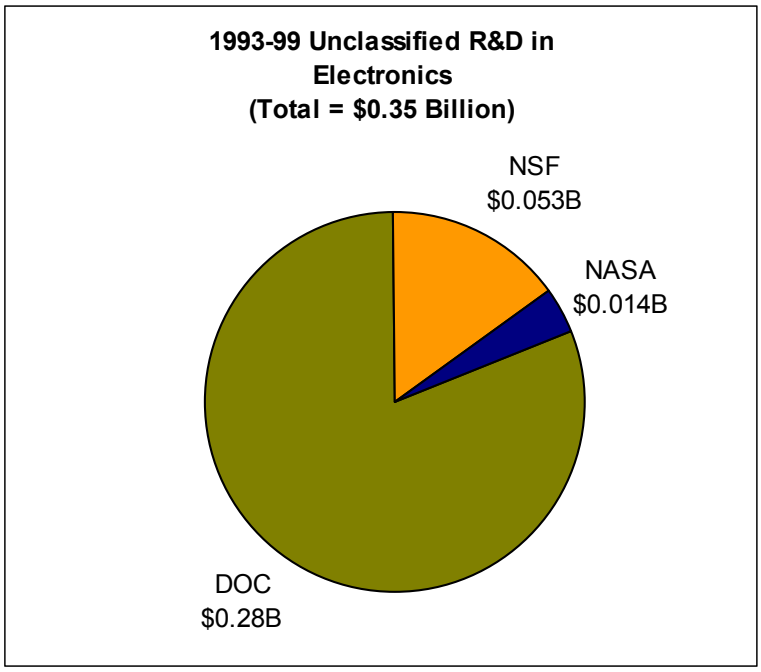


Figure V-F **1993-99 Agency Breakdown of R&D Funding to the Energy Sector Total = $2.884 Billion** ***(Source: RaDiUS)***

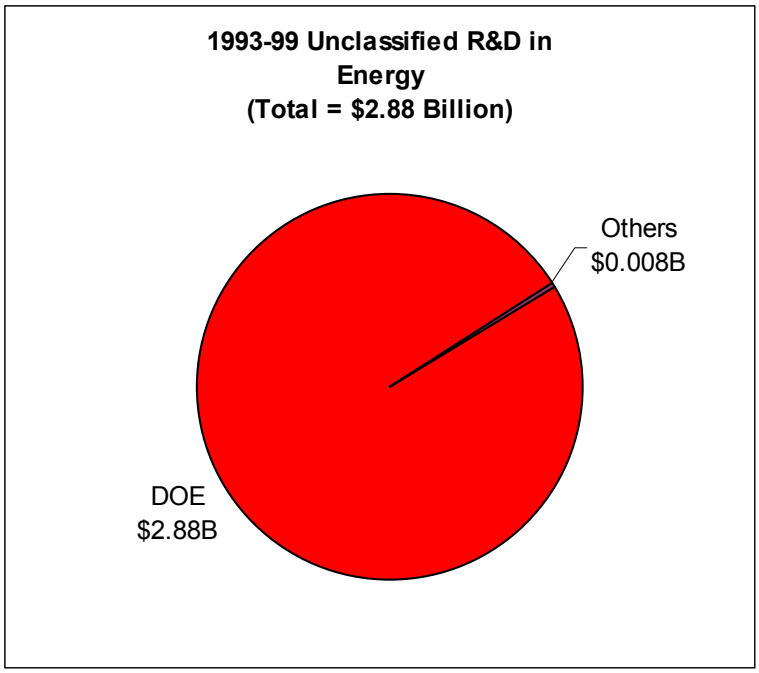


Figure V-G **1993-99 Agency Breakdown of R&D Funding to the Environmental Technologies Sector, Total = $2.480 Billion** ***(Source: RaDiUS)***

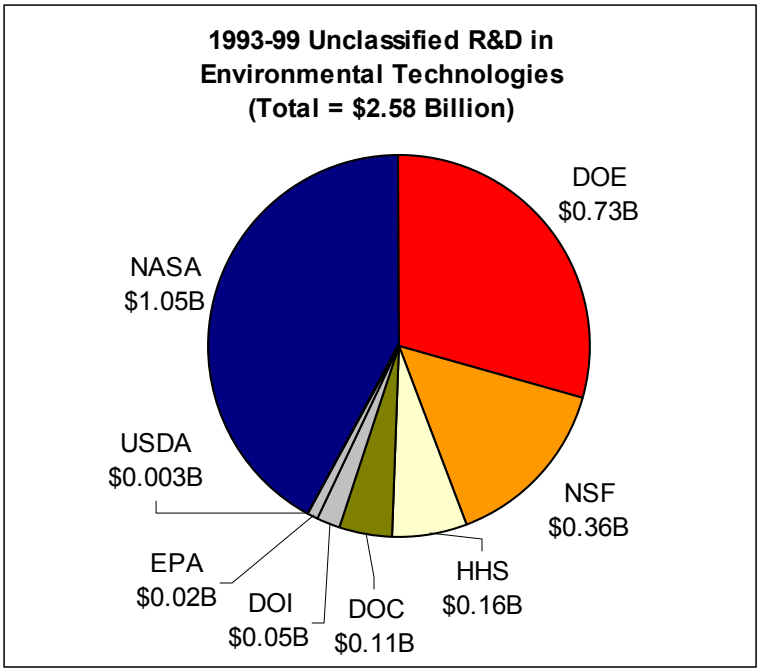


Figure V-H **1993-99 Agency Breakdown of R&D Funding to the Life Sciences Sector Total = $10.629 Billion** ***(Source: RaDiUS)***

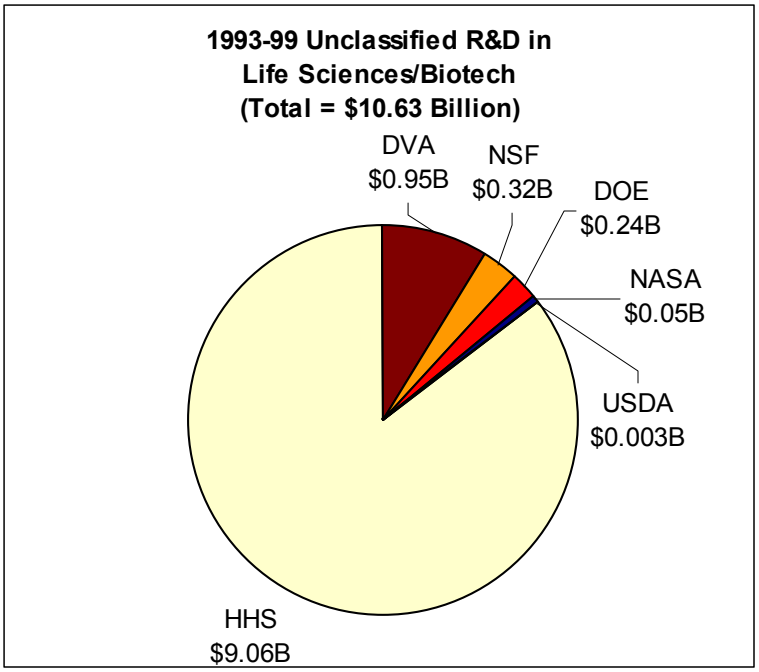


Figure V-I **1993-99 Agency Breakdown of R&D Funding to the Telecommunications Sector, Total = $0.263 Billion** ***(Source: RaDiUS)***

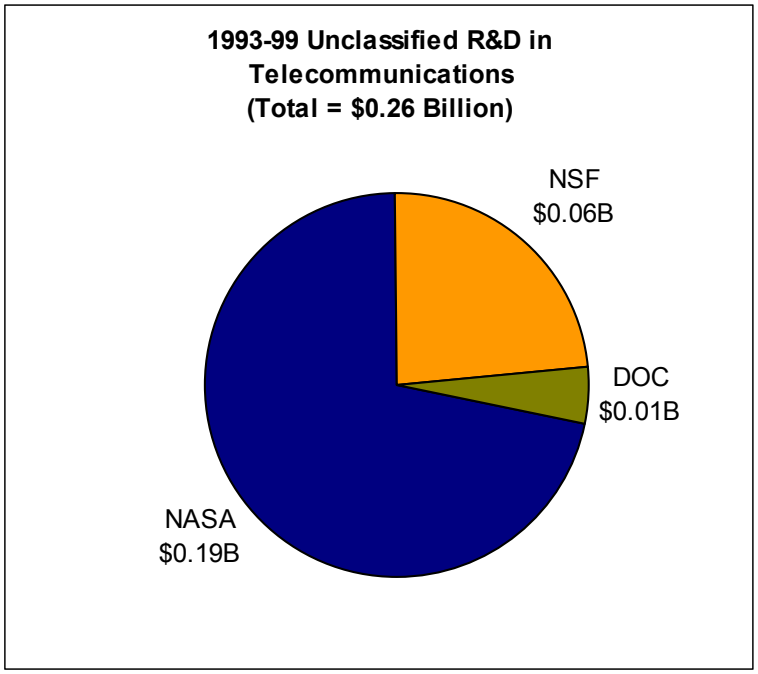


Figure V-J **1993-99 Agency Breakdown of R&D Funding to the Transportation Sector Total = $0.152 Billion** ***(Source: RaDiUS)***

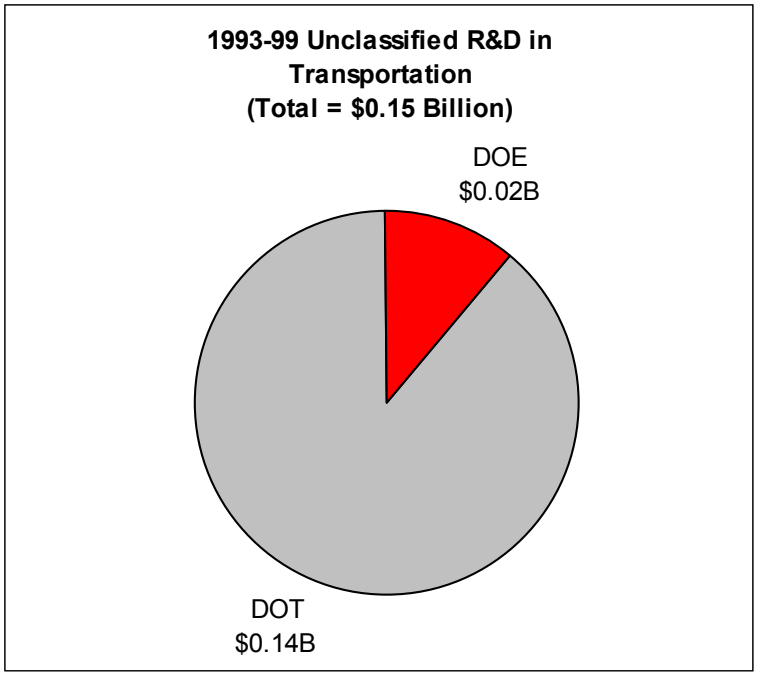
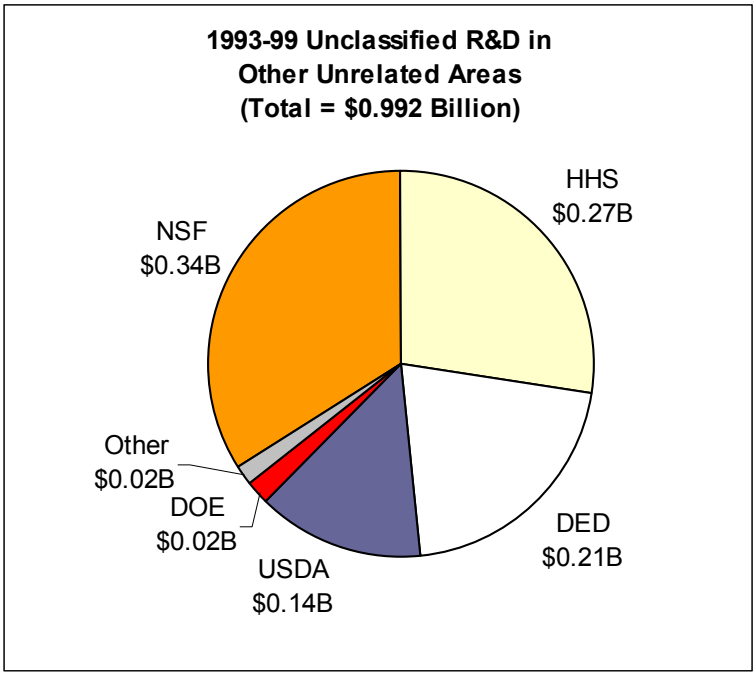


Figure V-K 1993-99 Agency Breakdown of R&D Funding to Other Unrelated Sectors, Total = $0.992 Billion ***(Source: RaDiUS)***

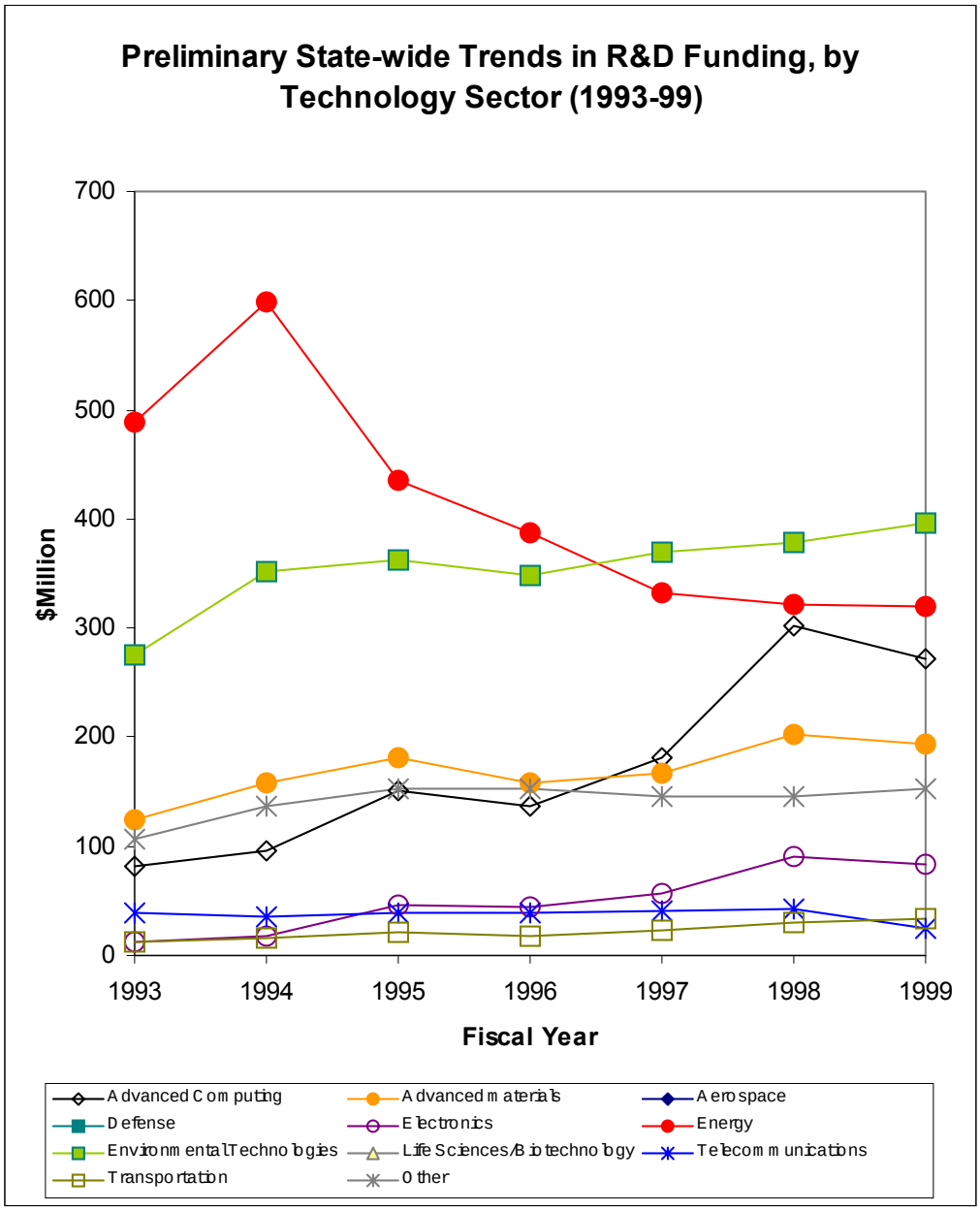


C. Technology Sector Funding Trends

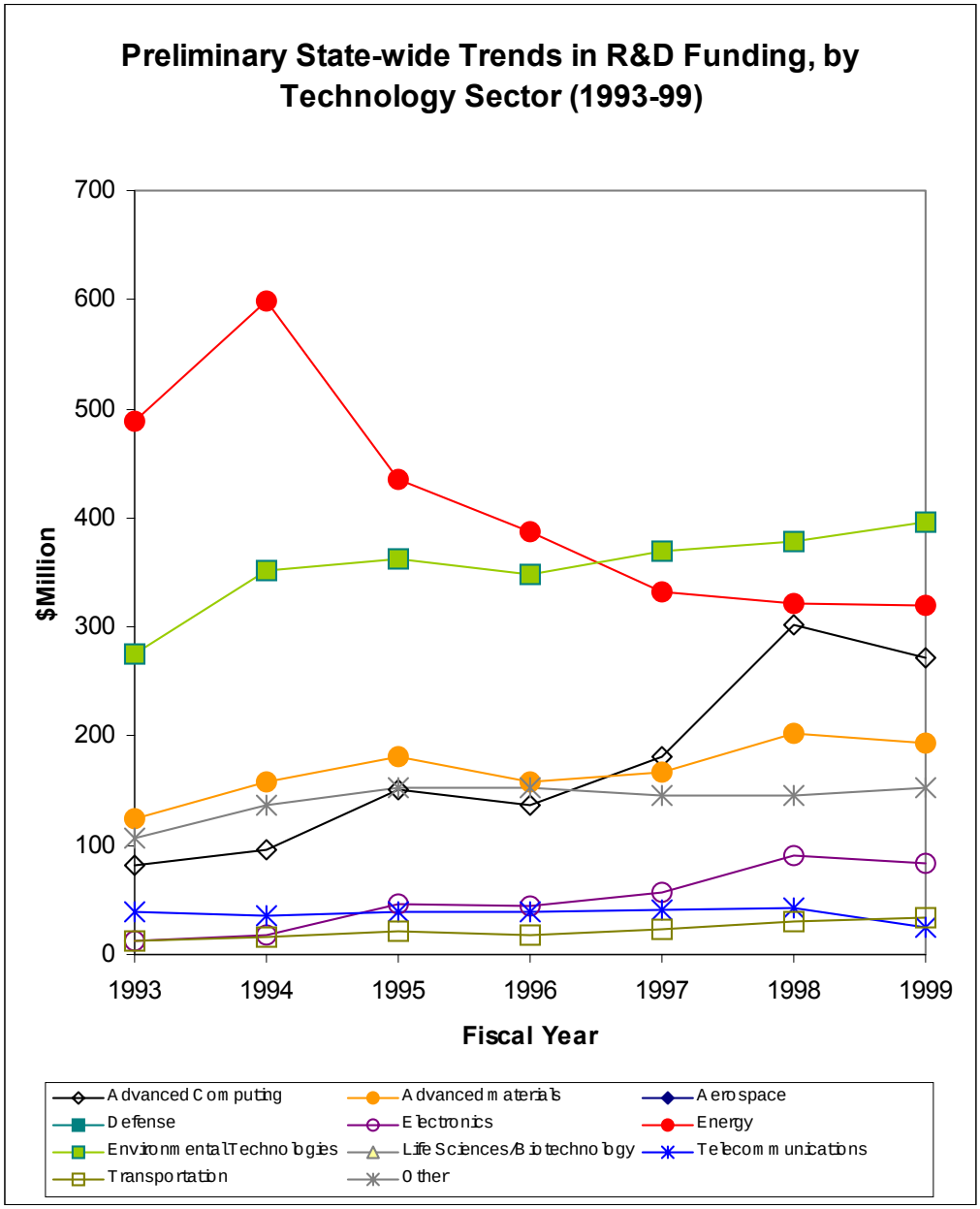
Aggregated state-wide funding trends for each technology sector are shown in Figure V-L(i,ii). From Figure V-L(i), it is clear that funding for Aerospace technologies decreased in the mid 1990s while life sciences funding has been steadily increasing. Funding for defense technologies have also decreased slightly in recent years. The expanded scale on Figure V-L(ii) highlights funding changes for sectors that receive much less funding that these three dominant areas. Figure V-L(ii) reveals that funding to the Energy Sector decreased by funding to Transportation technologies has increased. Funding to all other technology sectors remained relatively stable.

Figure V-L **1993-99 State-wide Funding Trends for Each Technology Sector (Source: RaDiUS)**

i) Full Scale Plot



ii) Expanded Y Scale Plot



D. Technology Sector Analyses of Top 8 Counties

In the earlier discussion in Section III, county level analysis of R&D funding revealed that each county exhibited different R&D strengths, based on the breakdown by agency. Hence it should come as no surprise that each county's R&D strengths differ by technology sector as well, especially since there is correlation between agency and technology sector funded. For instance, Los Angeles county receives a large portion of its R&D funding from NASA and DOD.

Similarly, a large portion of Los Angeles' R&D is conducted by the Aerospace and Defense technology sectors. Among the top eight counties receiving R&D funding, there are few surprises with technology sector funding more or less matching agency funding. Those counties that receive the majority of their R&D funding from NASA and DOD excelled in the aerospace and defense sectors. Alameda County was the only county that exhibited differences in that while DOE funded 62% of all R&D activity yet only 27% of R&D can be attributed to the Energy sector and 19% can be attributed to defense. However, this is not surprising as DOE does fund a significant fraction of defense related R&D activities.

Figures V-M through V-U consist of a series of pie charts detailing the technology sector breakdowns of R&D activities to the top eight counties receiving R&D funding in the state (see Section VIII of the Appendices for technology sector breakdowns of each individual county). Please note that the total funding amounts listed in these pie charts do not correspond to funding totals listed in other sections of this report. The technology sector methodology naturally leads to a slight over count of funding due to the methods used to assign program elements to technology sectors.

The following pie charts are uniformly coded by technology sector (i.e. Aerospace = dark blue, Defense = dark green, Life Sciences/Biotech = yellow, Advanced Materials = orange, Advanced Computing = brown, Energy = red, Environmental Technologies = light green and Others = gray).[23]

[23] Color codes refer to the appearance of screen colors only. Colors in printed copies of this report may differ slightly due to a particular color printer's ability to translate screen colors into ink renderings. If there is any doubt about coloration, please refer to the agency abbreviation corresponding to that particular section of the pie chart.

Figure V-M 1993-99 Technology Sector Breakdown of 1993-99 Unclassified R&D Funding to Los Angeles County, Total = $23.679 Billion ***(Source: RaDiUS)***

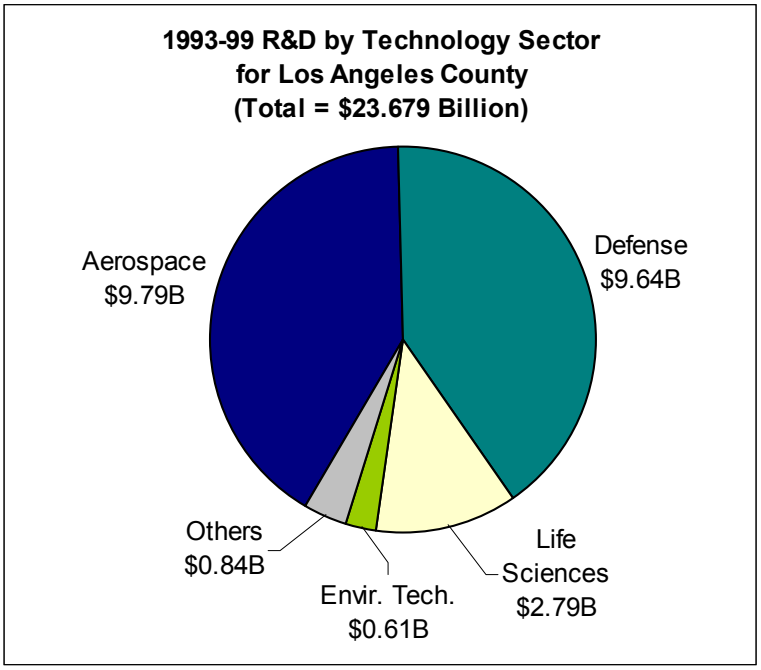


Figure V-N 1993-99 Technology Sector Breakdown of R&D Funding to San Diego County, Total = $6.816 Billion ***(Source: RaDiUS)***

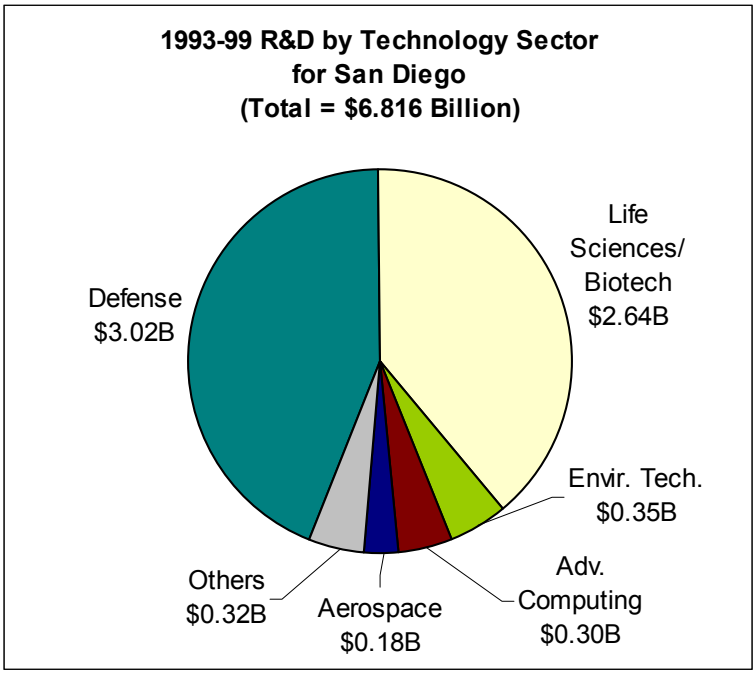


Figure V-O 1993-99 Technology Sector Breakdown of R&D Funding to Santa Clara County, Total = $6.261 Billion ***(Source: RaDiUS)***

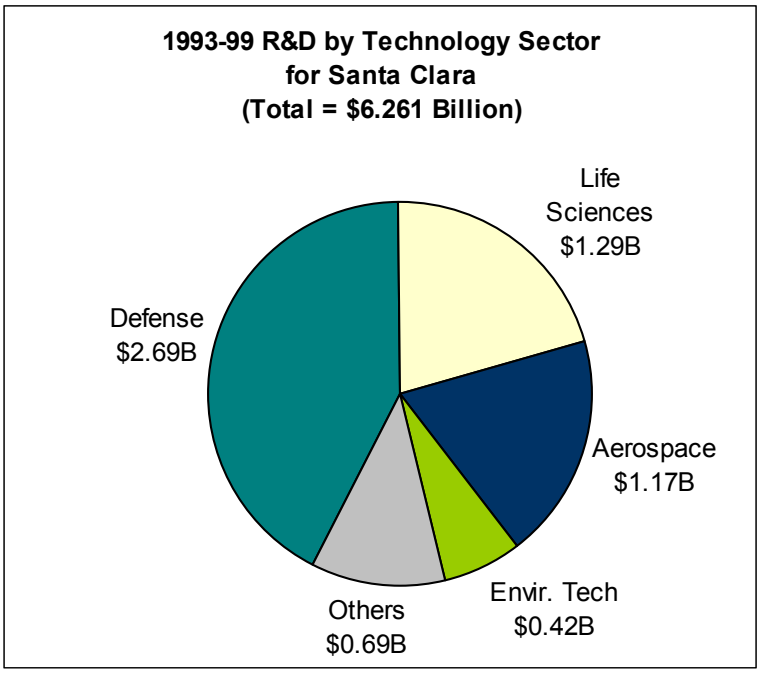


Figure V-P 1993-99 Technology Sector Breakdown of R&D Funding to Orange County, Total = $4.745 Billion ***(Source: RaDiUS)***

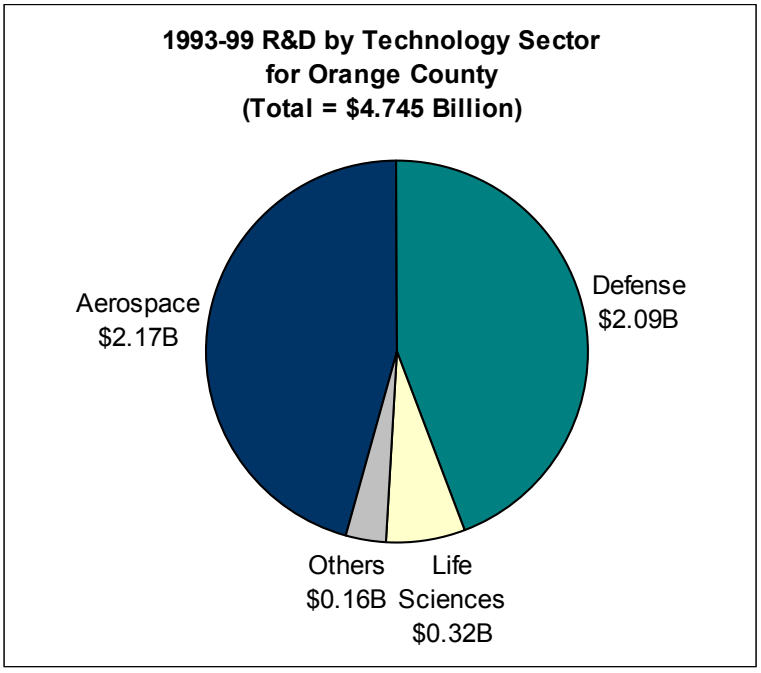


Figure V-Q 1993-99 Technology Sector Breakdown of R&D Funding to Alameda County, Total = $4.955 Billion ***(Source: RaDiUS)***

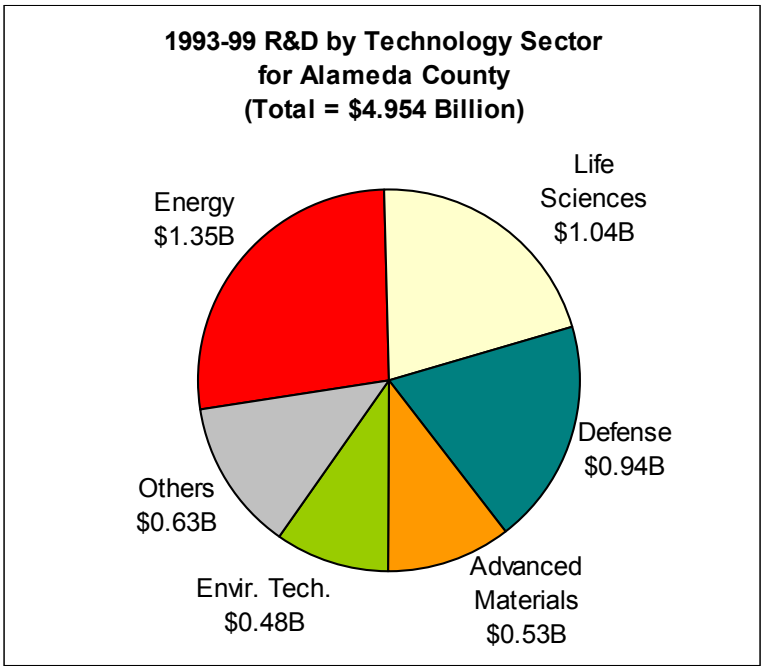


Figure V-R 1993-99 Technology Sector Breakdown of R&D Funding to San Francisco County, Total = $2.122 Billion ***(Source: RaDiUS)***

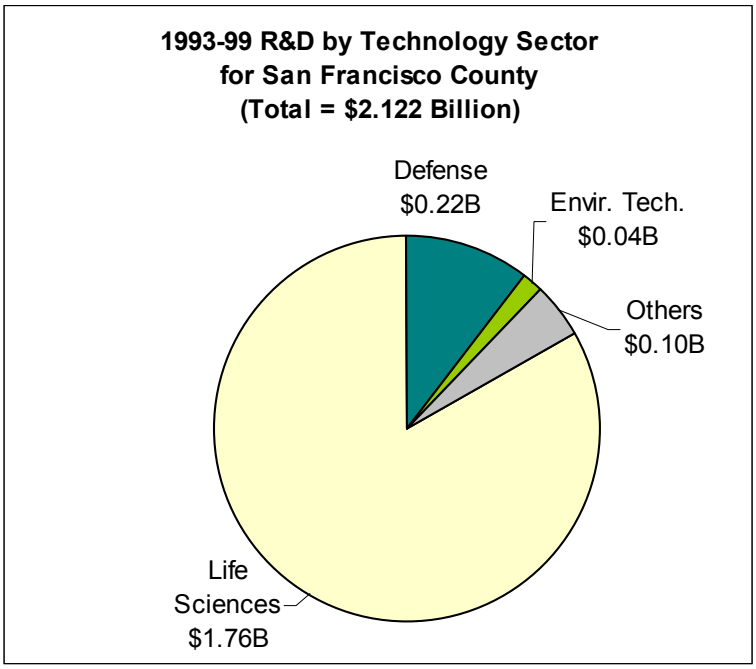


Figure V-S **1993-99 Technology Sector Breakdown of R&D Funding to San Mateo County, Total = $1.464 Billion** ***(Source: RaDiUS)***

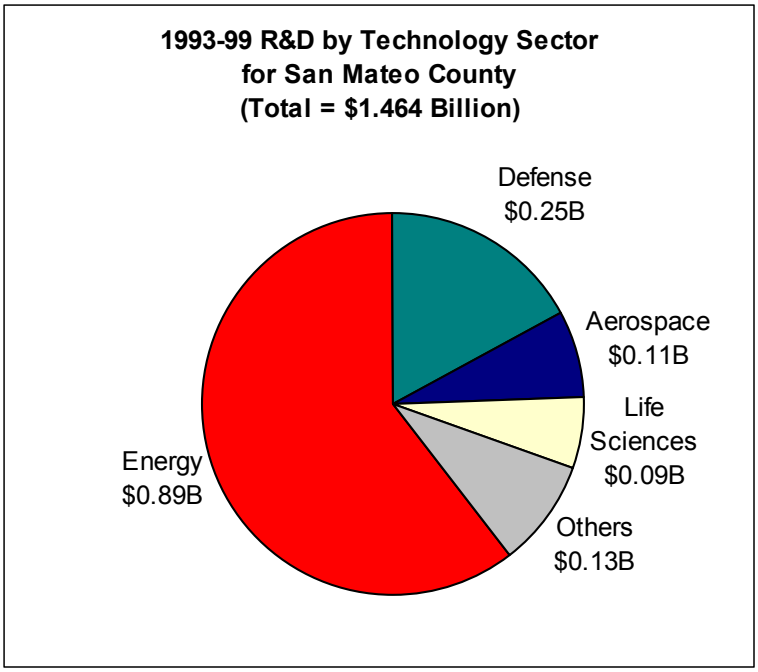


Figure V-T **1993-99 Technology Sector Breakdown of R&D Funding to Santa Barbara County, Total = $1.253 Billion** ***(Source: RaDiUS)***

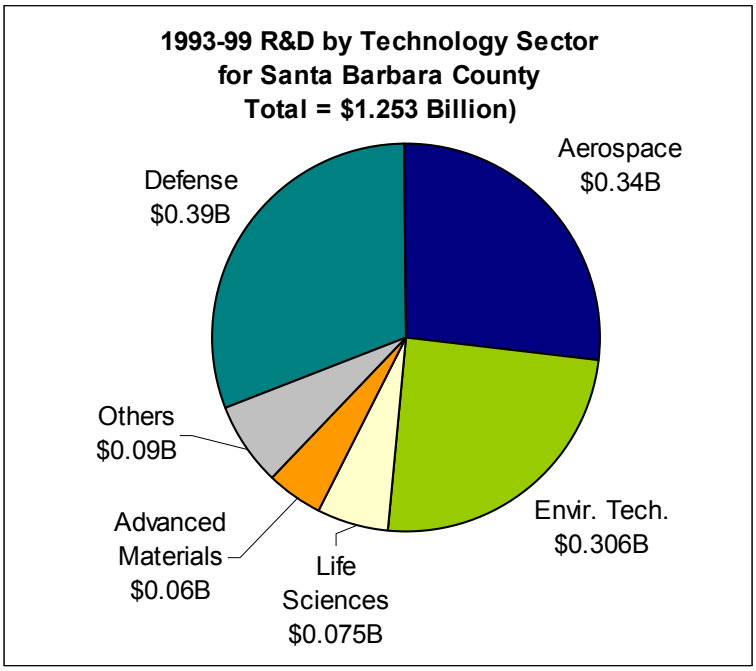
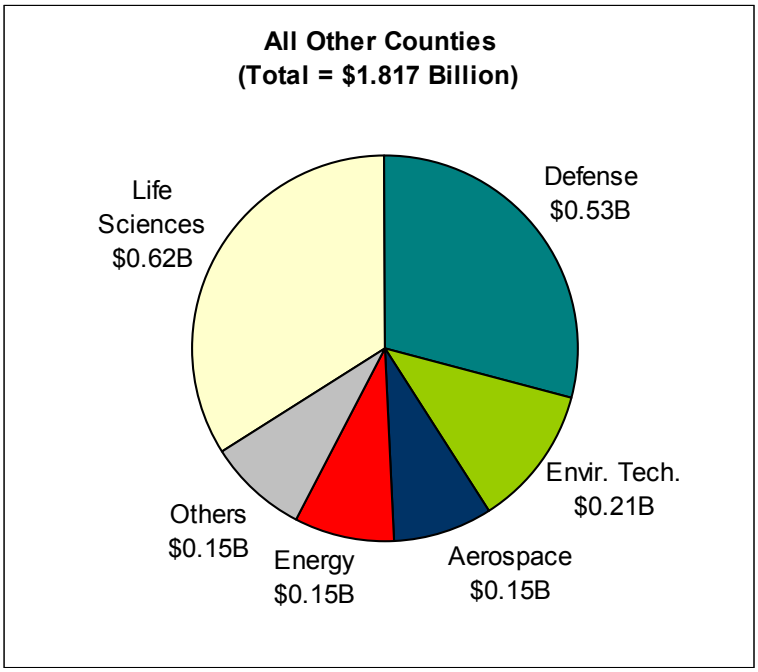


Figure V-U 1993-99 Technology Sector Breakdown of R&D Funding to All Other Counties, Total = $1.817 Billion ***(Source: RaDiUS)***



E. Technology Sector Funding Trends, by County

This section discusses technology sector funding trends to the top eight counties between 1993 and 1999. Results are plotted on a series of charts, Figure V-U through V-GG. These top eight counties set the trends as they receive approximately 94% of all R&D funding to California. Limitations on project time and scope preclude a detailed analysis of funding trends to all counties. However, full, complete data on technology sector funding trends for each county has been listed in Section IX of the Appendices.

Please note that points on all plots in the following sections are uniformly coded by counties (Alameda = red diamonds, Los Angeles = dark blue diamonds, Orange = light green triangles, San Diego = dark green squares, San Francisco = mauve triangles, San Mateo = yellow circles, Santa Clara = brown circles, Santa Barbara = orange squares, Others = gray asterisks)[24]

1. Advanced Computing

Funding for the Advanced Computing sector is small, constituting only 2.4% of all R&D activity (see Table V-B and Figure V-A). Figure V-Va,b plots the funding trends for the top eight counties receiving funding in Advanced Computing. True funding for this sector, if known, is

[24] Color codes refer to the appearance of screen colors only. Colors in printed copies of this report may differ slightly due to a particular color printer's ability to translate screen colors into ink renderings. If there is any doubt about coloration, please refer to the agency abbreviation corresponding to that particular section of the pie chart.

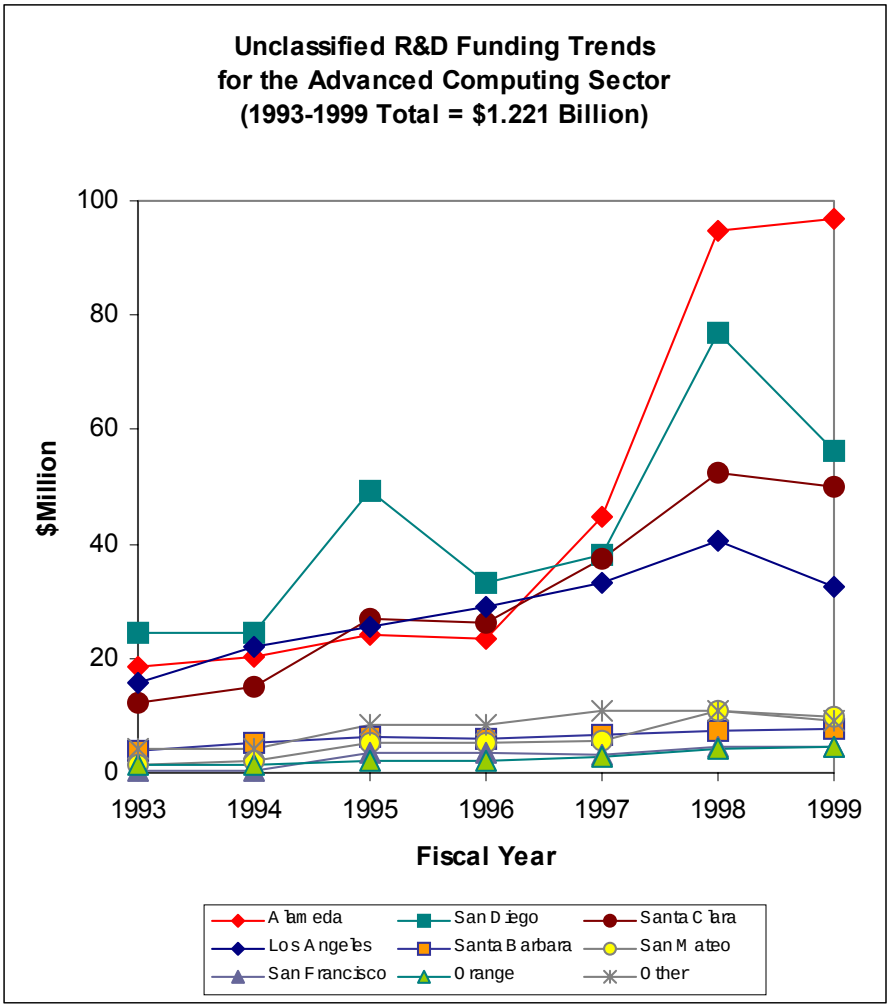
likely higher than is shown by this methodology. Using methodology which categorizes program elements by technology sectors does not fully account for all R&D activity in this sector because there are few targeted program elements with "Advanced Computing" in the title. Yet, it is almost certain that R&D in this technology sector intersects with the mission of many different agencies and these activities are supported by a wide range of federal agencies and sub-agencies, under other program/project names and titles.

Please note that the DOC contribution is likely an overstatement of true funding since a major program element is NIST's Advanced Technology Program (ATP) and there is no subject breakdown possible for this program line item. While ***some*** projects in NIST's ATP will fall into the Advanced Computer sector, not ***all*** projects funded by ATP are solely dedicated to advanced computing. Furthermore, if one includes classified research, then the DOD contribution to this sector is most surely larger than is shown. The problem with DOD data is that there is no funding data associated with specific advanced computing program elements. At the same time, many advanced computing projects may be hidden under catch-all categories such as "R&D contracts not specifically tied to program elements" associated with each branch of the Armed Forces. There is no way to distinguish project funding so there is no way to estimate the size of the program or effort involved.

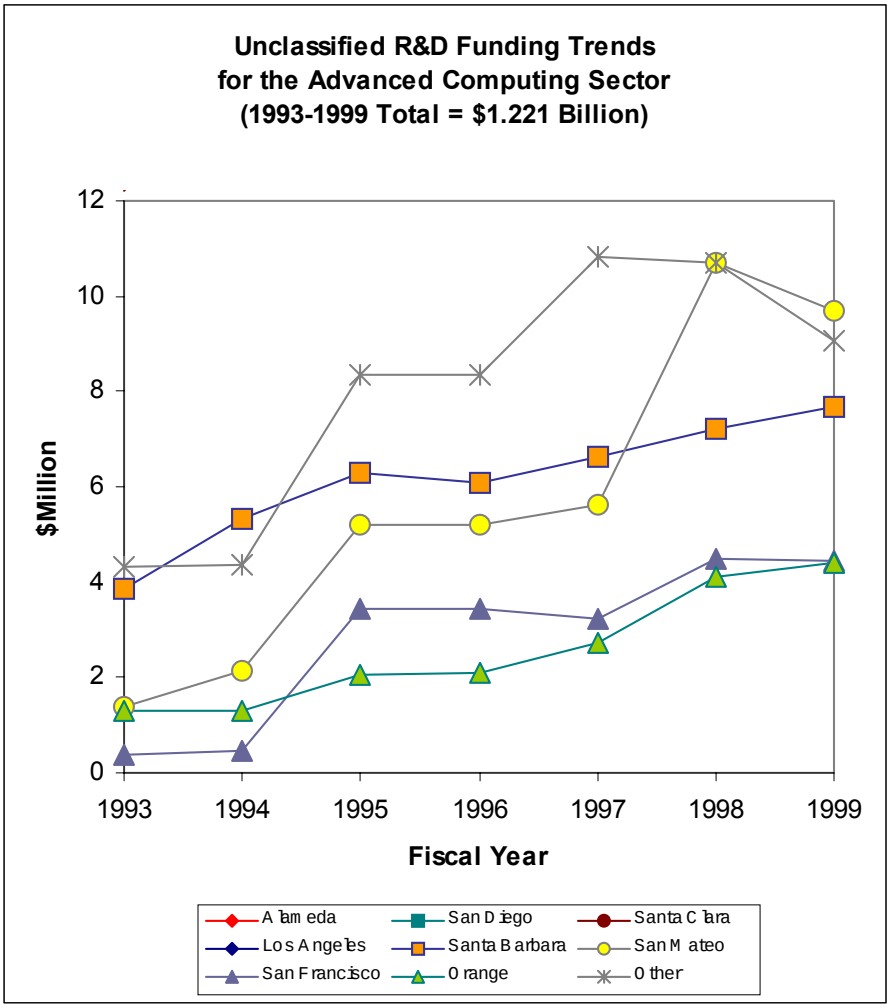
From Figure V-Va, we can see that Alameda leads all counties in research that can be unambiguously identified as advanced computing research. The three dominant counties are Alameda, San Diego and Santa Clara. Funding to this area has been rising for all eight counties in recent years (See Figure V-Vb). Because of the suspected incompleteness of this data, one needs to be extremely cautious when drawing conclusions from these data so we caution the reader to treat these results as ***strictly*** preliminary and inconclusive, but based on the best available data at this time.

Figure V-V **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Advanced Computing** ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Plot (Minus Alameda, San Diego and Santa Clara Counties)



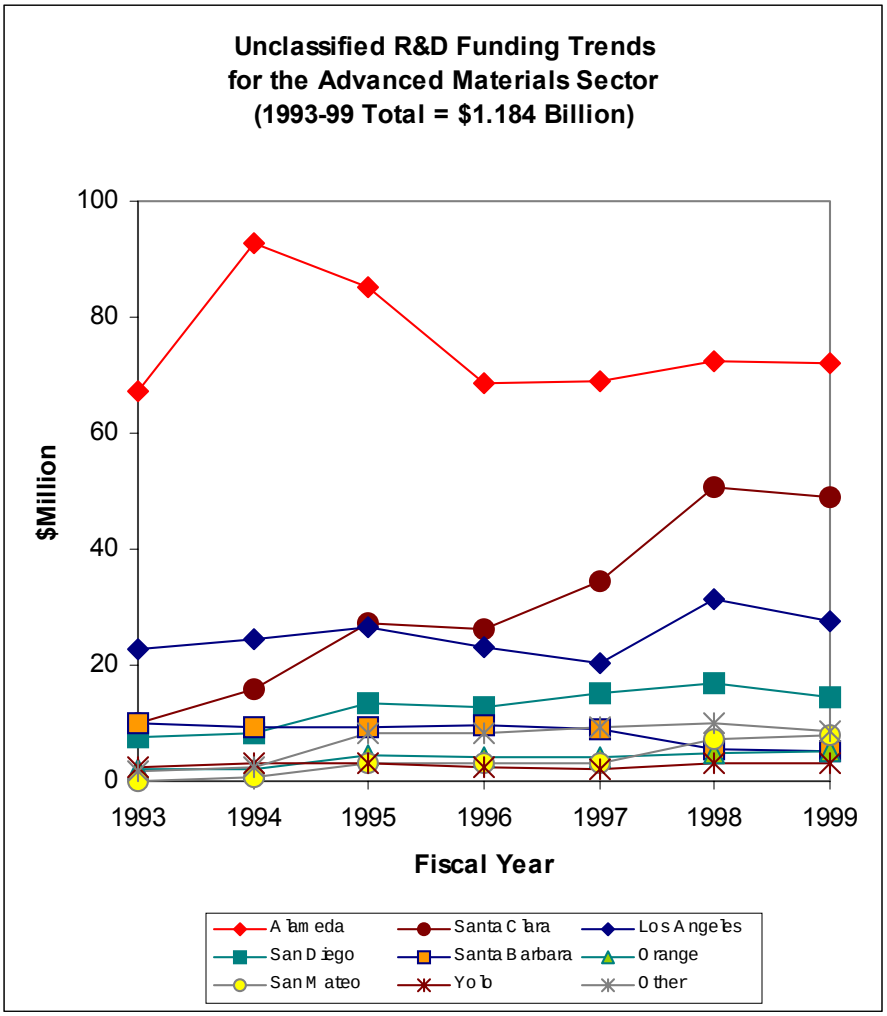
2. Advanced Materials

Like Advanced Computing, Advanced Materials constitutes a very small fraction, 2.4%, of the total R&D funding (see Table V-B and Figure V-B). The question is whether this sector is inherently a small fraction of the R&D activity or if there are additional R&D projects in this technology sector that are hidden under other program titles. Agencies that fund the lions' share of this research include the DOE and NSF, not DOD, so that the problems normally attributed to DOD data aren't a major contributing factor here, if there is an under-accounting of activity. Again, the DOC component is overstated because of previously described data issues with NIST's Advanced Technology Program program budgets and the inability to drill down further into this line item.

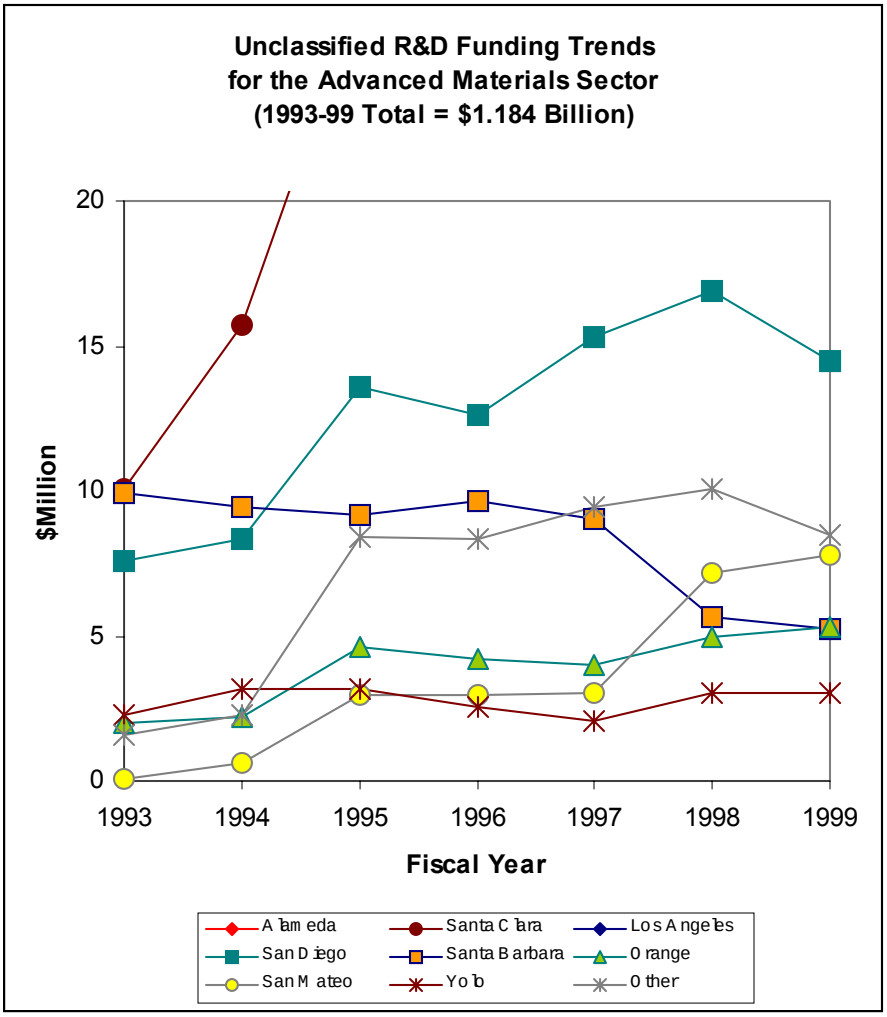
Figure V-Wa,b shows that funding for research activity in the Advanced Materials sector has been relatively flat. While Alameda received the most funding of all the counties, Santa Clara County's funding share has been rising noticeably over the late 1990s.

Figure V-W **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Advanced Materials** ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Plot (Minus Alameda, Santa Clara and Los Angeles Counties)

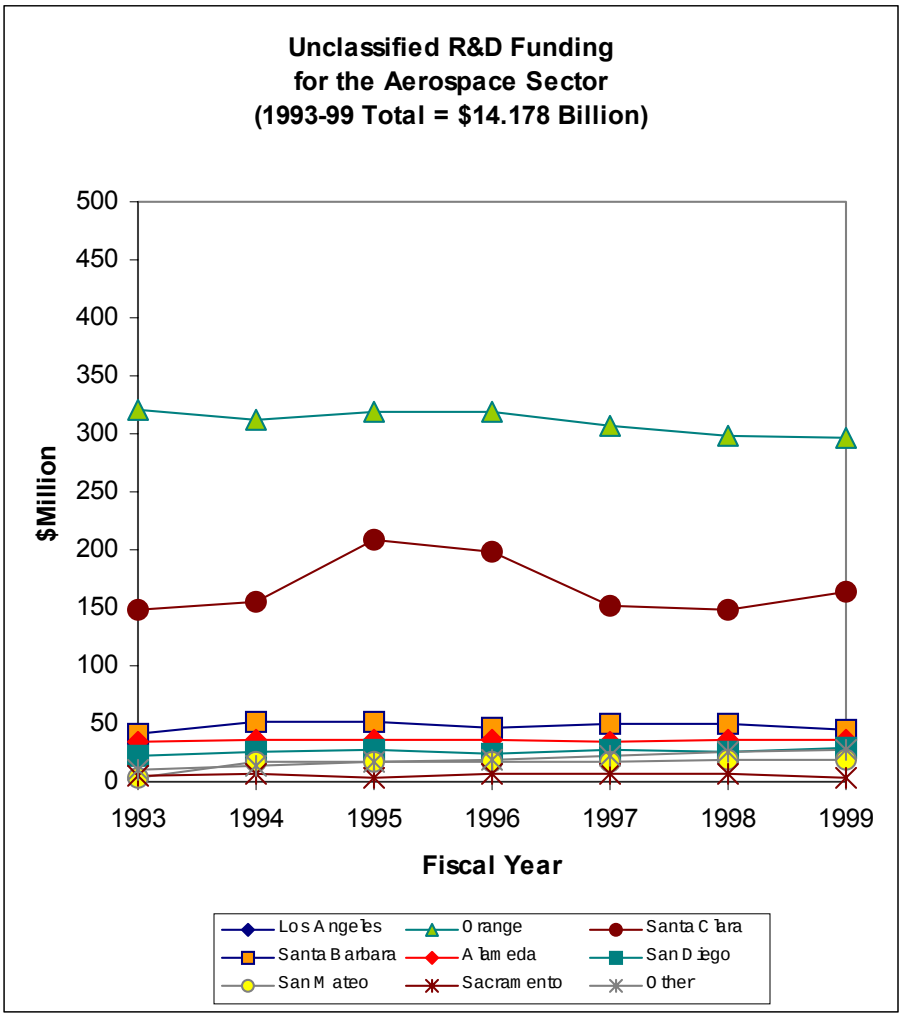


3. Aerospace

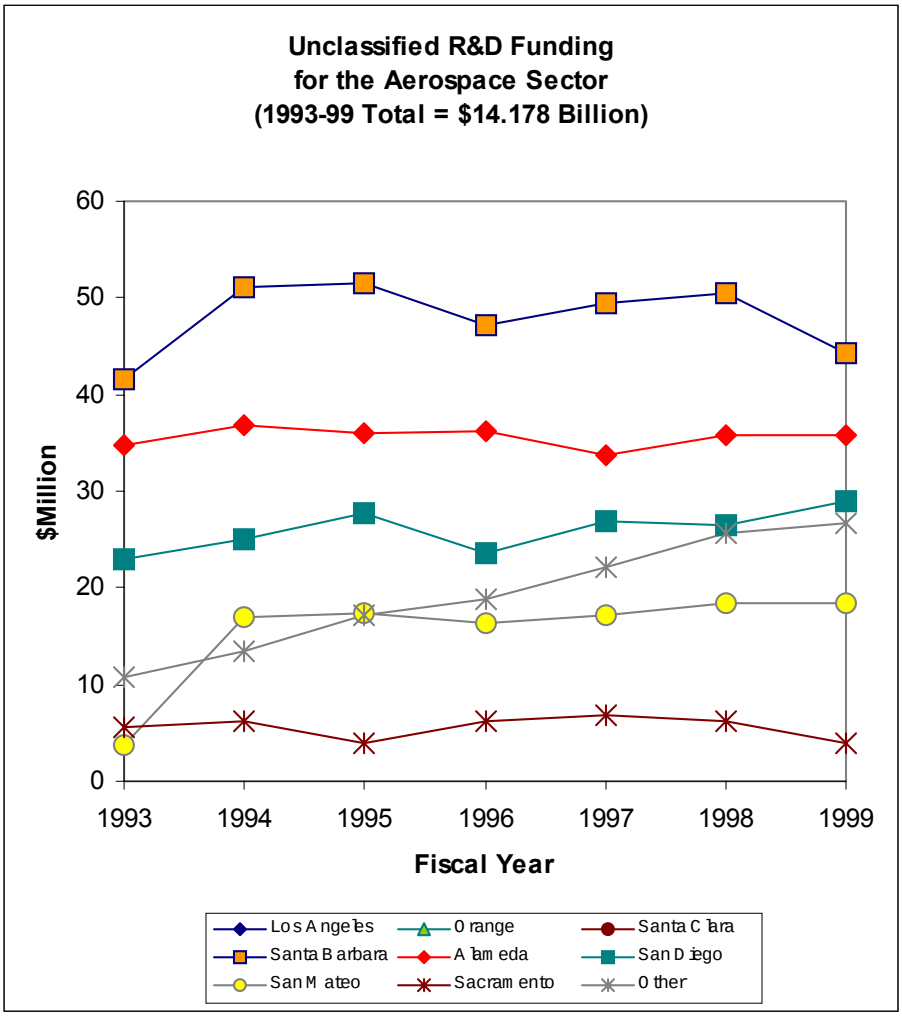
The Aerospace sector represents the second largest sector of R&D funding at 28.2%, behind Defense (see Table V-B and Figure V-C). Los Angeles County dominates the picture as it receives more funding for Aerospace research than all the other counties combined (69% of all funding to this sector or $9.78 billion). Aerospace funding to Los Angeles County dropped by half in 1995 and has been slowly decreasing ever since. Aerospace funding to the other top counties have held relatively steady, in contrast. See Figure V-Xa,b.

Figure V-X **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Aerospace** ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Plot (Minus Los Angeles, Orange and Santa Clara Counties)

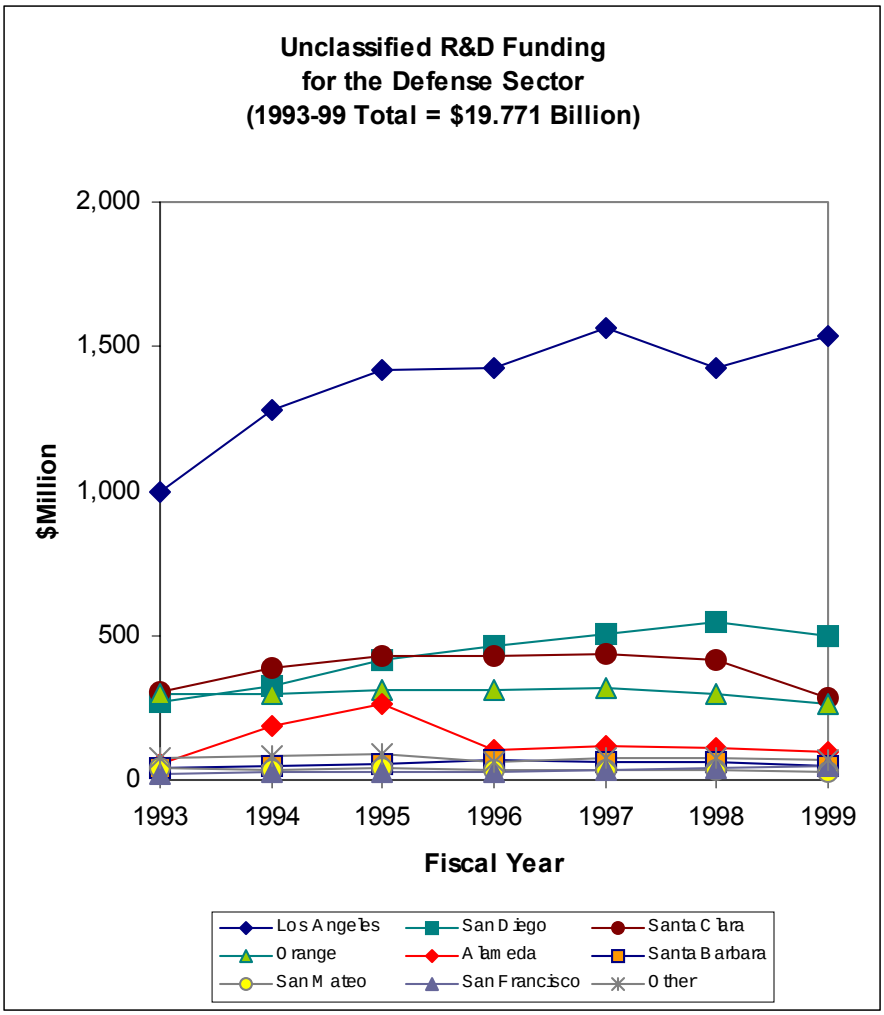


4. Defense

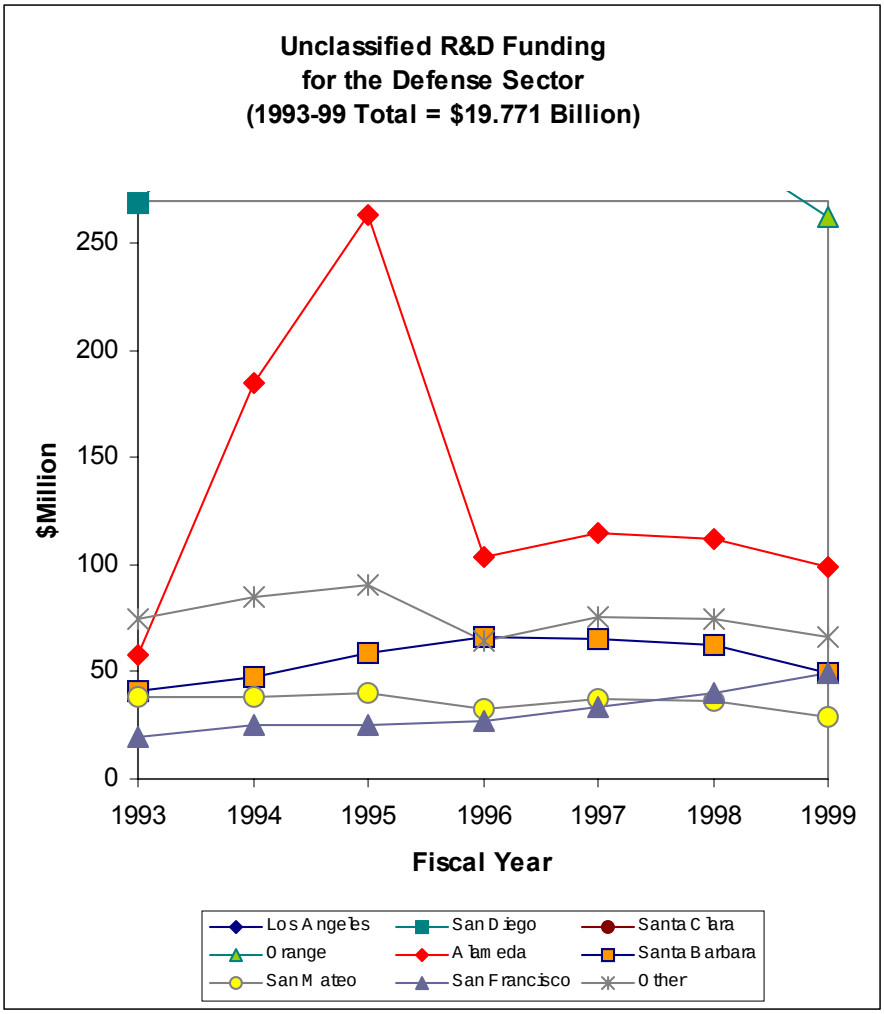
Defense constitutes the technology sector that received the most R&D funding over the time period in question, 39.4% of total funding. The major funding agency is DOD with minor funding contributions from DOE and DVA (see Table V-B and Figure V-D). Los Angeles County receives the lions' share of funding for this technology sector. Funding to Los Angeles county drives overall statewide trends for this sector and this funding has been rising slowly in the past few years. While funding has been fairly flat and stable for most counties, funding has been rising in San Diego County. Alameda County has also experienced some abrupt changes in funding. See Figure V-Ya,b.

Figure V-Y **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Defense** ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Plot (Minus Los Angeles, San Diego, Santa Clara and Orange Counties)



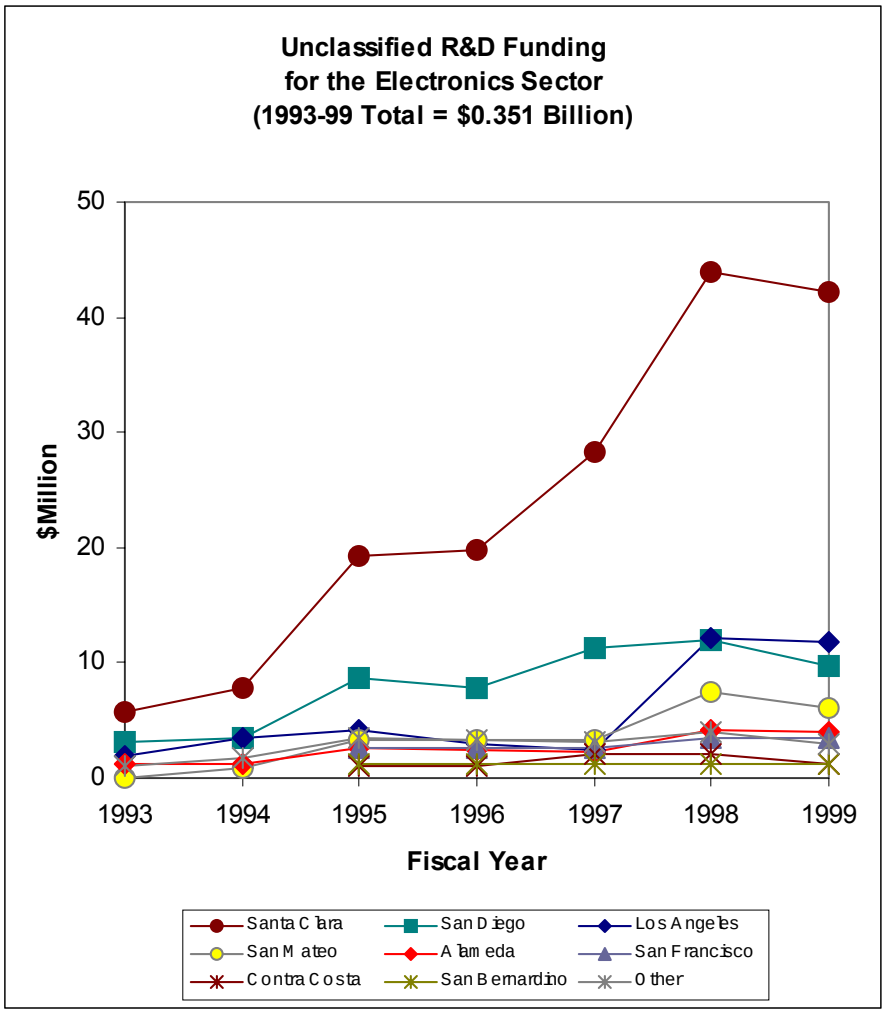
5. Electronics

Funding to the Electronics sector constitutes a small fraction (0.4% or $0.35 billion) of all state R&D activity (see Table V-B and Figure V-E). Again, these data may be distorted by an under-accounting of the true funding. Much of this funding may also be unclearly identified under Defense R&D program elements that don't explicitly state "electronics" in the title. Of the program elements that can be identified explicitly as electronics related, the lead agency funding electronics research is DOC, chiefly through NIST's Advanced Technology Program. Due to previously described data difficulties with the ATP budget, there was no way to break out this funding by technology sectors. Hence, the entire ATP budget has been attributed to each technology sector, leading to a likely over count.

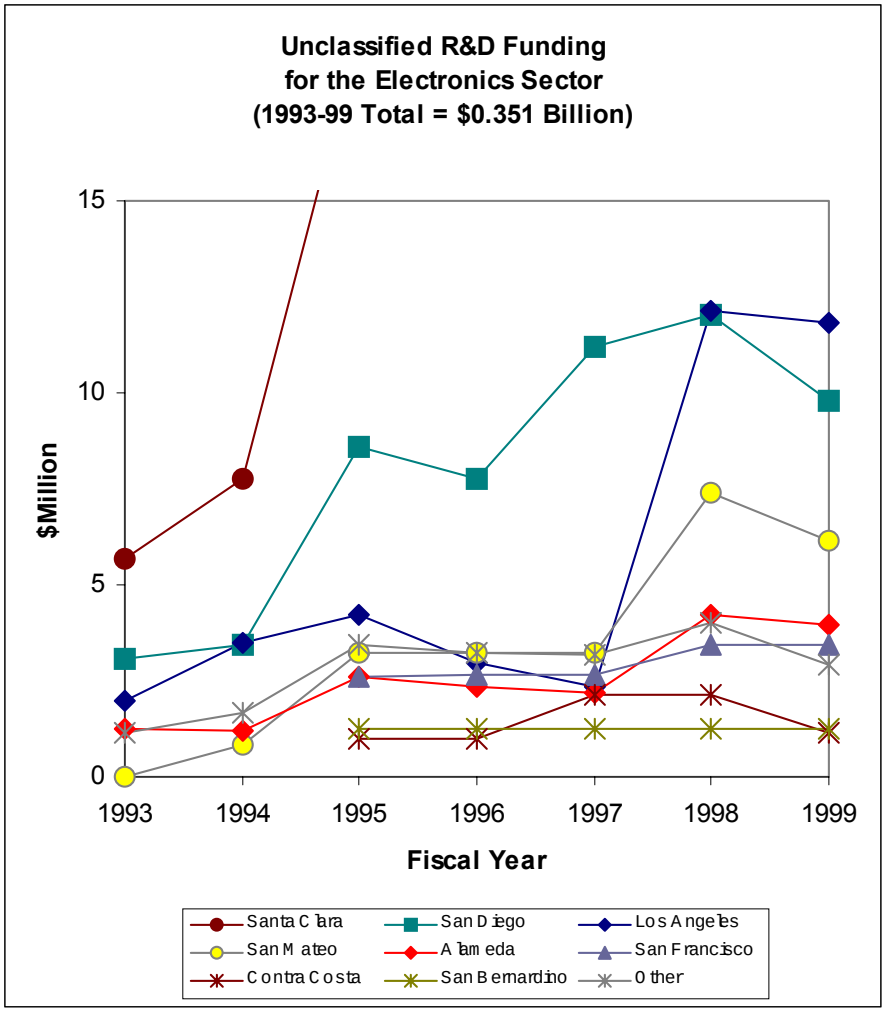
From Figure V-Za,b, it is evident that Santa Clara County dominates research in the Electronics Sector. Furthermore, funding to Santa Clara County has been rising sharply over the past decade. San Diego County has also experienced modest increases in funding during this time period.

Figure V-Z **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Electronics** ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Plot (Minus Santa Clara County)

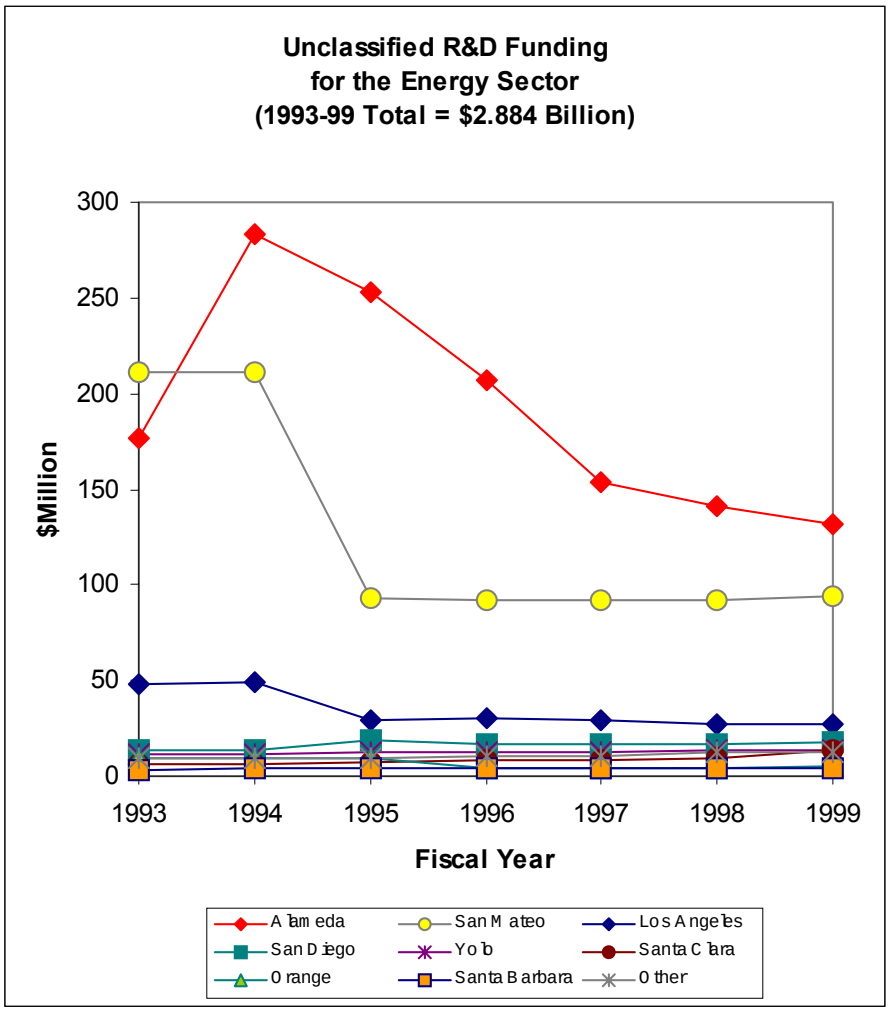


6. Energy

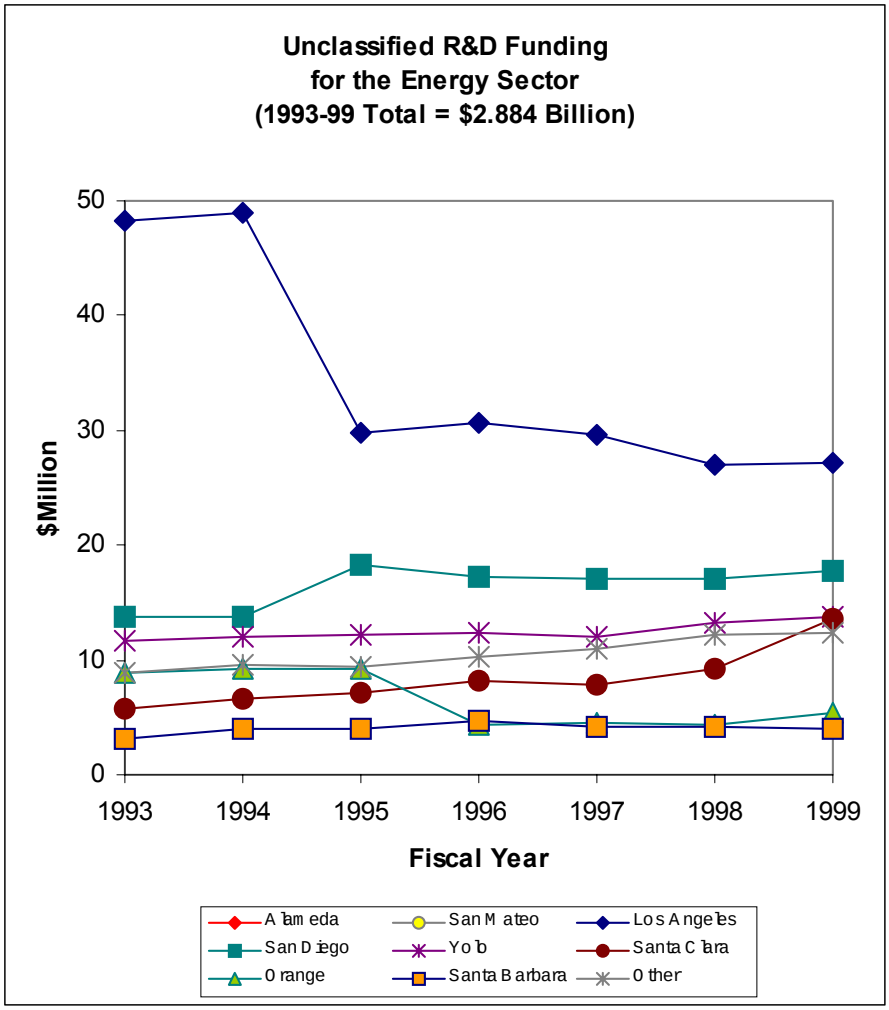
Research activities in the Energy sector are almost entirely funded by DOE. Total funding to this sector constitutes 5.7% of all R&D activities in the state (see Table V-B and Figure V-F). Alameda and San Mateo Counties dominate all the other counties in funding for Energy Sector research activities, because of the major DOE national labs that are located in these counties. Funding to these labs fell during the 1990s and this severely impacts the overall funding picture for this sector. See Figure V-AAa,b for details.

Figure V-AA **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Energy** ***(Source: RaDiUS)***

a) Full Scale Plot



b) Expanded Plot (Minus Alameda and San Mateo Counties)

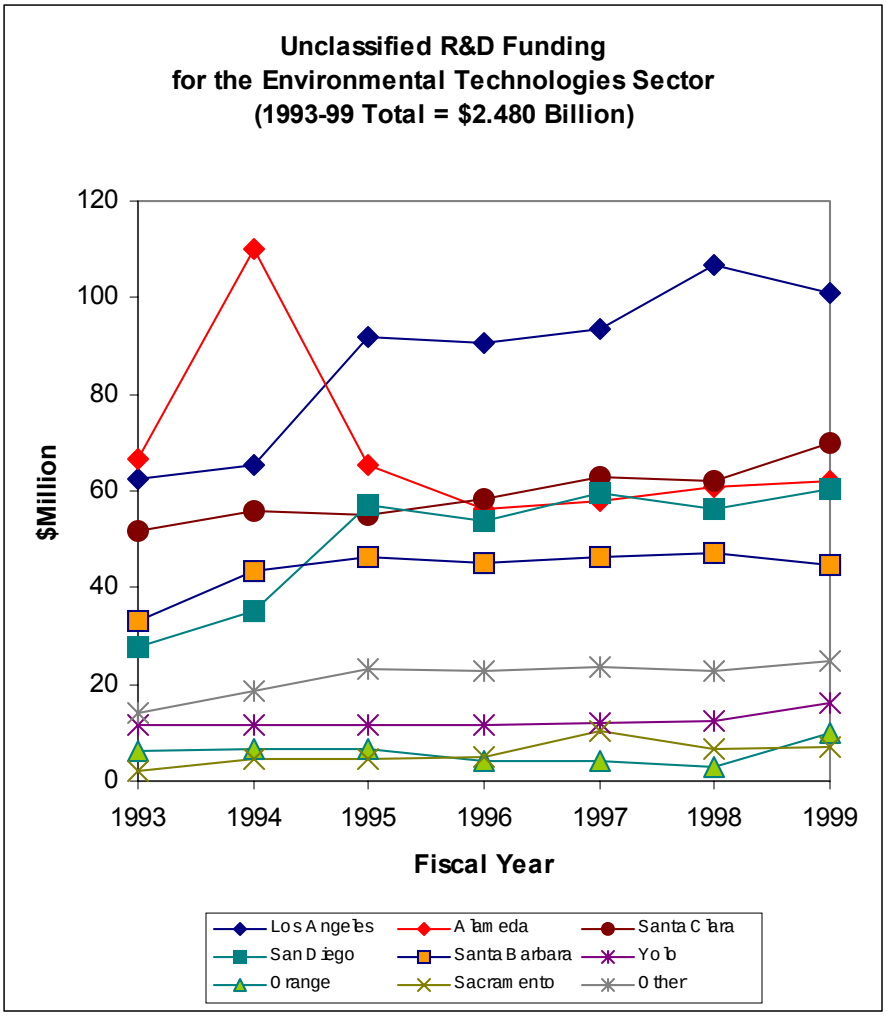


7. Environmental Technologies

Funding for Environmental Technologies 5.7% of the overall R&D funding to the state (see Table V-B). Broad arrays of technologies make up the Environmental Technologies sector. Research activities in this sector can range from sustainable agricultural techniques to ecological field studies, from development of alternative fuel, to more efficient engines for space travel, to global climate studies (see Section VIII of the Appendices and Figure V-G). Because of the large number of agencies involved and the broad array of technologies funded, it is difficult to draw general conclusions from the funding trend charts. The nature of research funded in Los Angeles County may be totally different from Yolo County. As a result, changes in agency funding priorities from year to year may affect one county to the exclusion of all other counties. For instance, Alameda County's drop in funding arises from decreases in DOE funding and is totally unrelated to the rise in funding for Los Angeles County, a large component of which arises from NASA. In general, it appears that the county level funding to the Environmental

Technologies sector has been steady with most counties experiencing a slight rise over the time period studied. See Figure V-BB.

Figure V-BB **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Environmental Technologies** ***(Source: RaDiUS)***



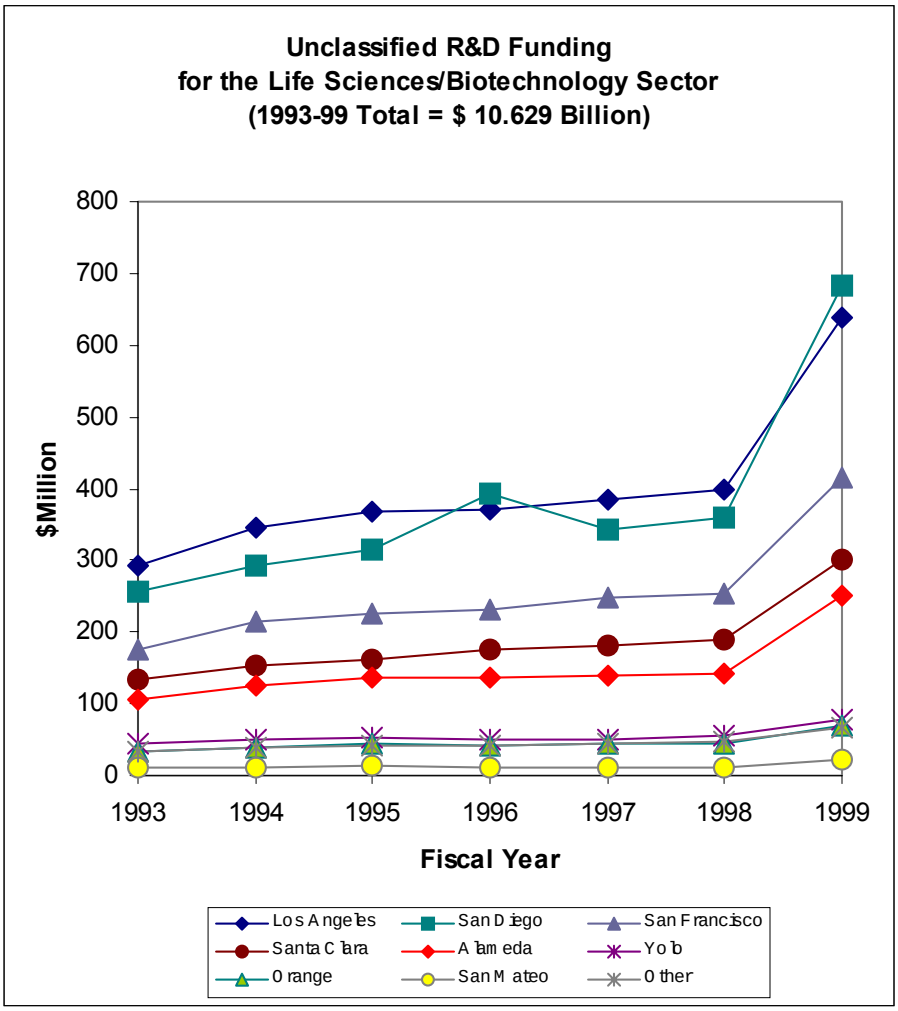
8. Life Sciences/Biotechnology

Funding for the Life Sciences sector makes up a large fraction (21.2%) of the state's overall R&D budget. Funding has been rising steadily and reflects increases in HHS budgets over the decade (see Table V-B and Figure V-H). The overall funding picture in this sector is distorted by the unavailability of data on DOD activities in this sector. For example, the United States Army funds quite a bit of medical research. However, these budgets are unavailable or are not amenable to current analysis because they are categorized under catch-all categories such as "R&D contracts not specifically tied to program elements" and the award descriptions are unavailable.

The three counties that dominate the Life Sciences sector include Los Angeles, San Diego and San Francisco. Each of these counties has at least one major medical school located in the county. Life Sciences funding for San Diego outstrips San Francisco, and is on par with funding to Los Angeles County.

The increases in each county's funding trends are driven in large part by overall HHS/NIH funding increases to the life sciences. There is no one county that exhibits an unusual trend. See Figure V-CC.

Figure V-CC **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Life Sciences/Biotechnology** ***(Source: RaDiUS)***



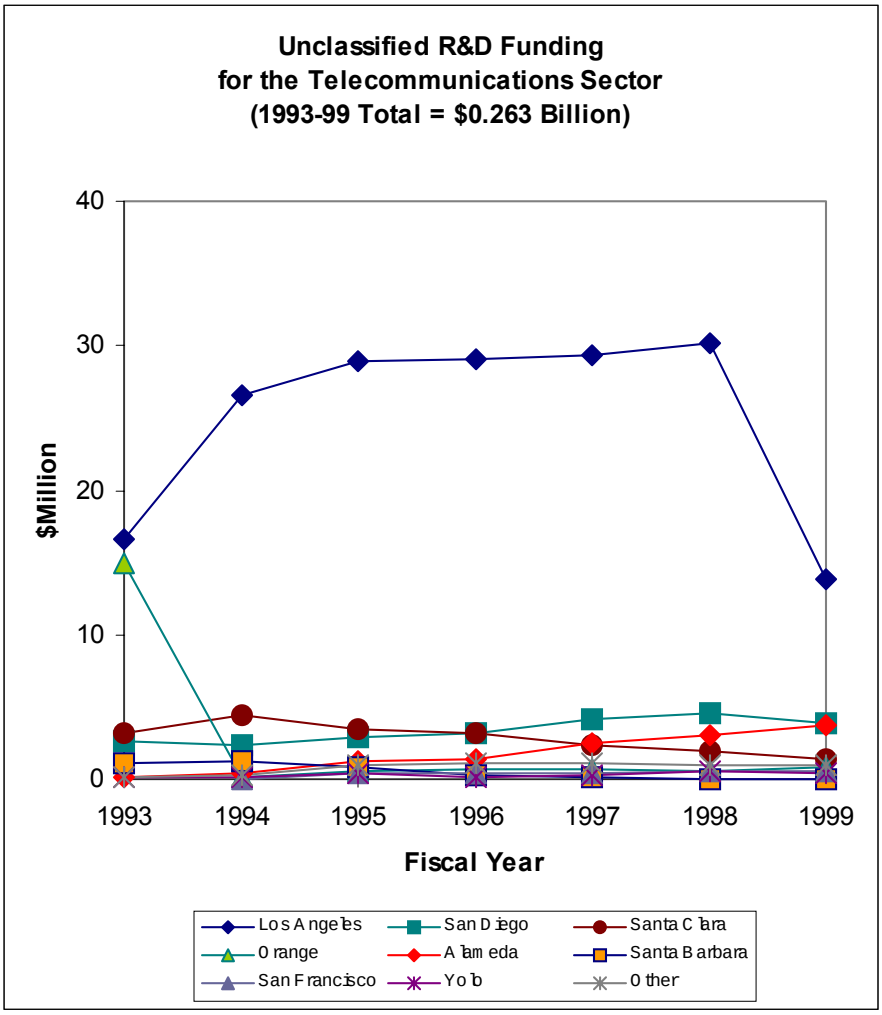
9. Telecommunications

Funding for the Telecommunications sector is minuscule compared to overall funding (0.5% of total funding, see Table V-B and Figure V-I). From Figure V-DDa,b, it can be seen that Los Angeles County receives the largest fraction of funding for identifiable telecommunications research activities and that funding has decreased precipitously in recent years. However, the reader is cautioned against over-interpretation of the results presented in Figure V-DDa,b. Funding to the Telecommunications Sector is small (0.5% of total R&D funding, see Table V-B). There are few program elements that can be identified as telecommunications related research, from the title alone. Furthermore, there are many DOD program elements that can be identified as telecommunications related, yet funding data is missing or classified under the

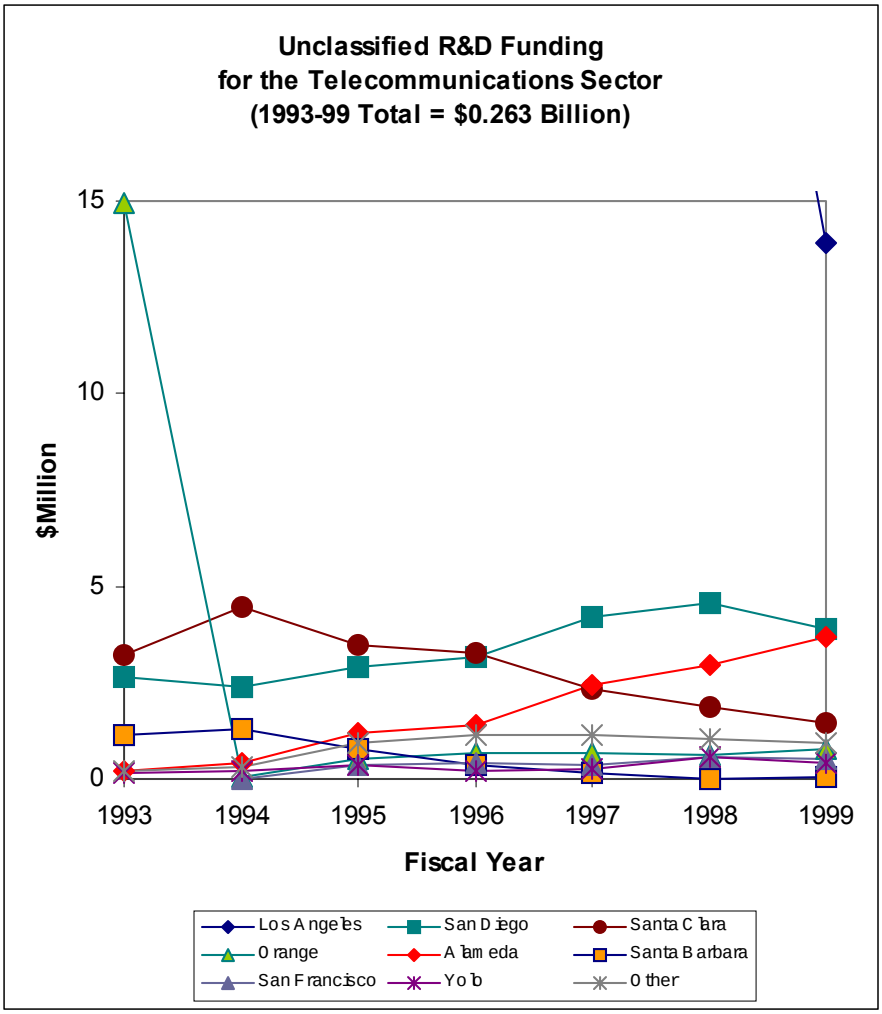
catchall category of "R&D Contracts not tied to program elements". These two factors distort the true funding picture for this sector.

Figure V-DD **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Telecommunications** ***(Source: RaDiUS)***

a) Full Scale Plot



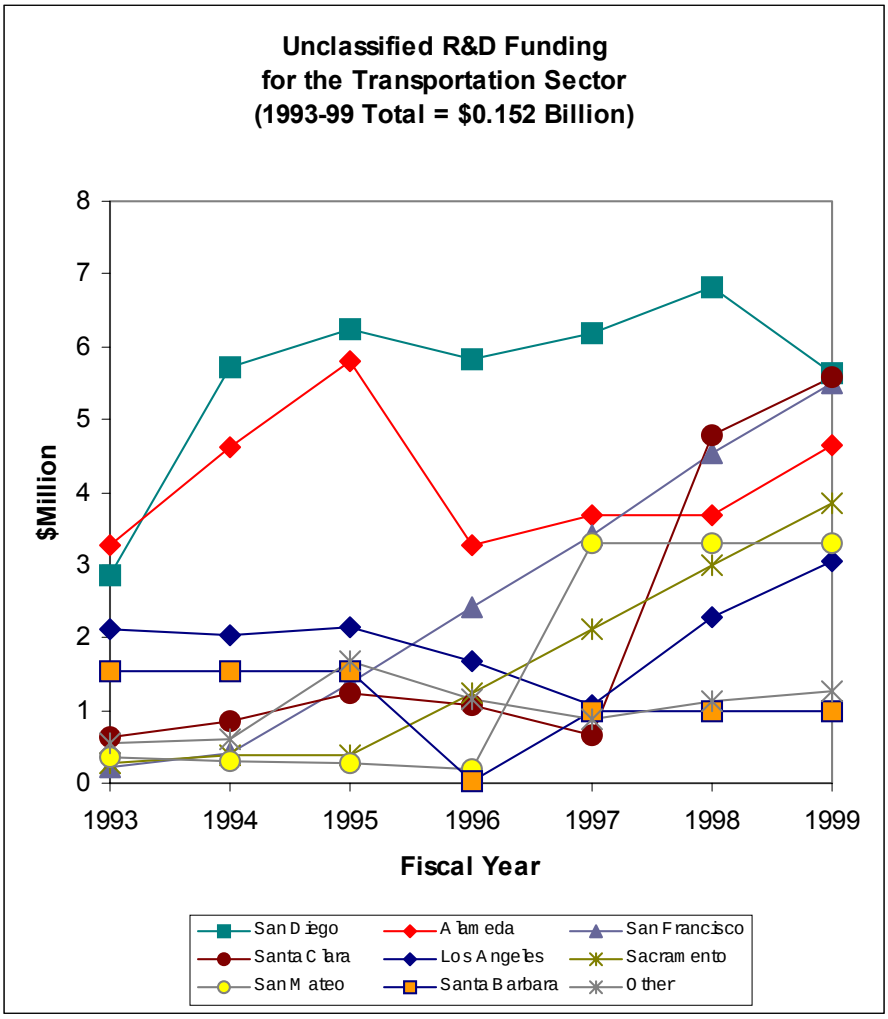
b) Expanded Plot (Minus Los Angeles County)



10. Transportation

Funding to the Transportation Sector is small (0.3% of total R&D funding, see Table V-B). Most of the funding derives from the Department of Transportation with a small amount of funding coming from the Department of Energy. Figure V-EE reveals that San Diego County receives the largest amount of funding for this technology sector. However, funding to several counties (San Francisco, San Mateo and Sacramento) has been rising steadily for the past few years.

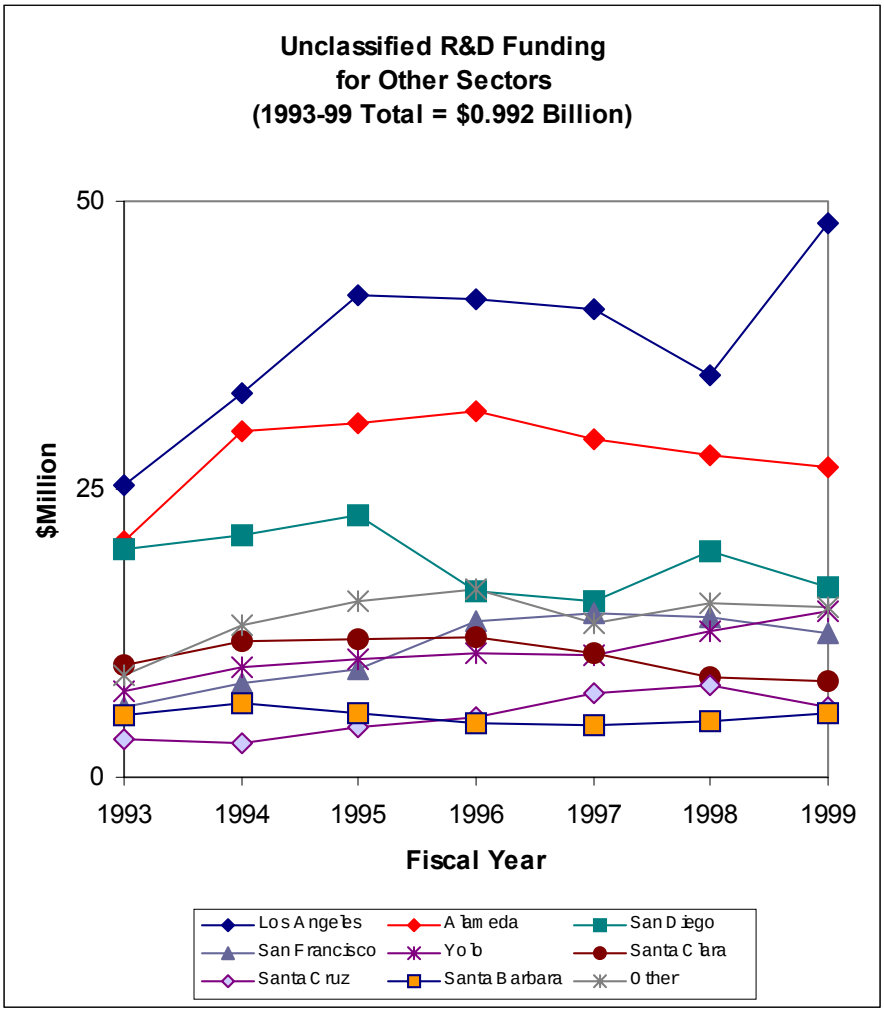
Figure V-EE **1993-99 Unclassified R&D Funding Trends to the Top 8 Counties Receiving Funding for Transportation** ***(Source: RaDiUS)***



11. Other Unrelated R&D Funding

This section has been included for completeness. Not all program elements are related to a particular technology sector. Indeed, R&D activities from some agencies such as the Department of Justice or the Department of Education can't be identified as technology related at all listed. These program line items have been summed up in a category called "Other", to give the reader a feel for the relative size of all research activities that fall outside of the technology sectors of interest (2% of total R&D, see Table V-B). Figure V-FF charts the trends in funding for this category, for the top eight counties. See Section VIII-K of the Appendices for a full breakdown of the program elements that constitute "Other."

Figure V-FF **Unclassified R&D Funding Trends to the "Other" Unrelated Areas for the Top 8 Counties**



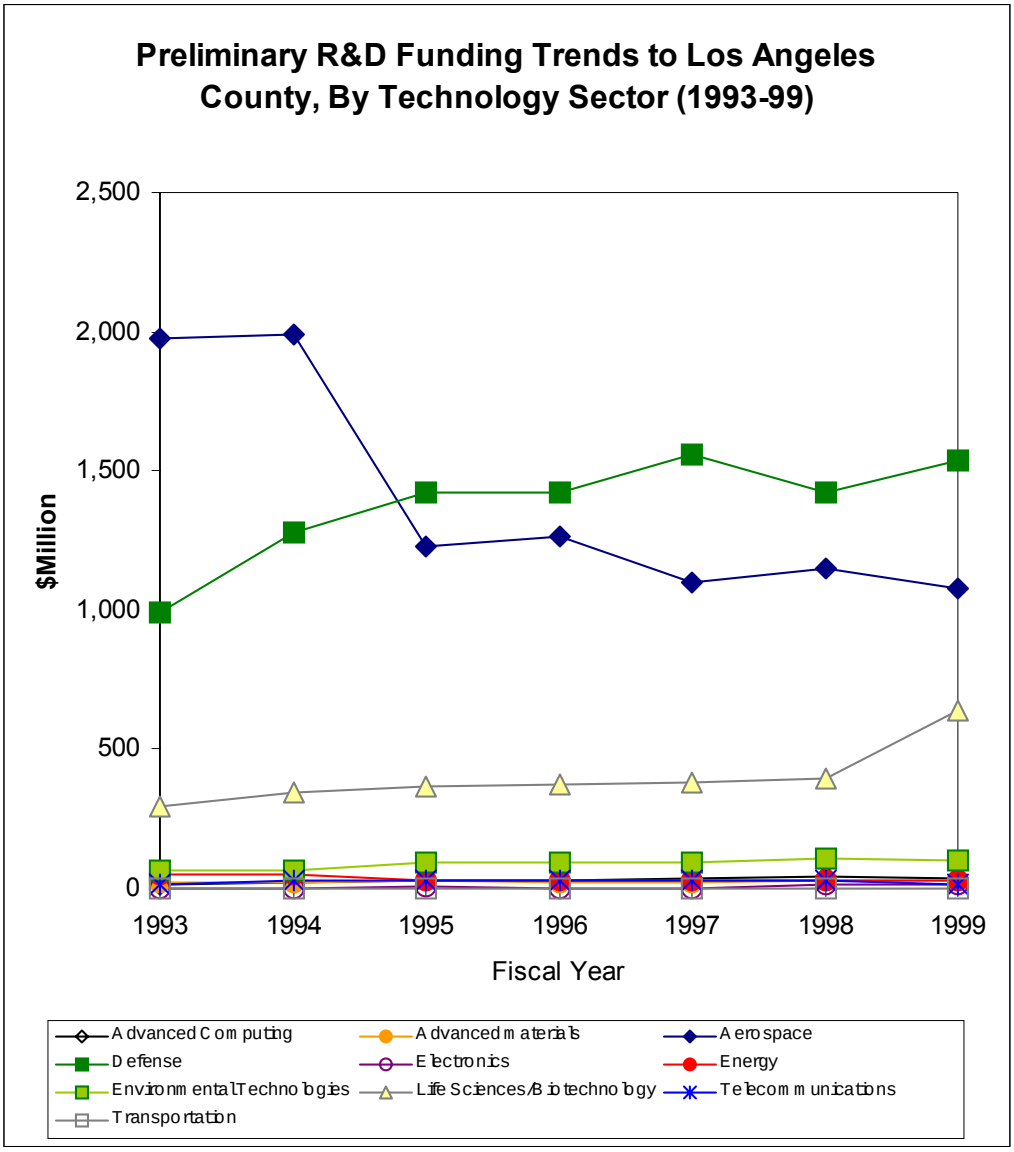
F. Funding Trends for The Top 8 Counties, by Technology Sector

The following series of charts Figure GG(i-viii) replots the data from the previous section, to highlight funding trends in each of the Top 8 counties.

The following plots are uniformed coded by technology sector (i.e. Advanced Computing = black diamonds, no fill; Advanced Materials = orange circles; Aerospace = blue diamonds; Defense = dark green squares; Electronics = purple circles, no fill; Energy = red circles; Environmental Technologies = green squares, light green fill; Life Sciences/Biotechnology = grey triangles, yellow fill; Telecommunications = bright blue stars; Transportation = grey squares, no fill)

Figure V-GG(i) **1993-99 Unclassified R&D Funding Trends for Los Angeles County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot

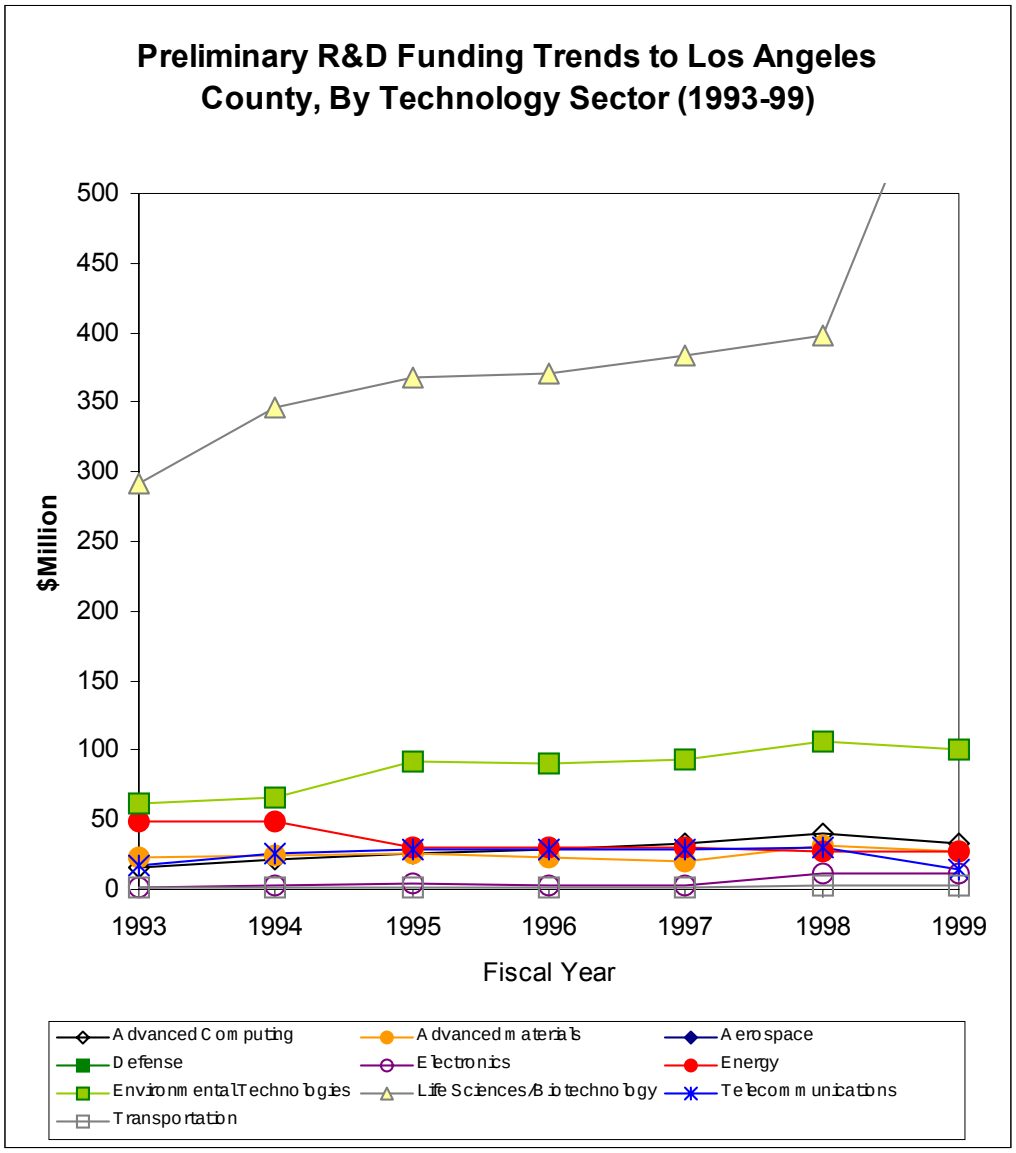
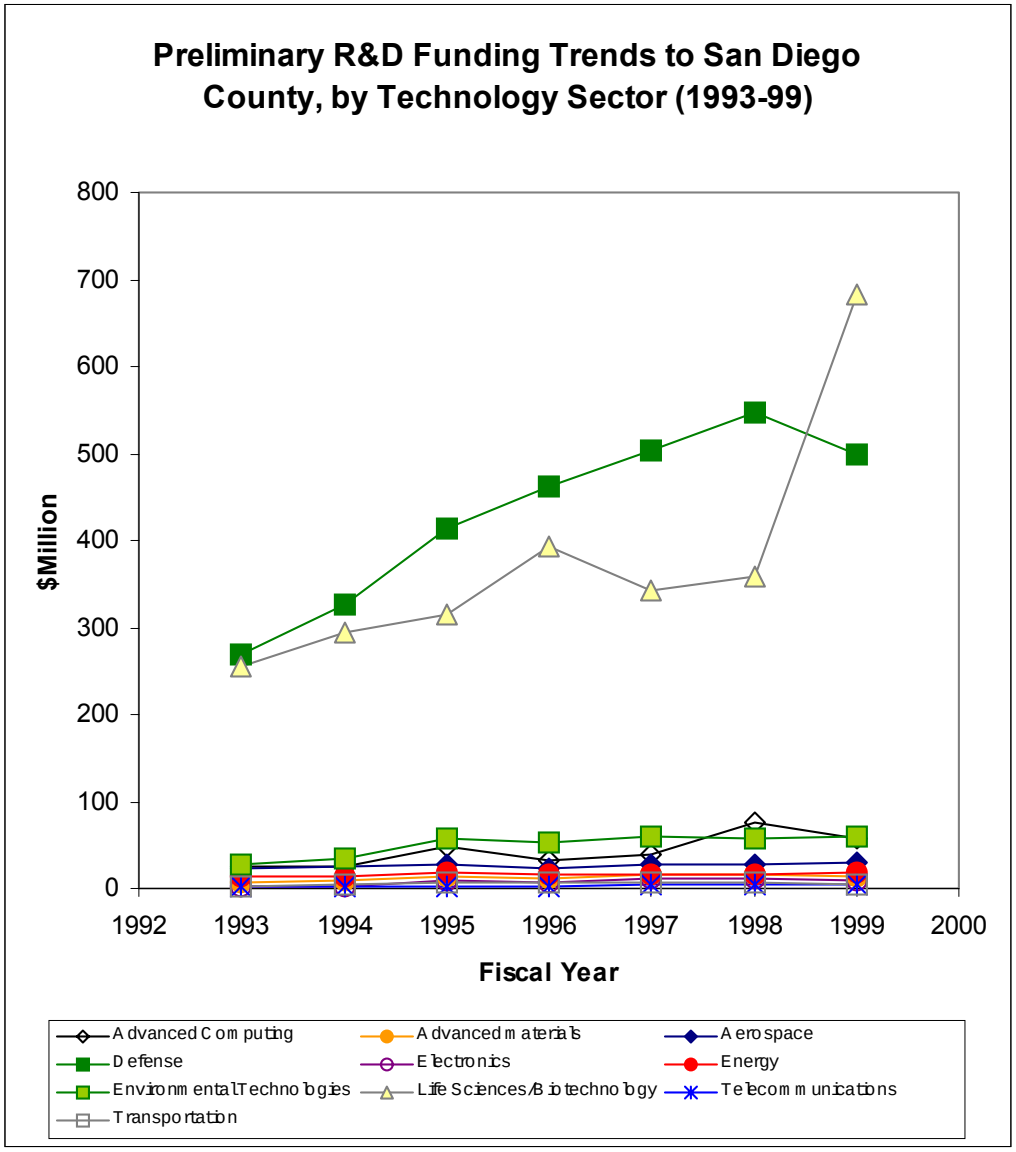


Figure V-GG(ii) **1993-99 Unclassified R&D Funding Trends for San Diego County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot

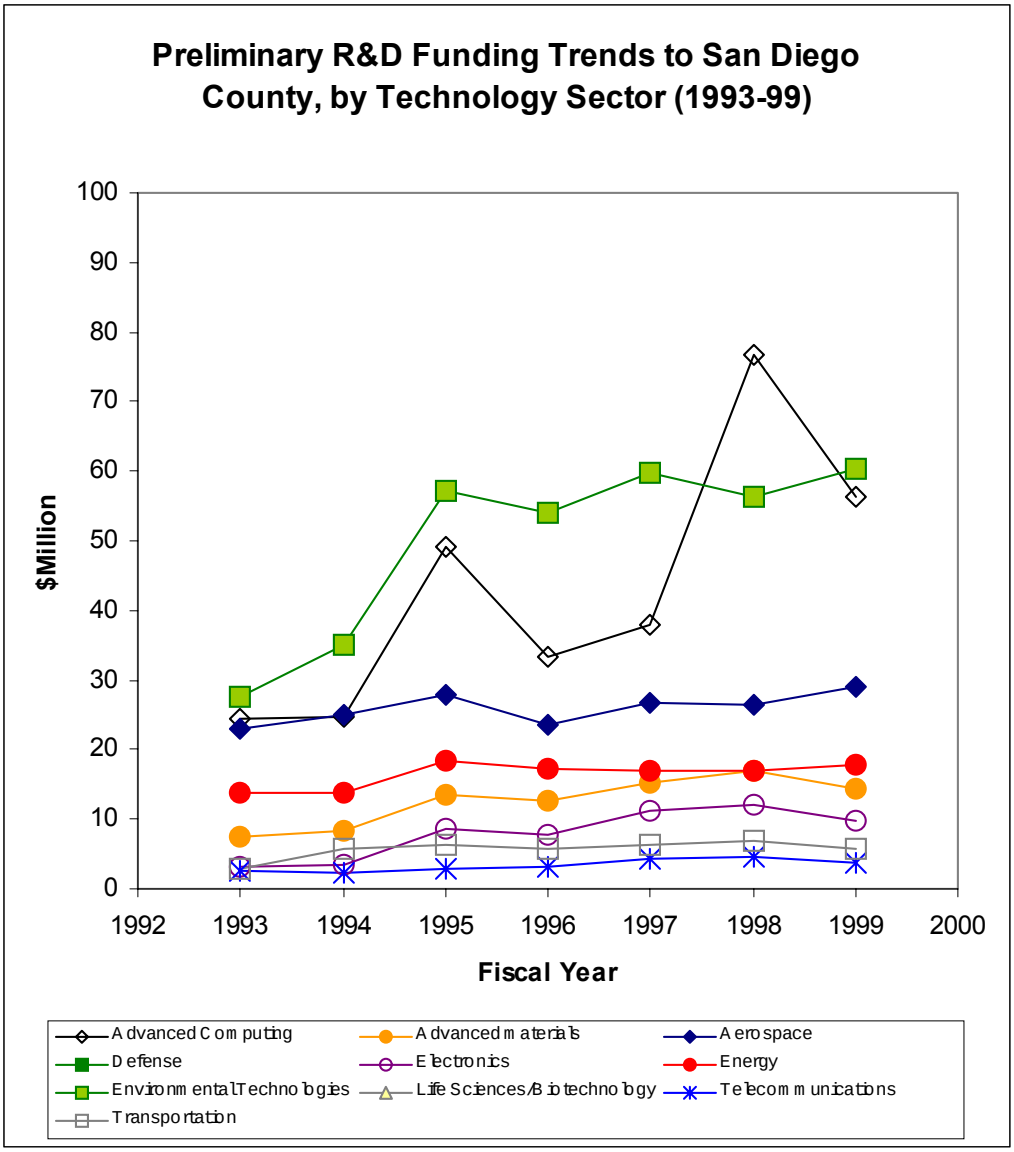
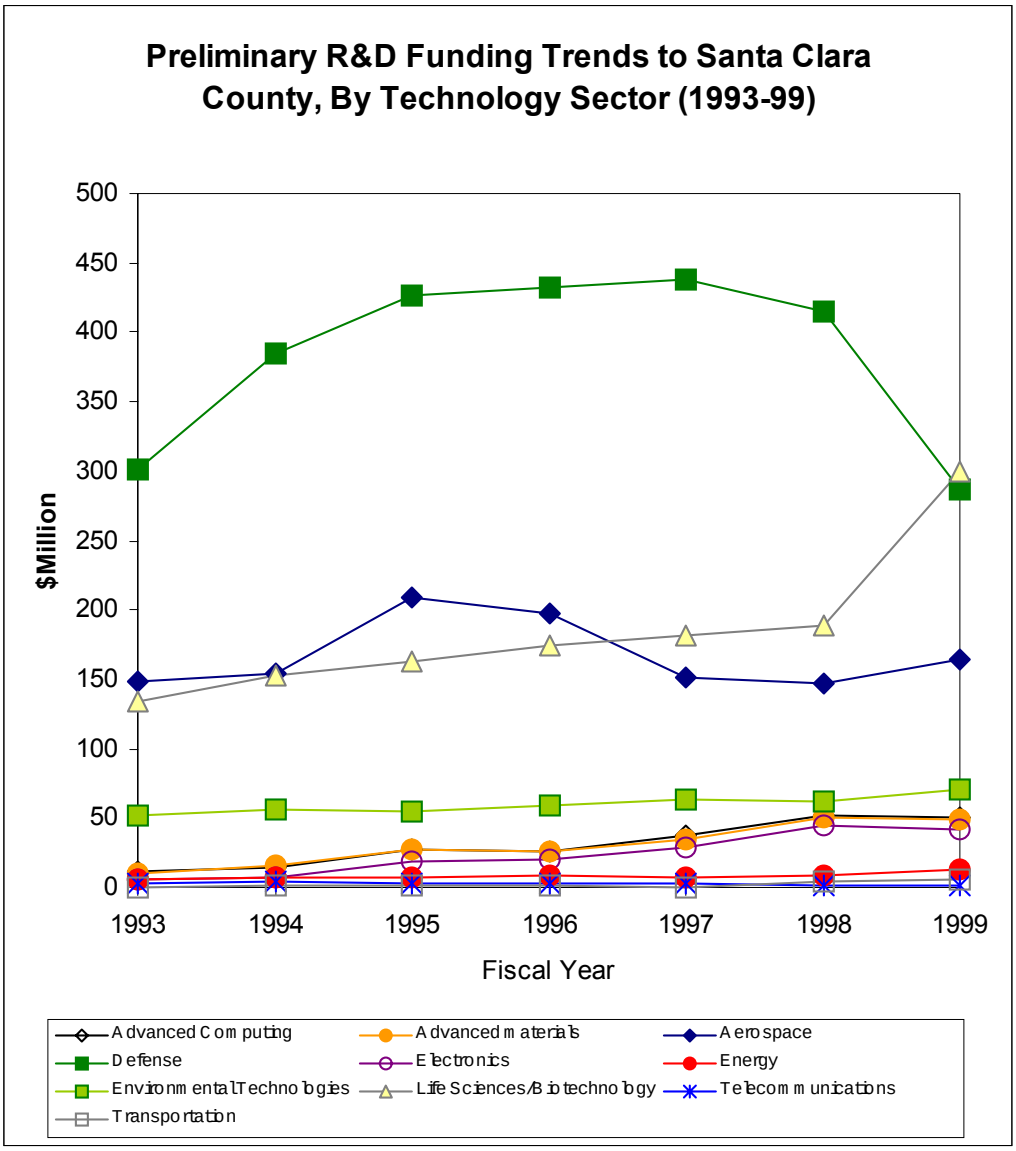


Figure V-GG(iii) **1993-99 Unclassified R&D Funding Trends for Santa Clara County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot

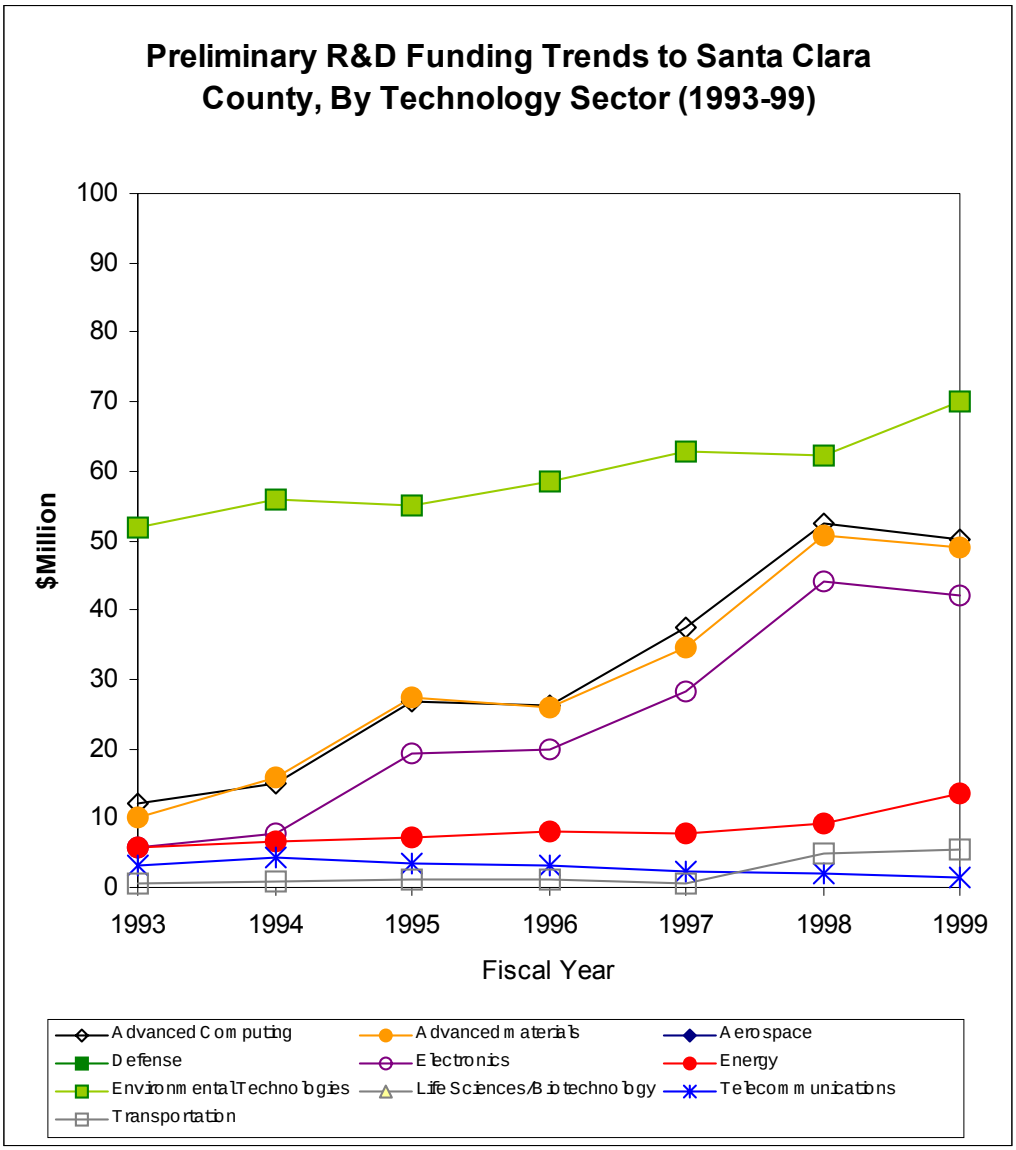
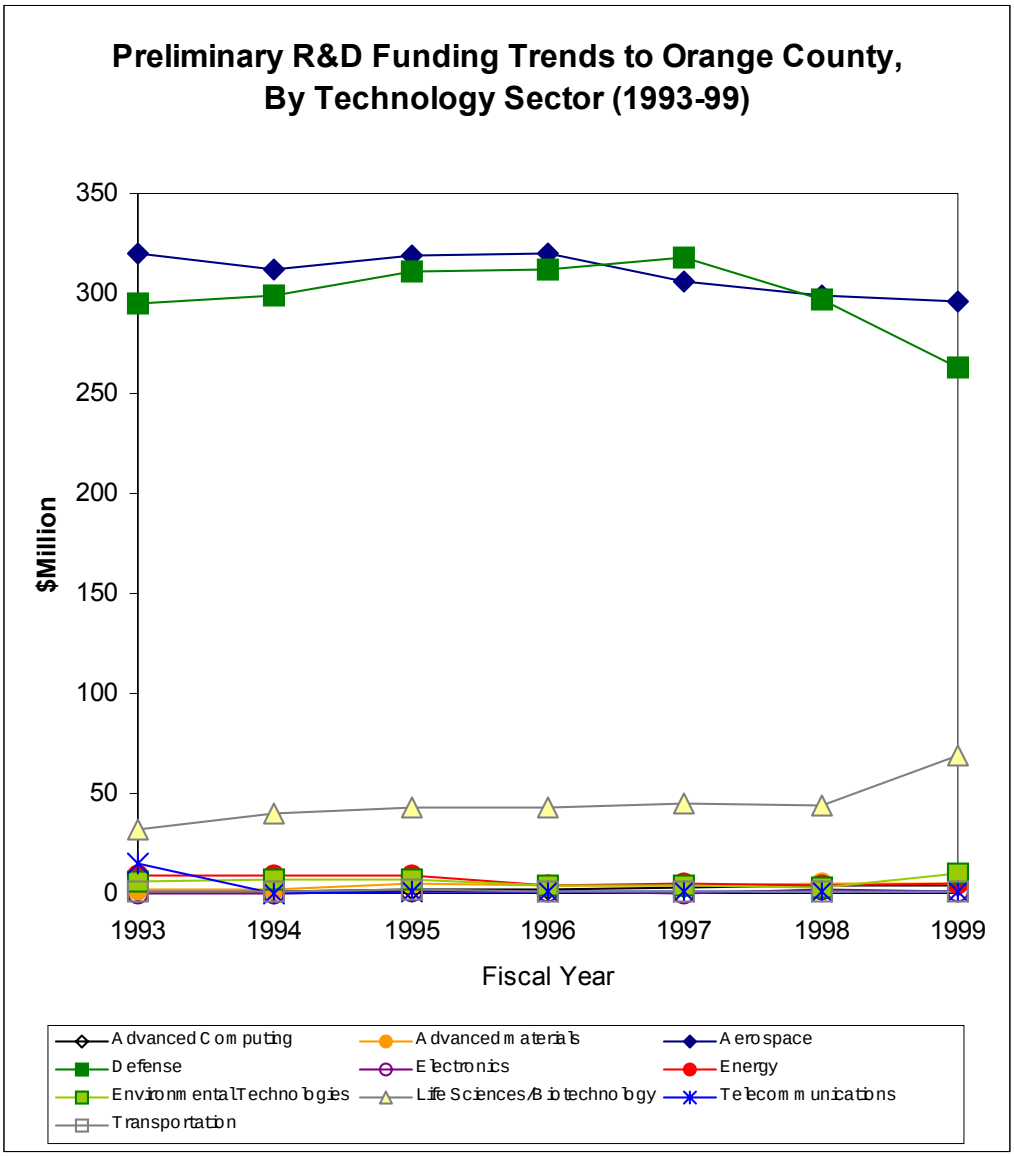


Figure V-GG(iv) **1993-99 Unclassified R&D Funding Trends for Orange County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot

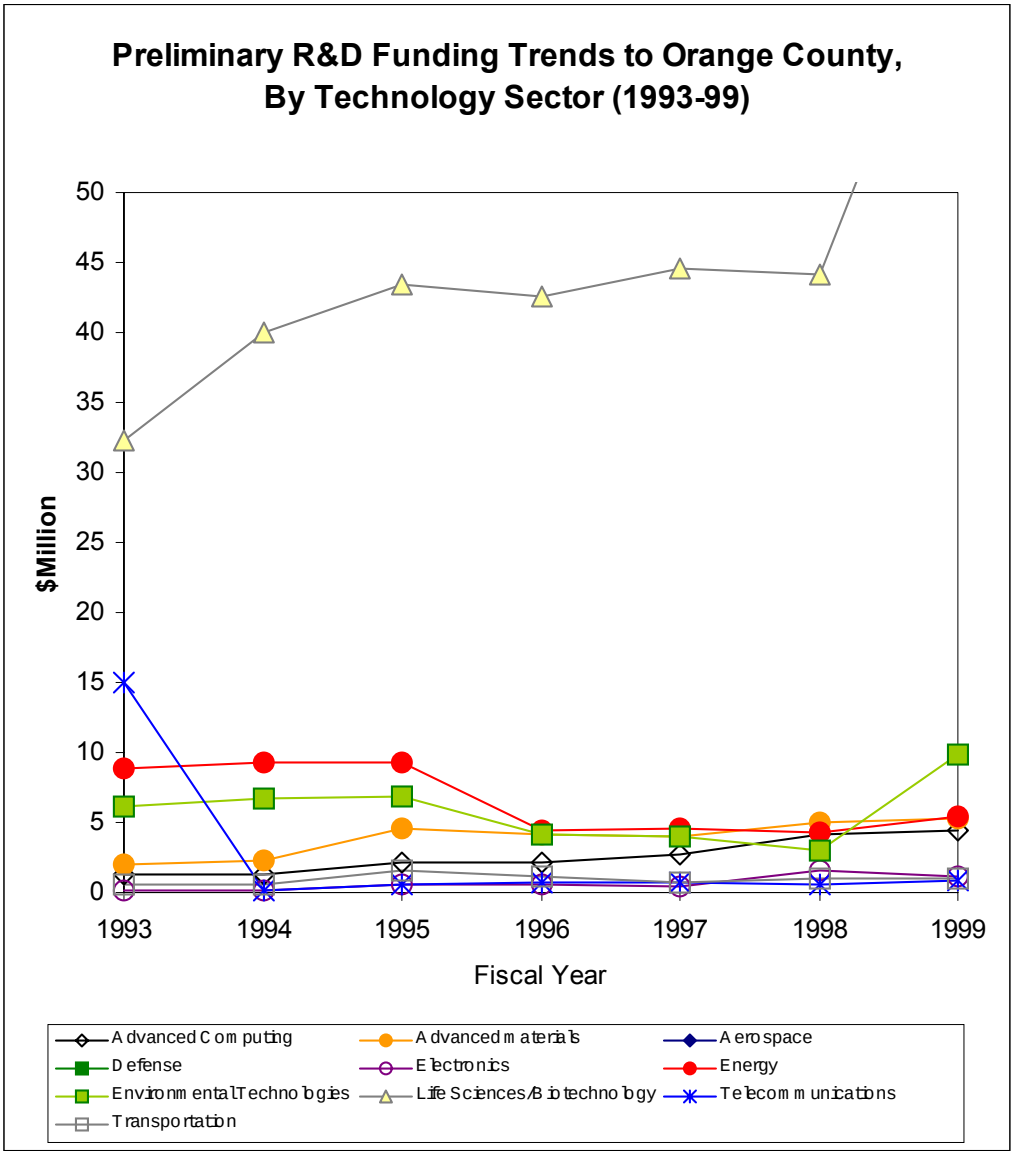


Figure V-GG(v) **1993-99 Unclassified R&D Funding Trends for Alameda County, by Technology Sector (Source: RaDiUS)**

Full Plot

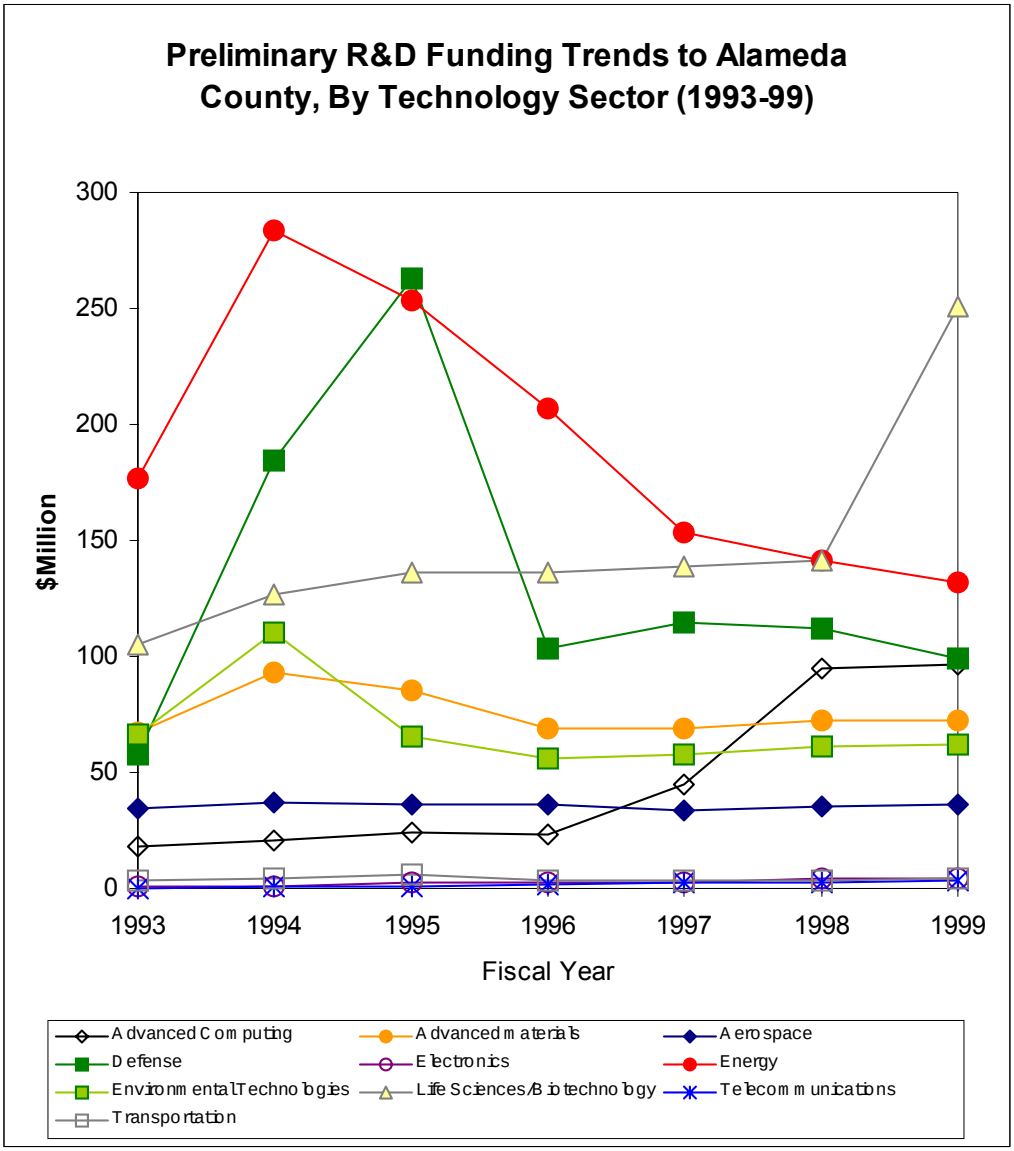
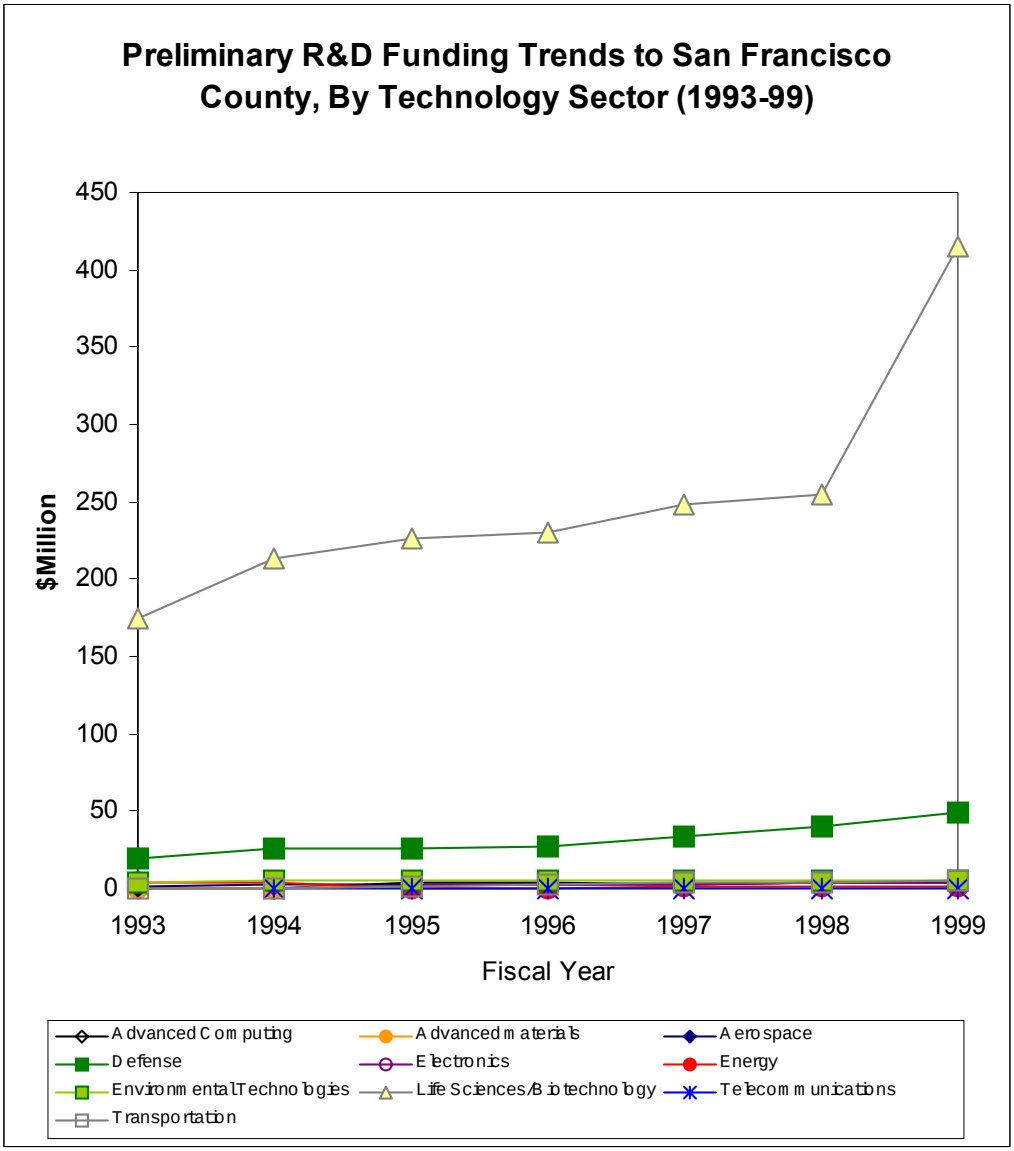


Figure V-GG(vi) **1993-99 Unclassified R&D Funding Trends for San Francisco County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot

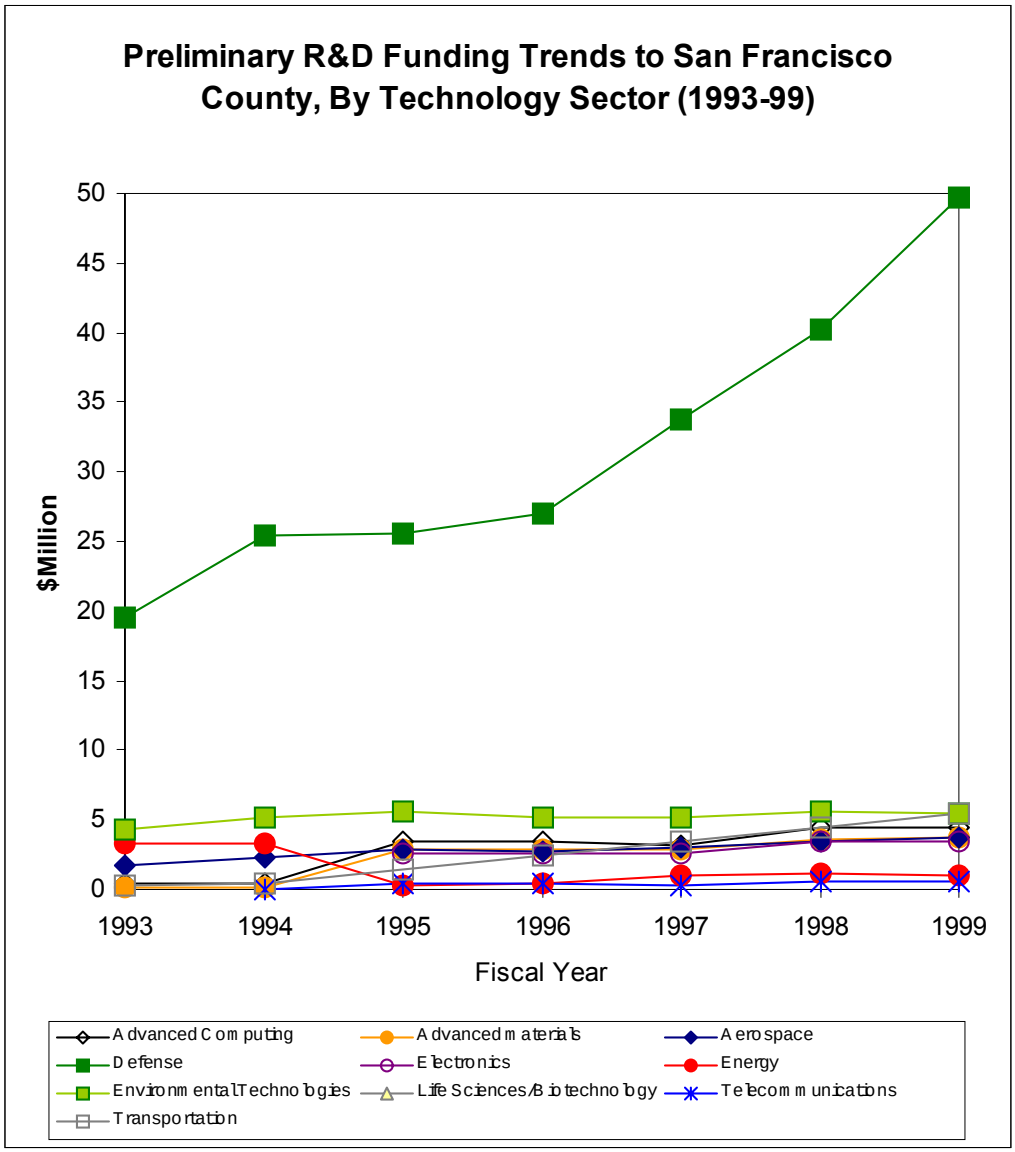
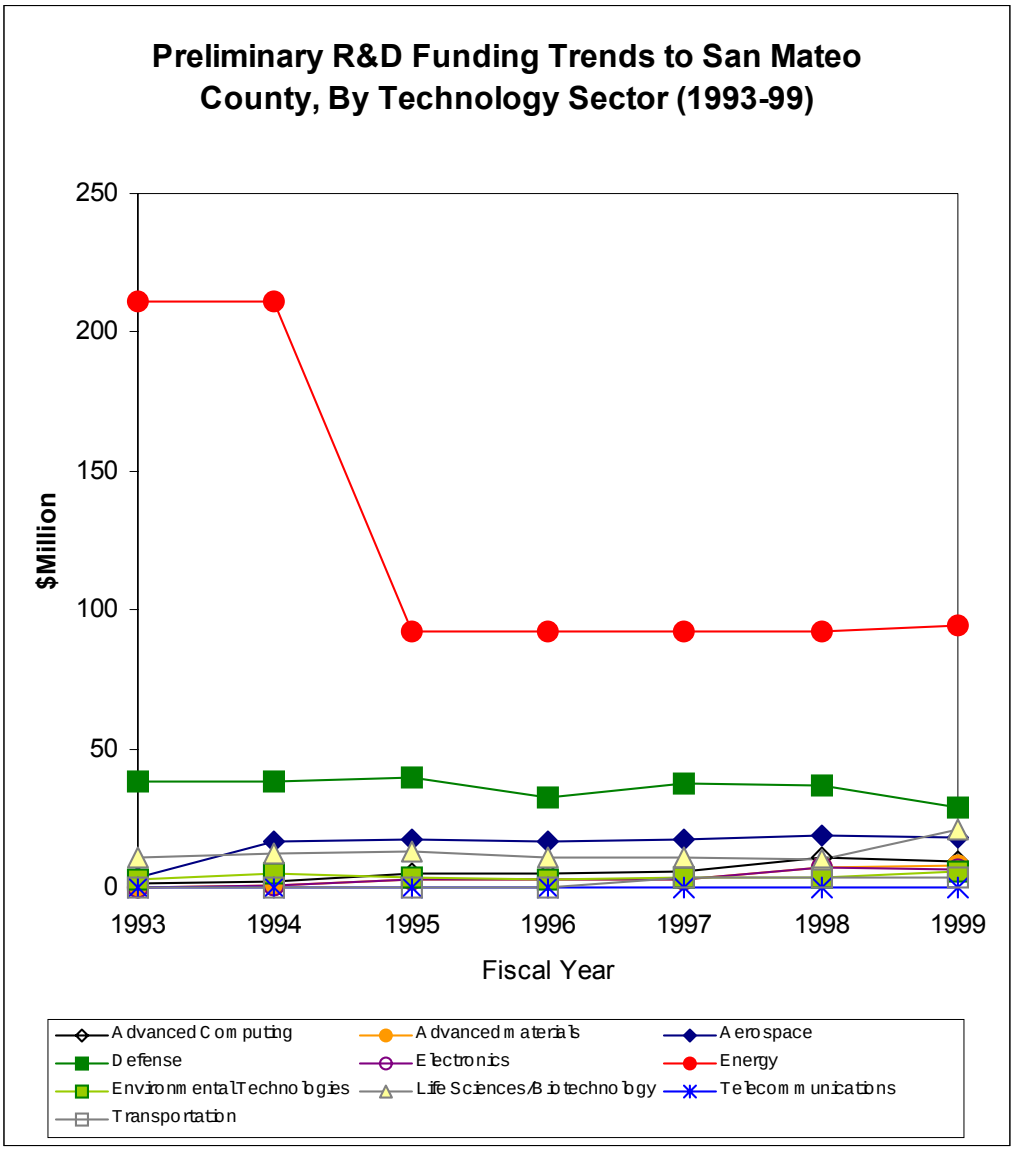


Figure V-GG(vii) **1993-99 Unclassified R&D Funding Trends for San Mateo County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot

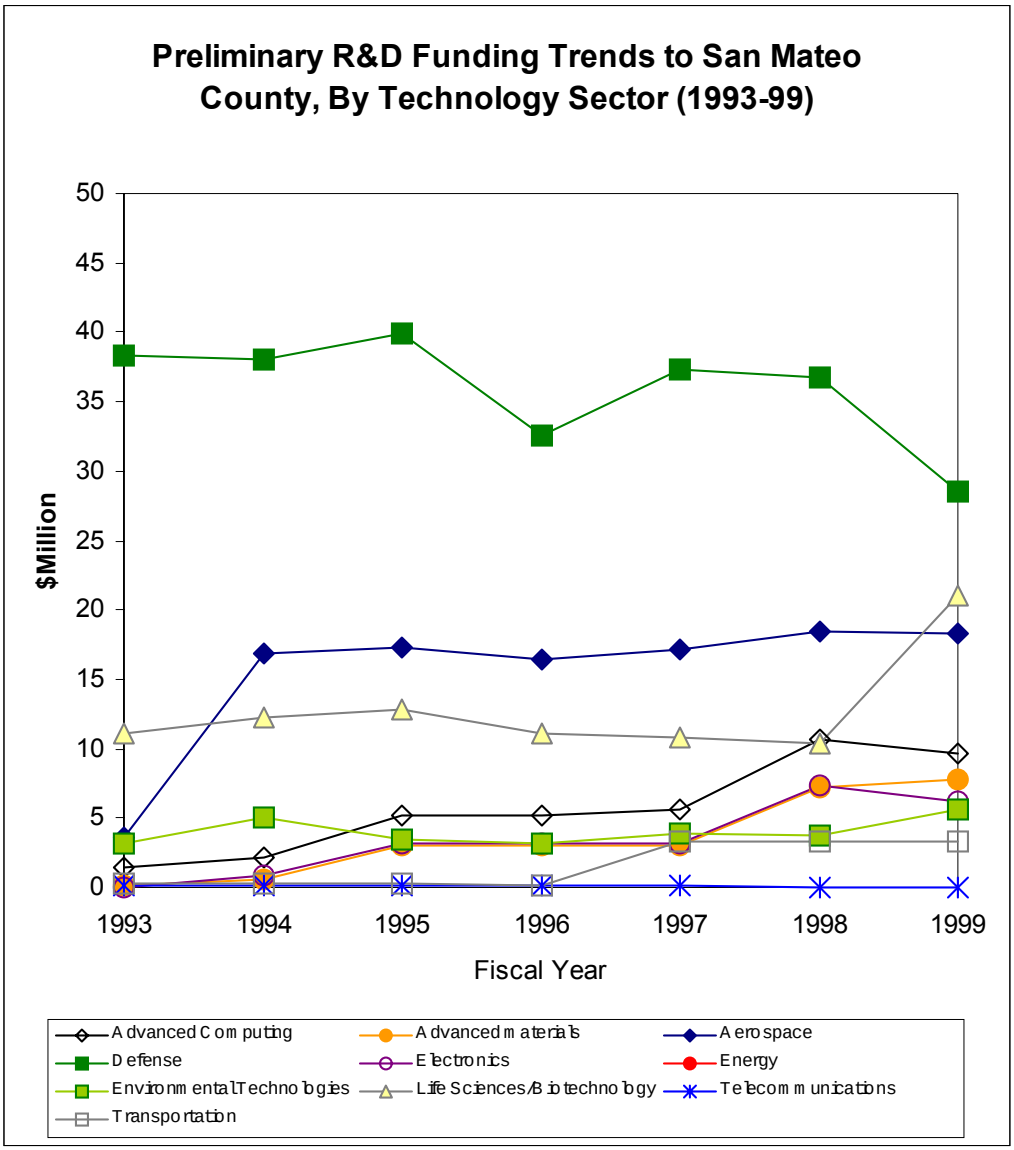
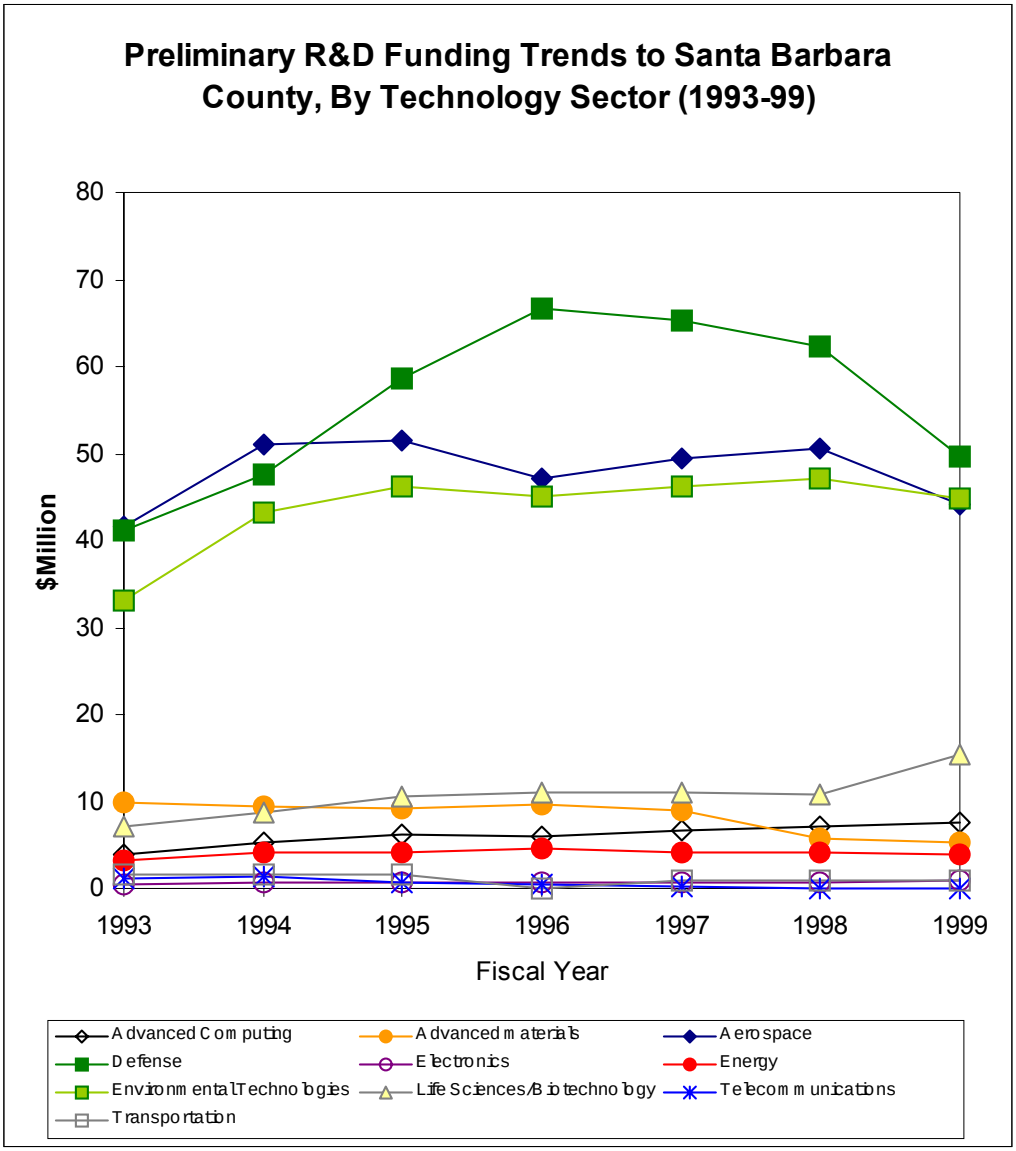
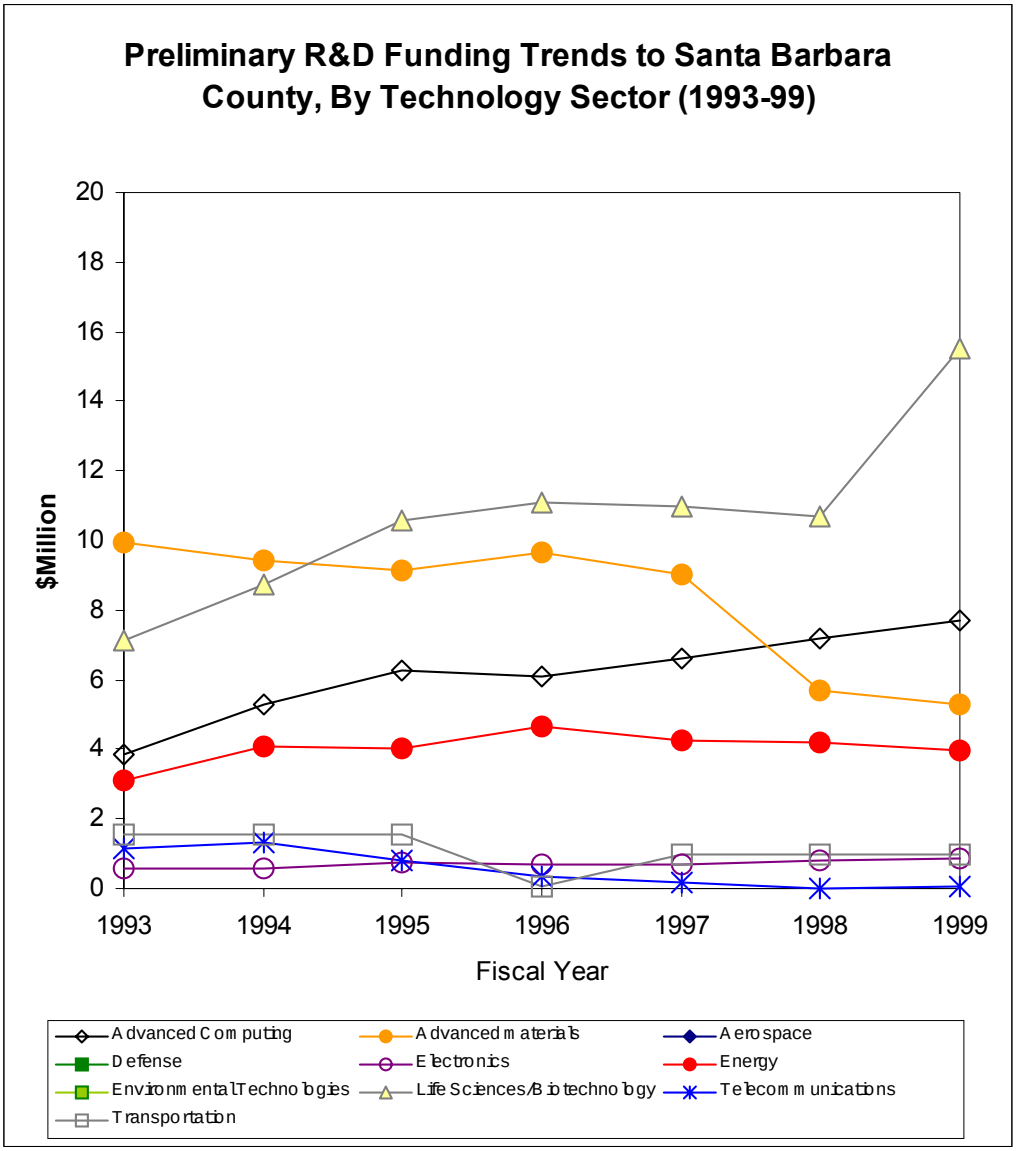


Figure V-GG(viii) **1993-99 Unclassified R&D Funding Trends for Santa Barbara County, by Technology Sector (Source: RaDiUS)**

Full Plot



Expanded Plot



VI. County Level Analysis of Unclassified Small Business Innovation Research (SBIR) Funding

This section presents a summary overview of unclassified small business innovation research (SBIR) funding, by county. Similar to the previous section, this discussion will be on a very general level in order to give the reader a broad picture. Full tables with data for all counties are listed in Sections X and XI of the Appendices.

A. Unclassified SBIR funding to Each County

The top counties receiving unclassified federal SBIR funding are shown in Figure VI-A and Table VI-A. As with the unclassified R&D funding picture, ten counties receive 94% of all unclassified SBIR funding to the state. Santa Clara County is the top recipient with Los Angeles and San Diego counties ranked in second and third places. Even though Los Angeles County is the top recipient of R&D funding, it is second in unclassified SBIR funding. See Tables VI-A and VI-B for details.

In all, there are 27 counties receiving unclassified SBIR funding. This number corresponds to 54% of the 50 counties receiving unclassified federal R&D funding. Of the counties receiving unclassified SBIR funding, 17 (or 63%) have a research university located in the county. While SBIR funding goes to fund companies for the most part, it is interesting to note this association between universities ("knowledge creation centers") and SBIR technology commercialization activities.

Figure VI-A Top 10 Counties Receiving Unclassified SBIR Funding, 1993-99
(Source: RaDiUS)

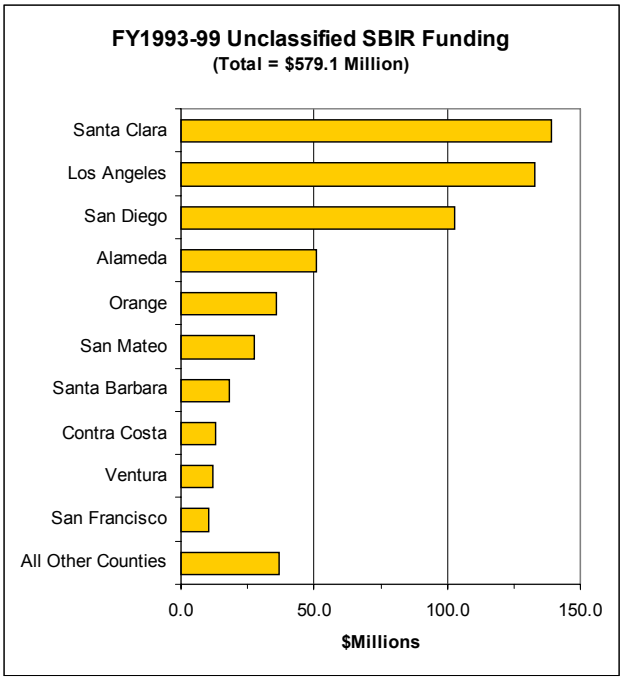


Table VI-A County Rankings for 1993-99 Unclassified SBIR Funding
(Source: RaDiUS)

Ranking	County Name	1993-99 Unclassified SBIR Funding ($Million)	Research Universities in County
1	Santa Clara	138.868	Stanford, San Jose State
2	Los Angeles	132.620	CalTech, UC Los Angeles, USC, Cal Poly Pomona, CSU Dominguez Hills, CSU Los Angeles, CSU Long Beach, CSU Northridge
3	San Diego	102.885	UC San Diego, San Diego State, CSU San Marcos
4	Alameda	51.100	UC Berkeley
5	Orange	35.843	UC Irvine, CSU Fullerton
6	San Mateo	27.269	
7	Santa Barbara	18.199	UC Santa Barbara, CSU Channel Islands
8	Contra Costa	12.907	CSU Hayward
9	Ventura	11.932	
10	San Francisco	10.543	UC San Francisco, San Francisco State
11	Marin	9.095	
12	Sacramento	5.790	CSU Sacramento
13	Santa Cruz	4.908	UC Santa Cruz
14	Yolo	3.339	UC Davis
15	Placer	2.416	
16	Riverside	1.923	UC Riverside
17	Solano	1.718	California Maritime Academy
18	Kern	1.572	
19	San Bernardino	1.470	CSU San Bernardino
20	San Luis Obispo	1.357	CSU San Luis Obispo
21	Sonoma	0.777	Sonoma State
22	Inyo	0.740	
23	Monterey	0.566	CSU Monterey Bay
24	Shasta	0.468	
25	Butte	0.285	
26	Fresno	0.258	
27	El Dorado	0.245	
	Agency Total:	**579.096**	

Table VI-B 1993-99 Unclassified SBIR Funding to the Top 5 Counties
(Source: RaDiUS)

County Name	Ranking By Unclassified SBIR Funding	1993-99 Unclassified SBIR Funding ($Millions)	Ranking By Unclassified R&D Funding	1993-99 Unclassified R&D Funding ($Billions)
Santa Clara	1	138.868	3	5.527
Los Angeles	2	132.620	1	23.124
San Diego	3	102.885	2	6.289
Alameda	4	51.100	5	4.344
Orange	5	35.843	4	4.736

B. Agency Breakdown of Unclassified SBIR Funding to Each County

As was the case with R&D funding, agency sources of unclassified SBIR funding differ substantially by county. Additionally, because DOD SBIR data was unavailable, there was no way to compare DOD R&D funding to DOD SBIR funding. Figures VI-B through K and Table VI-B provide details. Leaving DOD aside, unclassified SBIR funding mirrored trends in unclassified R&D funding in most counties. For instance, Los Angeles and Orange counties receive a high percentage of unclassified R&D funding from NASA. NASA also funded the largest percentage of both counties' unclassified SBIR funding. Outside of DOD, HHS is the largest funder of unclassified R&D activities for San Diego County. HHS also funds approximately 48% of all unclassified SBIR activities in San Diego.

Except for Alameda and San Mateo Counties, DOE did not fund a significant fraction of R&D activities in each of the top five counties. In contrast, DOE funds a significant fraction of SBIR activity in the top ten counties. Similarly, NSF is a minor component of the total R&D pie for each of the top five counties but funds a significant fraction of the SBIR activity in each of these counties. These effects could be a data anomaly arising from the missing DOD data and they merit further attention.

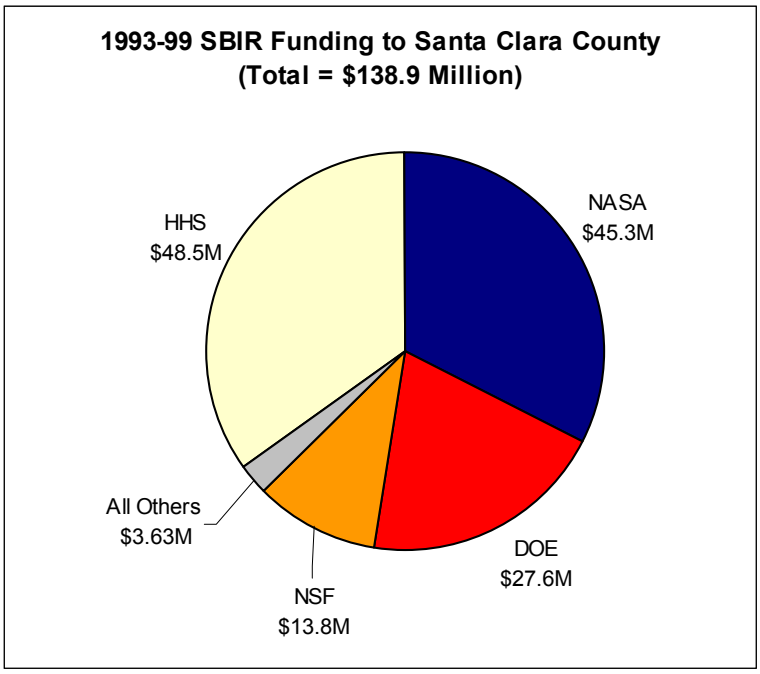
DOD SBIR funding data is not available at this time and hence is missing from **all** of the pie charts in Figures VI-B through F. However, RaDiUS does give an indication of the number of DOD SBIR awards and grants to each region. The number of DOD SBIR awards is listed in Table XI-C of the Appendices. DOD only awarded SBIR grants to 11 counties and these 11 counties include the top ten counties mentioned plus Placer county. Interestingly, of these top five counties, Alameda is the only county that did not rank in the top 5, as far as the number of DOD SBIR awards; it ranked eighth. Instead, lower ranked Santa Barbara County outranked Orange County to take fourth place, in terms of the *number* of DOD SBIR awarded, by county. These rankings might look different had actual funding data rather than the number of awards been available.

DOC funds a very small fraction of the overall unclassified SBIR awards. In the pie charts, this agency's contribution has been subsumed into the category called "All Others." DOC

administers the Advanced Technology Program[25] (ATP) but this program is not categorized as SBIR activity in RaDiUS, even though these grants are given to primarily to companies, not universities or other non-profit research entities. Please see Section VII of this report for a separate discussion of ATP funding to the state of California. T

Please note that the following pie charts below are uniformly coded by agency (i.e. NASA = dark blue, HHS = yellow, NSF = orange, DOE = red, All Others = Gray).[26]

Figure VI-B 1993-99 Unclassified Federal SBIR Funding to Santa Clara County, Total = $138.9 Million *(Source: RaDiUS)*

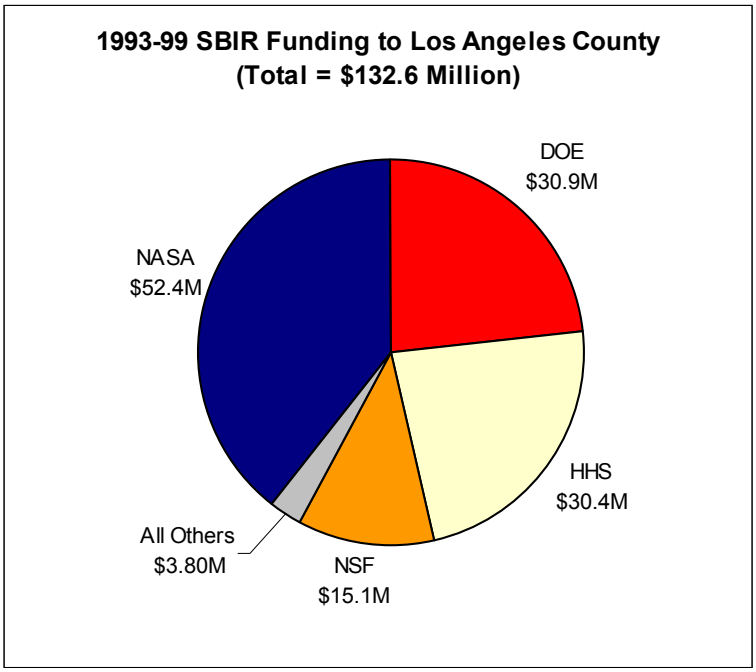


(DOD funded 54 SBIR awards in Santa Clara County during this time period. Funding data is unavailable and hence not shown.)

[25] The Advanced Technology Program is administered by the National Institute of Standards & Technology (NIST), a sub-agency of the Department of Commerce (DOC).

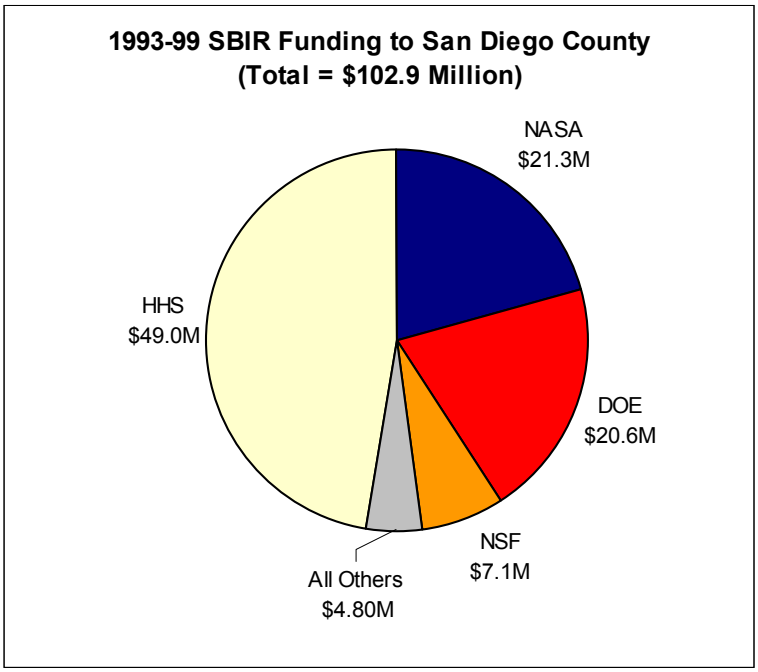
[26] Color codes refer to the appearance of screen colors only. Colors in printed copies of this report may differ slightly due to a particular color printer's ability to translate screen colors into ink renderings. If there is any doubt about coloration, please refer to the agency abbreviation corresponding to that particular section of the pie chart.

Figure VI-C 1993-99 Unclassified Federal SBIR Funding to Los Angeles County, Total = $132.6 Million ***(Source: RaDiUS)***



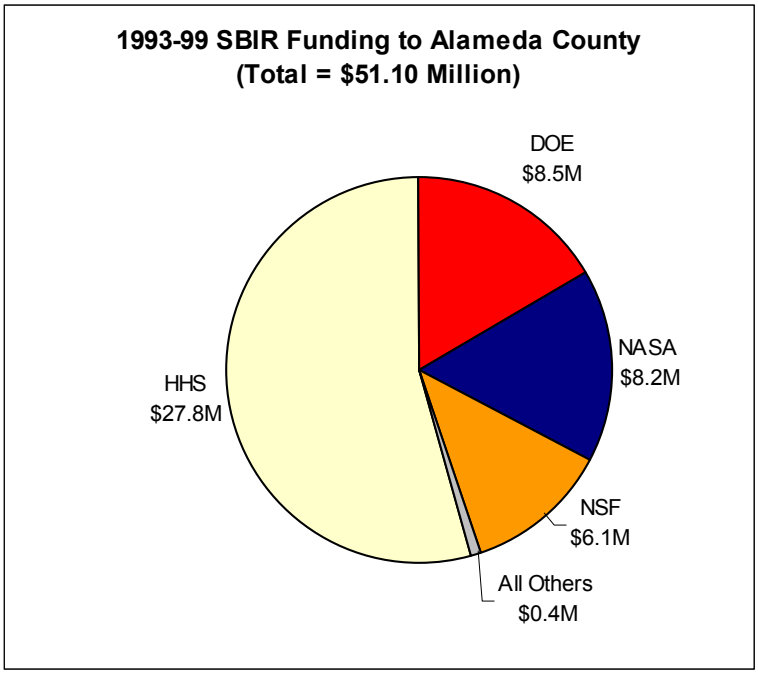
(DOD funded 63 SBIR awards in Los Angeles County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-D 1993-99 Unclassified Federal SBIR Funding to San Diego County, Total = $102.9 Million ***(Source: RaDiUS)***



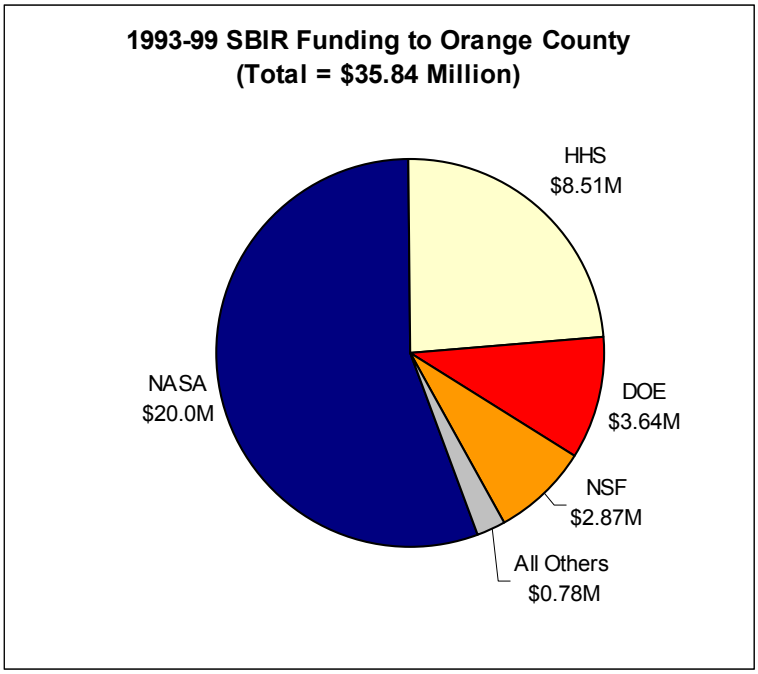
(DOD funded 57 SBIR awards in San Diego County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-E 1993-99 Unclassified Federal SBIR Funding to Alameda County, Total = $51.10 Million ***(Source: RaDiUS)***



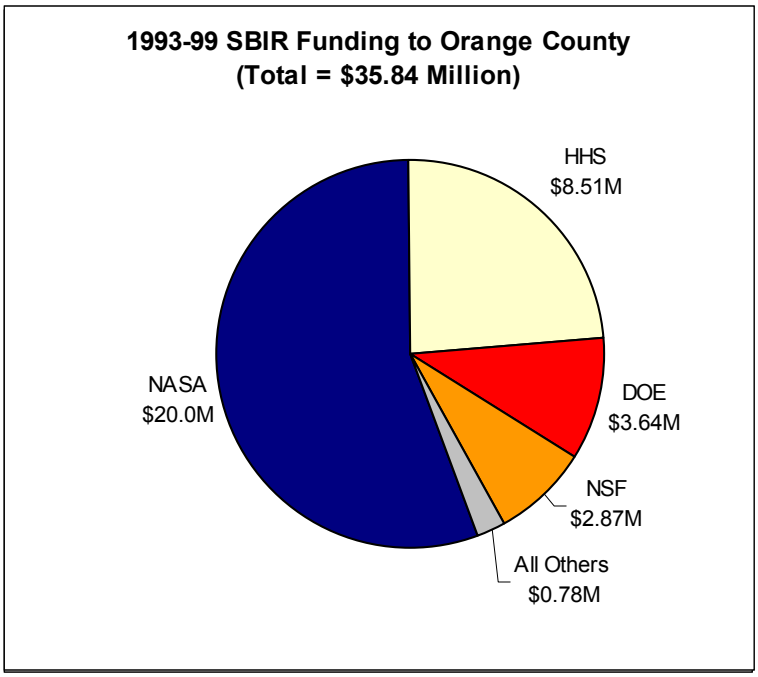
(DOD funded 9 SBIR awards in Alameda County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-F 1993-99 Unclassified Federal SBIR Funding to Orange County, Total = $35.84 Million ***(Source: RaDiUS)***



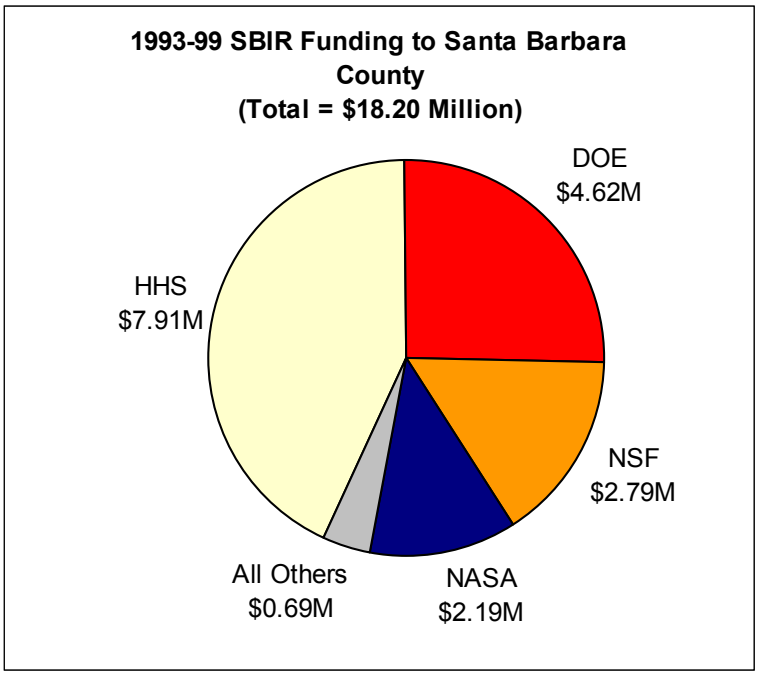
(DOD funded 19 SBIR awards in Orange County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-G 1993-99 Unclassified Federal SBIR Funding to San Mateo County, Total = $27.27 Million *(Source: RaDiUS)*



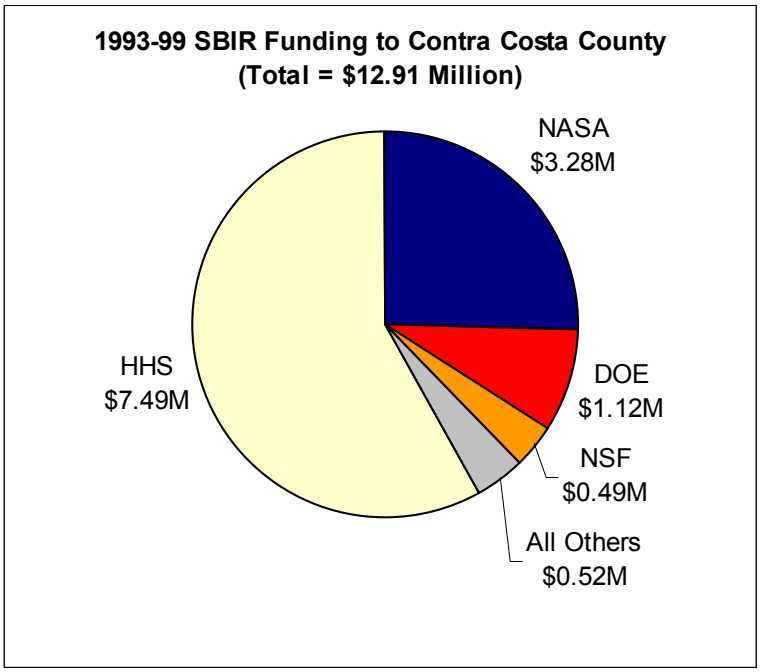
(DOD funded 19 SBIR awards in San Mateo County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-H 1993-99 Unclassified Federal SBIR Funding to Santa Barbara County, Total = $18.20 Million *(Source: RaDiUS)*



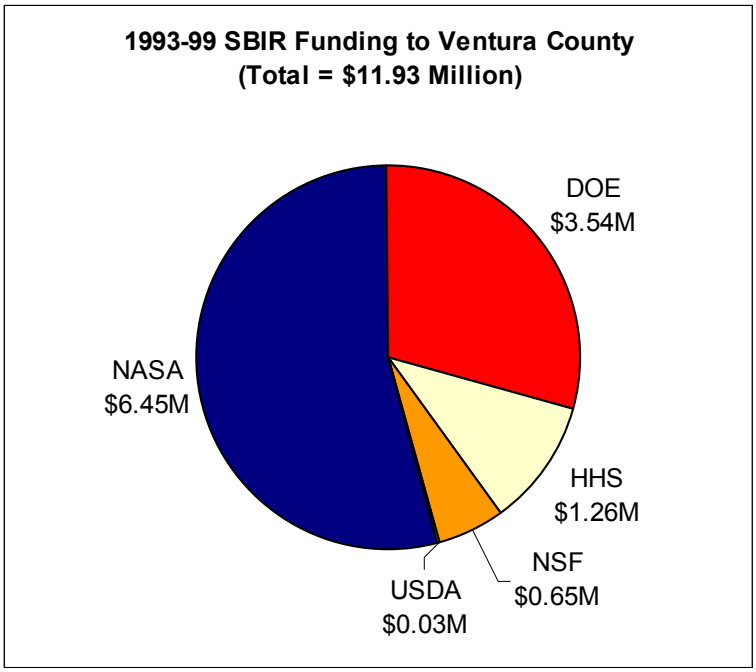
(DOD funded 19 SBIR awards in Santa Barbara County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-I 1993-99 Unclassified Federal SBIR Funding to Contra Costa County, Total = $12.91 Million *(Source: RaDiUS)*



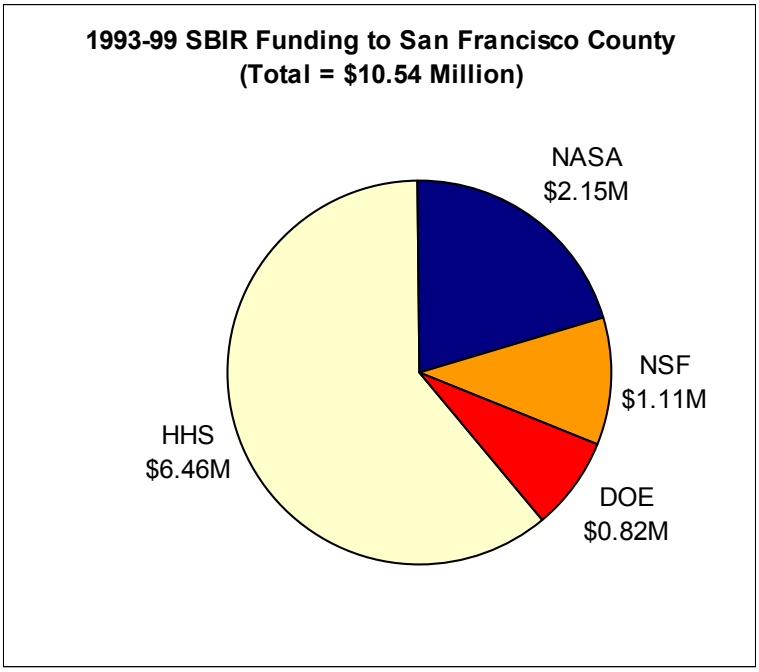
(DOD funded 19 SBIR awards in Contra Costa County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-J 1993-99 Unclassified Federal SBIR Funding to Ventura County, Total = $11.93 Million *(Source: RaDiUS)*



(DOD funded 19 SBIR awards in Ventura County during this time period. Funding data is unavailable and hence not shown.)

Figure VI-K 1993-99 Unclassified Federal SBIR Funding to San Francisco County, Total = $10.54 Million ***(Source: RaDiUS)***



(DOD funded 19 SBIR awards in San Francisco County during this time period. Funding data is unavailable and hence not shown.)

C. 1993-99 Unclassified SBIR Funding Trends

Federal support for unclassified SBIR funding activities rose substantially in the mid-1990's increasing 116.7% between 1993 and 1999. While increases were sharp during the first part of the 1990s, these have now tapered off in recent years (see Figure VI-L and Table VI-C). As shown in Figure VI-M, where the data has been broken out by agency, the recent tapering off of funding can be attributed to slight decreases in funding from three of the four major agencies (HHS, NASA and DOE). Only NSF SBIR funding has remained stable during the entire period.

Given the RaDiUS data problems with HHS data for FY2000 and perhaps even FY1999, the reported HHS SBIR trends should be considered as preliminary and by no means definitive. The decreases could be due to missing data, and may not be real.

Figure VI-L 1993-99 Unclassified Federal SBIR Funding to the State of California ***(Source: RaDiUS)***

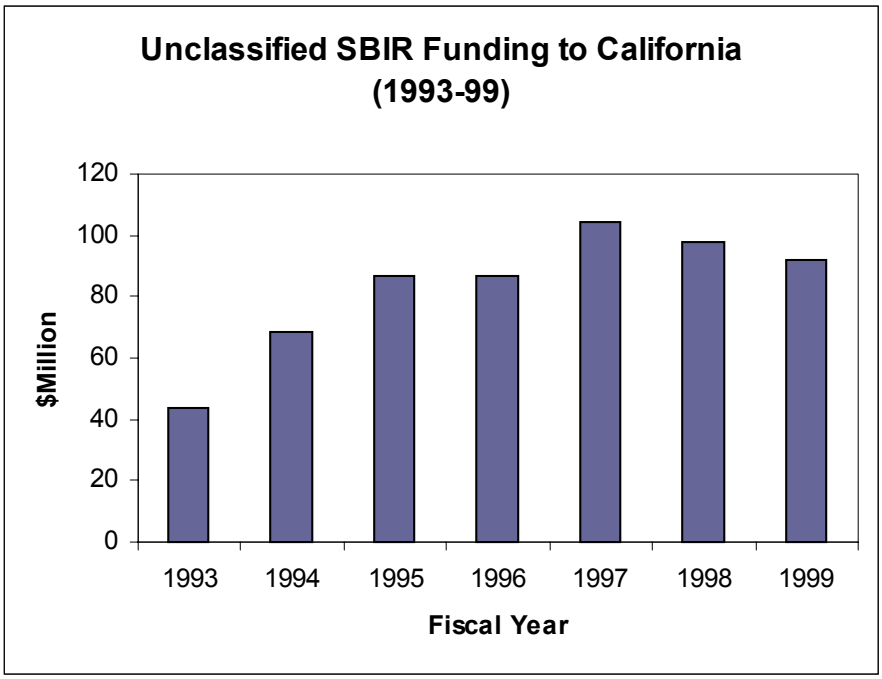
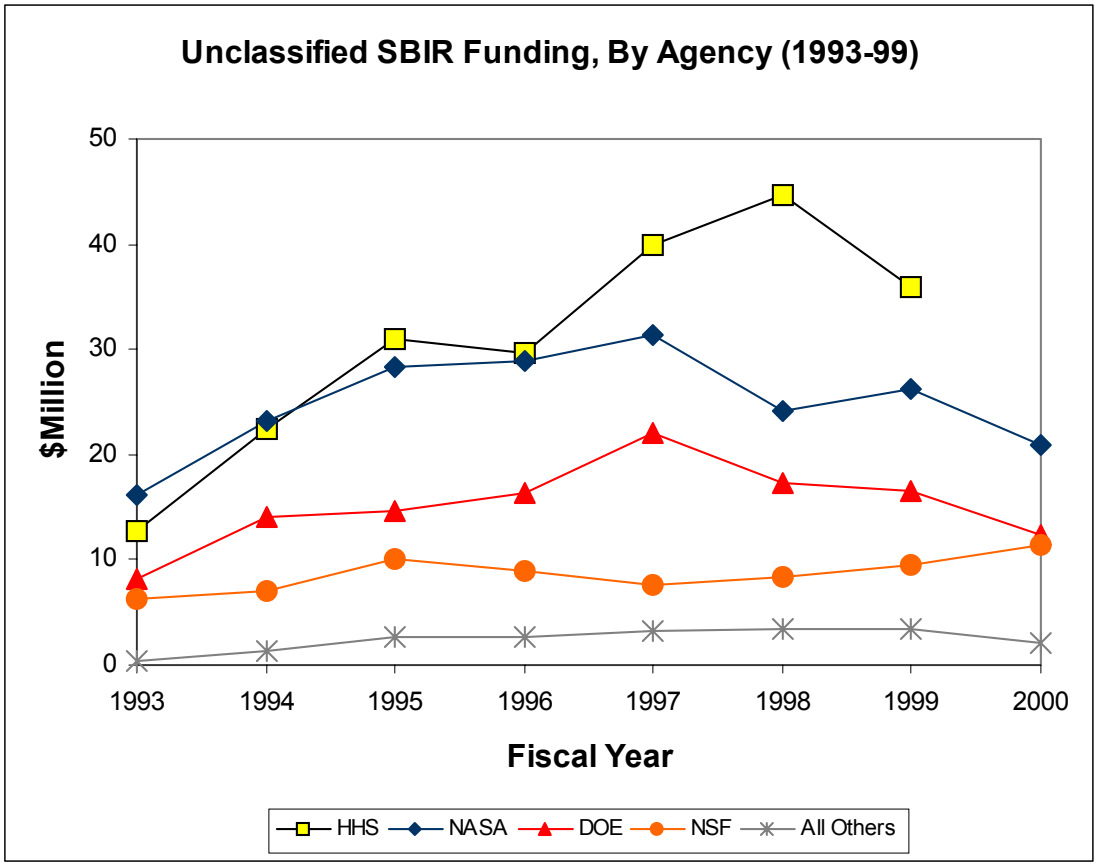


Table VI-C 1993-2000 Agency Trends in Unclassified SBIR Funding to the State of California ***(Source: RaDiUS)***

Agency Abbrev.	1993	1994	1995	1996	1997	1998	1999	2000	1993-2000 Total
DOC		0.242	1.332	1.204	1.164	0.970	1.032	0.504	**5.943**
DOD	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
DOE	8.237	14.114	14.607	16.444	22.042	17.255	16.591	12.303	**109.291**
DOT	0.303	0.884	0.934	0.899	1.264	1.029	0.996	0.709	**6.309**
EPA		0.008	0.092	0.084	0.238	0.348	0.645	0.471	**1.414**
HHS	12.821	22.429	30.922	29.667	39.887	44.705	35.954	--	**216.384***
NASA	16.216	23.196	28.352	28.821	31.439	24.205	26.255	20.909	**178.484**
NSF	6.337	7.123	10.121	8.877	7.570	8.295	9.517	11.386	**57.839**
USDA		0.249	0.249	0.439	0.632	1.058	0.804	0.396	**3.431**
FY Total:	**43.914**	**68.245**	**86.609**	**86.435**	**104.236**	**97.865**	**91.793**	**46.678**	**--**

**1993-99 Total only because FY2000 HHS data is unavailable at this time.*

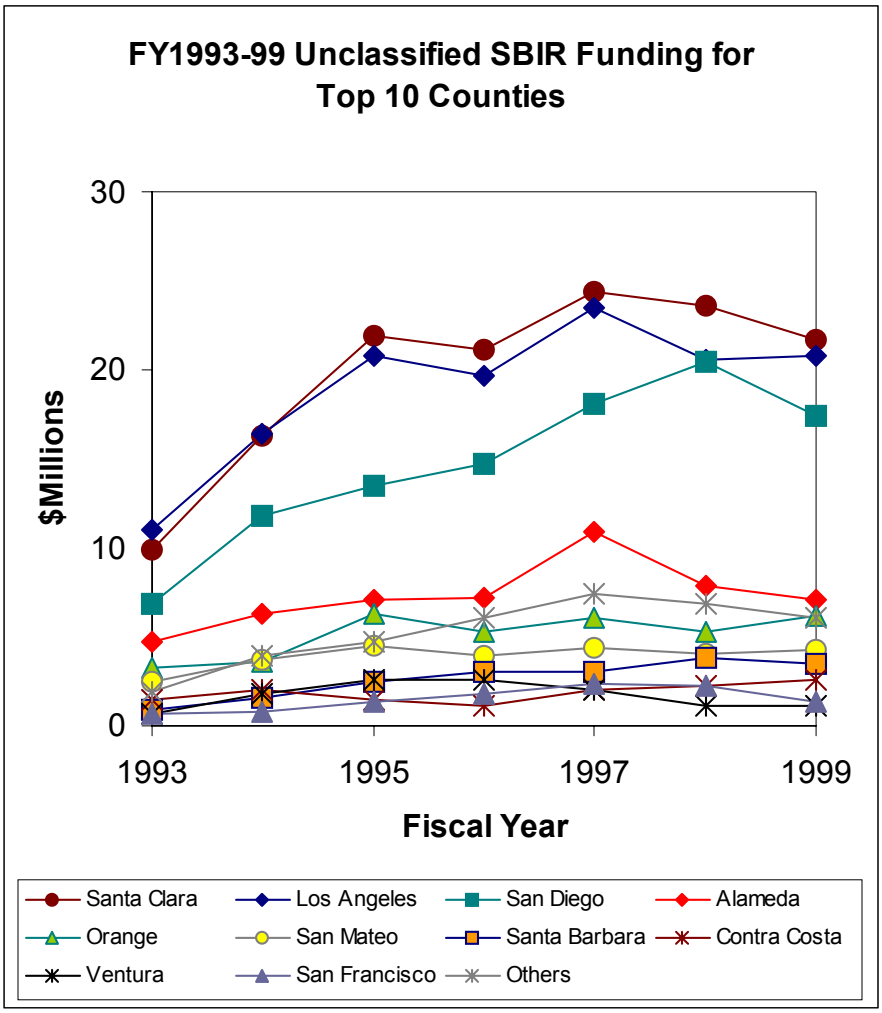
Figure VI-M 1993-99 Agency Trends for Unclassified SBIR funding to the State of California ***(Source: RaDiUS)***



D. Unclassified SBIR Funding Trends to the Top 10 Counties

Disaggregating the state data by county reveals that funding did not increase uniformly across all regions. Substantial, sustained increases in funding to the top three counties (Santa Clara, Los Angeles and San Diego) fueled much of the rise in unclassified SBIR funding between 1993 and 1999. See Figure VI-I.

Figure VI-I 1993-99 Unclassified SBIR Funding Trends to the Top 10 Counties
(Source: RaDiUS)



To determine which county sustained the largest increase in SBIR funding, the percent difference in funding between 1993 and 1999 was also calculated. Results are shown in Table VI-D. This analysis highlights regions that may not necessarily have a large base of SBIR funding. By this measure, San Bernardino, Solano and Marin counties ranked as the three fastest growing regions of the state with percentage changes of 2,680%, 819% and 743%. Santa Barbara and Riverside are not far behind at 291% and 253%. Of these five regions, Santa Barbara experienced the largest absolute increase in SBIR funding, both in terms of funding and the number of grants since it started from a larger base. While the other four regions fluctuated between one and 3-4 grants each year, during the entire period, unclassified SBIR funding almost tripled in Santa Barbara and the number of grants rose from 14 to 33.

Table VI-D Unclassified SBIR Funding Changes Between 1993 and 1999 for All Counties Receiving SBIR Funding ***(Source: RaDiUS)***

SBIR Ranking[27]	County Name	1993 Funding ($Millions)	1999 Funding ($Millions)	Difference ($Millions)	% Difference
19	San Bernardino	0.021	0.584	0.563	2679.8%
17	Solano	0.050	0.460	0.410	819.1%
11	Marin	0.188	1.582	1.394	743.1%
7	Santa Barbara	0.893	3.492	2.598	290.9%
16	Riverside	0.075	0.264	0.189	253.0%
3	San Diego	6.905	17.396	10.491	151.9%
1	Santa Clara	9.866	21.631	11.765	119.2%
10	San Francisco	0.680	1.368	0.688	101.1%
5	Orange	3.211	6.128	2.917	90.9%
2	Los Angeles	11.003	20.761	9.758	88.7%
13	Santa Cruz	0.350	0.645	0.296	84.5%
8	Contra Costa	1.463	2.529	1.065	72.8%
6	San Mateo	2.508	4.236	1.728	68.9%
9	Ventura	0.719	1.121	0.402	55.9%
4	Alameda	4.745	7.100	2.356	49.6%
21	Sonoma	0.159	0.150	-0.009	-5.8%
14	Yolo	0.399	0.277	-0.123	-30.7%
12	Sacramento	0.488	0.300	-0.187	-38.4%
15	Placer	0.116			
18	Kern		0.535		
20	San Luis Obispo		0.529		
22	Inyo				
23	Monterey		0.200		
24	Shasta		0.435		
25	Butte		0.070		
26	Fresno	0.025			
27	El Dorado	0.050			
		37.932	**82.197**	**44.265**	**116.7%**

[27] Ranking is determined by aggregated funding from 1993-99 inclusive.

VII. Department of Commerce NIST ATP Funding Trends

The Advanced Technology Program is a federal program that provides bridge funding to help move inventions from the research lab into the marketplace. This program is administered through the National Institute of Standards & Technology (NIST) and resembles the SBIR program in terms of activities funded. However, it is not part of the SBIR program and hence is not aggregated with that portion of the RaDiUS database. Rather, it is aggregated with other R&D funding data. Thus, if one is interested in this particular program, this data must be pooled and analyzed separately. See Figure VII-A and VII-B and Appendix XII for further details.

The total aggregated funding awarded by ATP is roughly half that awarded by SBIR. However, the total number of counties receiving ATP funding is much smaller than the total number of counties receiving SBIR grants. Only 11 counties in California received ATP funding. All of these counties are located in metropolitan areas near major research universities. Unlike SBIR funding where a small fraction of the funding went to entities located in rural counties, none of the entities receiving ATP funding are located very far from a knowledge creation center such a major research university. These counties and the amount funded is shown in Figure VII-A and Table VII-A. Santa Clara County receives the lions' share of funding at 52% of the total $325.26 million awarded between 1993 and 2000.

Figure VII-A 1993-2000 Advanced Technology Program (ATP) Funding by County ***(Source: RaDiUS)***

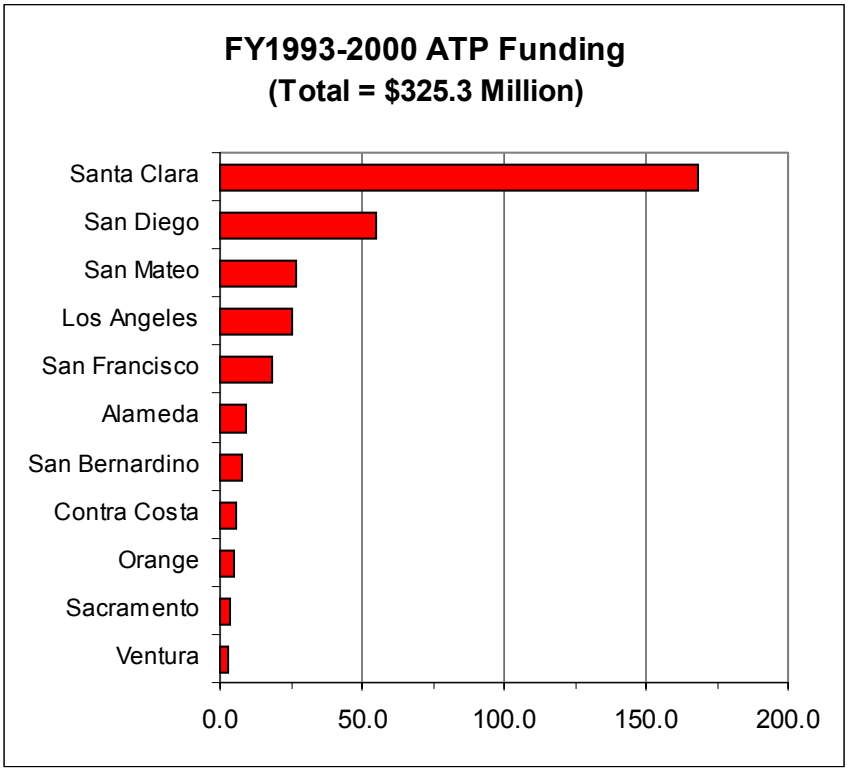
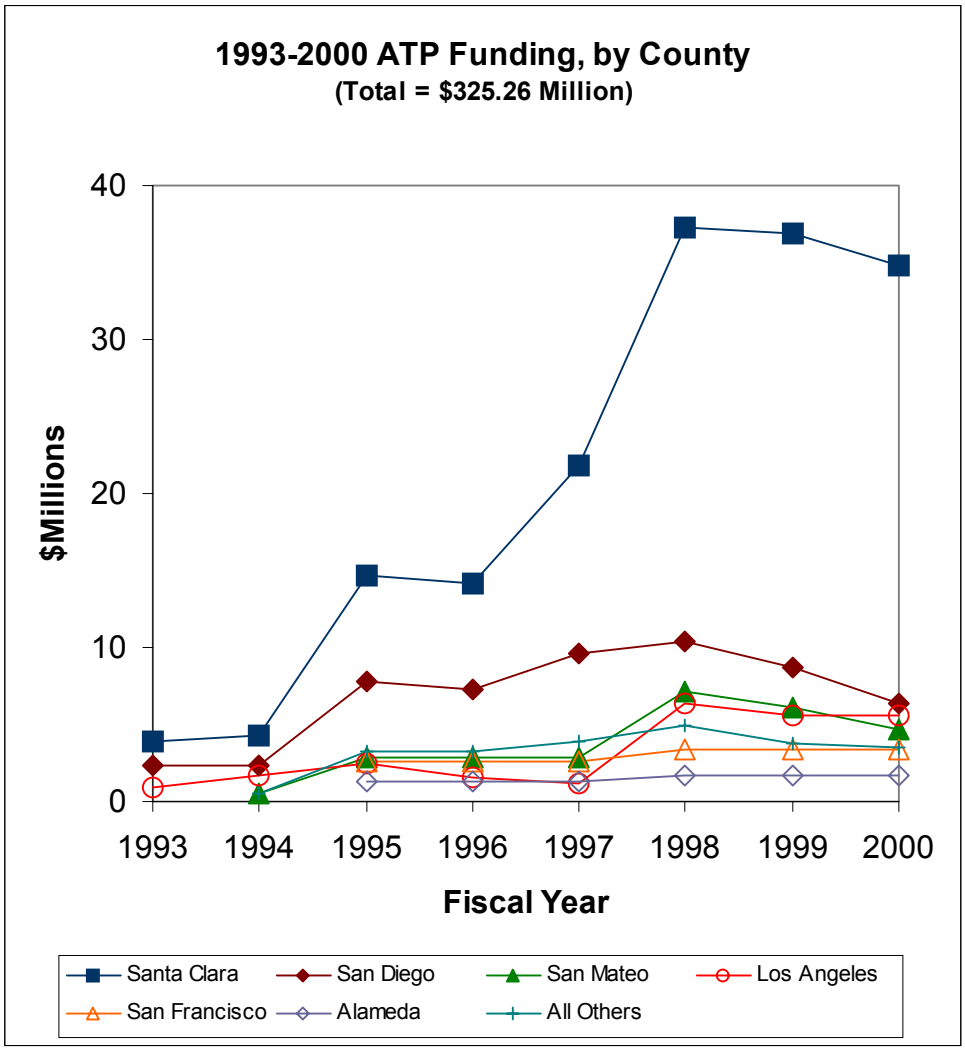


Table VII-A 1993-2000 Advanced Technology Program (ATP) Funding, by County ***(Source: RaDiUS)***

County Name	1993-2000 Funding ($Millions)	% Total
Santa Clara	168.040	52%
San Diego	54.745	17%
San Mateo	27.112	8%
Los Angeles	25.240	8%
San Francisco	18.065	6%
Alameda	8.808	3%
All Others	23.250	7%
Total:	**325.260**	**100%**

Figure VII-B 1993-2000 Trends in Advanced Technology Program (ATP) Funding to the Top 6 Counties ***(Source: RaDiUS)***



VIII. Summary of Findings

A. R&D Funding

California is home to 58 counties, some of which are the size of small states. To adequately describe the size and type of research activities of *each* of these counties is beyond the scope of this project. Hence, this study is but a preliminary look at a rich and complex picture of where we are, as a state, at this particular point in time, utilizing databases which are still in development.

This preliminary effort to provide regional data dramatizes that California's R&D landscape truly is a patchwork quilt with research strengths that differ as one moves from one county to another. No one county looks like any other county in the state. For instance, among the five top R&D funded counties, Los Angeles and Orange Counties are very strong in the defense and aerospace sectors while San Diego's strengths derive from defense and life sciences and Alameda's energy. Santa Clara County, home to Silicon Valley, excels in electronics.

Furthermore, this study is but a small first step towards understanding how regional differences in research strengths play out in the development of specific high tech industry clusters. Given the notable differences in funding levels, as well as the types of technology funded, should we expect similar industry clusters to develop in different areas of the state? The answer is that it's unlikely. The reality is much more complex because the top ranked counties are home to many thriving industry clusters despite their research dominance in one area. We are only beginning to understand the dynamics of the relationship between established research clusters and emerging industry clusters.

Another important finding is that despite the diversity of research strengths in practically every California county, a small number of metropolitan counties secure the lions' share of federal R&D funding. Research activities for the top eight counties accounted for approximately 94% of the total funding to California between 1993 and 1999, the last year for which complete data was available. If one were to widen the net to encompass 99% of the R&D funding, this would only expand the list of counties from 8 to 13.

The R&D funding characteristics of these top counties also differ from other counties. These counties have all received $1 billion or more over the time period studied (1993-1999). The funding differences are remarkably steep as one compares the county rankings. The range in funding from the 10th ranked Sacramento County and 20th ranked San Joaquin County is almost a twenty-fold difference dropping from over $200 million to less than $10 million, aggregated over the time period studied (1993-1999). This suggests that it may be very difficult to sustain significant levels of R&D funding in counties that are far from major knowledge creation centers or large technology-based companies.

This study also suggests the possible role played by major universities and institutions of higher learning, in combination with large technology-based companies as anchors for the research clusters of a region. Of the top eight counties receiving federal R&D funding, seven of the eight counties have *at least one* major research university (a University of California campus or a

private university equivalent) sited in that county. Many of the high-performing counties also are home to robust industry clusters. Los Angeles is a dramatic example of this. San Mateo is the only county that does not include a research university but it is home to the Stanford Linear Accelerator Center, a major National Lab funded primarily by the Department of Energy. San Mateo is also situated between San Francisco and Santa Clara Counties and hence the industry clusters in this county are likely tied to research capabilities in San Francisco and Santa Clara Counties.

One question that remains unanswered by this preliminary assessment of regional R&D activities is whether or not there is a minimum basis of R&D funding required to jumpstart the knowledge creation activities that are a precursor to the development of high tech industry clusters. The RaDiUS database allows provisional categorization of counties as large, medium and small performers of R&D. Vibrant industry clusters appear to exist in counties that are large performers of R&D. Did the growth of these clusters take off once R&D activities reached this minimum threshold or do private companies stimulate the growth of R&D activity? Can middle ranged counties create the critical mass necessary to create robust industry clusters? Can these counties expand their research base and transition into the top tiers? How can lower ranked counties increase their funding base, if this is a necessary precursor to jumpstarting innovation-intensive industries in their region?

In examining which counties sustained the largest changes in research funding between 1993 and 1999, the spotlight shifts from the traditionally well-funded, top-ranked counties to smaller counties. However, one needs to be careful when looking at large percentage changes in funding from a small base. In many rural counties (e.g., Placer County), the size of a single grant can greatly skew the results. On the other hand, it is important to pay closer attention to a county that has sustained large, annual increases in funding over the course of several years (e.g., Sonoma County). Both Placer and Sonoma counties sustained R&D funding increases of over 1200% between 1993 and 1999. Sonoma County's increase appears to be both in numbers of grants and total dollars, whereas Placer County's is a dollar increase in one research area. These differences may signal different long-term consequences of research initiatives for each county and merit closer analysis.

B. R&D Performer Types

Counties differ by who are the major performers of research. Among the top ranked counties, in those counties where DOD and NASA funds the majority of research activities, individual businesses dominate as the performer of R&D activities. They are complemented by research institutions such as universities, national labs, and other non-profit research entities that still perform a significant fraction of research. It is entirely possible that the nature of the R&D activity changes depending on the agency that funds the work. DOD and NASA fund a large number of engineering and mission-critical research programs and hence may contract with individual businesses for these research activities rather than with educational institutions that are primarily devoted to basic research for the sake of extending the frontiers of human knowledge. On the other hand, in those counties such as San Diego and San Francisco that are major recipients of life sciences/biotech funding, educational institutions and non-profit research

entities are major performers of R&D. This may reflect a fundamental difference in the role of the research enterprise in different technology sectors. Many of the fundamental breakthroughs that have fueled the growth of the biotechnology industry have come from basic research in the life sciences. This research is conducted largely by universities and non-profit research institutes, rather than by individual businesses.

C. Technology Sectors

The RaDiUS database is not set up to address R&D funding by technology sectors. But, because of interest in categorizing R&D by broad technology sectors, an approach was developed which assesses research funding to subject areas such as life sciences, aerospace, defense and electronics, among others. This approach relies primarily on assigning program elements to subject areas based on the title of the program element. While most of the research program titles are descriptive of the technologies being funded, they do impose limitations. Sometimes, the titles reflect program missions and are not descriptive of the technologies being funded. Thus, the reader is cautioned against over-interpreting these results because some technologies (e.g., advanced computing and electronics among others) are probably undercounted using this method of categorization.

When re-analyzed on a regional (county) level, the technology sector analysis reveals additional insights about the kinds of research activity being funded at the county level. For Los Angeles, Orange and other counties that receive large shares of their R&D funding from NASA and DOD, it is not surprising that much of their research activity is devoted to defense and aerospace technologies. On the other hand, Alameda county receives a substantial fraction of its funding from DOE. However, based on project titles, it appears that a substantial fraction of this DOE funding is devoted to defense-related research rather than energy-related research.

Given the recent energy crisis in California, it is interesting to note that funding for energy related research has been declining steadily since the mid-1990s. If this data had not been analyzed by technology sectors, this downward trend may have been hidden since overall funding from DOE to the state has actually remained fairly stable with modest increases in the recent past. This trend may also reflect a shift in priorities within DOE. A closer examination of Alameda County DOE data to clarify what is happening may be appropriate.

D. SBIR Funding

The regional (county level) patterns of SBIR funding mirror that of R&D funding. While there are isolated pockets of SBIR funding in rural counties, the number of grants and the size of the funding pie increases dramatically within the top ranked R&D counties. This suggests that innovation intensive companies may choose to locate close to knowledge creation centers. Of the top eight counties receiving R&D funding, there was only one county, San Francisco, that failed to make the top eight list for receiving SBIR funding. San Francisco dropped to tenth place with Contra Costa County replacing it at eighth place. San Francisco's ranking may be related to San Francisco's high cost of real estate and lack of land for industrial expansion.

Moreover, the agency breakdown of SBIR funding to each county mirrors R&D funding to that county. Among the top tier counties that receive a large percentage of R&D funding from NASA and DOD, these counties also receive substantial SBIR funding from NASA and DOD. The same situation exists for counties that excel in the life sciences. If HHS funds a substantial amount of life sciences research in a particular county, there is a probability that HHS also funds a large fraction of the SBIR awards to that county. This funding pattern suggests that regions that have built up a competitive advantage in R&D funding for one technology area are more likely to be successful in commercializing the fruits of knowledge creation activities in that area. Since federal agencies allocate 2% of their funds for SBIR grants, it would be interesting to assess if counties are getting less or more than 2% of their R&D allocations from agencies towards technology commercialization funded by SBIR. This could prove an interesting indicator of "entrepreneurial" capacity in a region.

While it is also beyond the scope of this project to map the location of SBIR funded firms in relation to the regional research institutions, this is certainly a worthwhile extension of this work.[28] We anticipate that the results of such an analysis would highlight the close geographical proximity between knowledge creation centers (such as research universities and national labs) and the emerging companies that are the basis of new industry clusters.

Finally, SBIR is not the only source of funding for emerging technology companies. The total amount of private angel investment and venture capital to technology companies in many fields far eclipses the total amount of federal government funding in the form of SBIR awards. However, SBIR funding is critical "proof-of-concept" funding for extremely risky ventures that are not mature enough for private sector venture funding. Hence, while the total dollar amounts are small, this funding may be a bellwether indicator of commercializable technologies emerging from the research lab. To determine a full picture of innovation in the state of California, one would need to extend this study to encompass regional breakdowns of private angel investments and venture capital.

E. Insights About the R&D Activities in the Top 8 Counties

1. Los Angeles County

Los Angeles County represents almost half of all R&D funding to the state of California ($23.124 billion between 1993 and 1999). It dominates all other counties in the state as a performer of R&D. Besides being the site of three major research universities (CalTech, UCLA, and USC), Los Angeles is also home to two other major research centers: NASA's Jet Propulsion Laboratory, and a DOD Aerospace FFRC in El Segundo. Even so, funding to Los Angeles County has been flat for most of the 1990s. Funding for aerospace research has been declining slightly since a sharp drop-off in 1995. These decreases have been compensated by slight increases in defense and life sciences research.

[28] RaDiUS data does not include the performer address or zip code. Hence, one would have to manually look up and merge this data with RaDiUS data for any mapping study.

Besides its dominance in the areas of aerospace and defense research, Los Angeles County is also active in the life sciences, environmental and telecommunications sectors. Funding to these areas are rather substantial in absolute terms but can seem minor in relative terms when compared to the billions of dollars earmarked for aerospace and defense research.

2. San Diego County

San Diego County's high rank in R&D compared to the other counties in the state may be a surprise to many. Indeed, when one compares the economic indicators for San Diego County against other California regions, San Diego County almost always comes in as a distant third place, because most studies break down California regions into "The Bay Area", "Greater Los Angeles" and "San Diego" metropolitan areas. However, both the Bay Area and Greater Los Angeles are multi-county metropolitan areas, while San Diego is a single county. While it's true that San Diego County can't match the Bay Area or Greater Los Angeles in terms of population or size, what San Diego County has is a high concentration of high tech activity compressed into a very small area anchored by UCSD. When one compares density of activity, San Diego County has achieved a level of R&D and innovation activity that closely matches the Silicon Valley.

In this county level analysis, San Diego County exceeds Santa Clara County in overall R&D funding with a total of $6.289 billion in unclassified R&D funding between 1993 and 1999. Funding doubled during this time with annual funding rising from $600 million plus to over $1.2 billion. There have been no sharp spikes in funding for any technology sector, either upwards or downwards. San Diego County's regional research strengths predominantly lie in the defense and life sciences sectors. In terms of defense research, San Diego County is home to SPAWAR, a DOD unit that specializes in information and communication research for naval warfare operations. In the life sciences, San Diego County is home to UCSD, The Salk Institute for Biological Studies, The Scripps Research Institute and several other non-profit research institutes specializing in the biomedical sciences.

The total amount of life sciences funding to San Diego County rivals that of Los Angeles County and exceeds that of San Francisco, San Mateo or Santa Clara counties, other major centers of life science research. In terms of funding for defense-related research activities, San Diego County also exceeds Santa Clara County, ranking second in the state.

SBIR awards to San Diego County have also risen steadily over the course of the 1990's, doubling over the period between 1993 and 1999. While San Diego County ranks second in R&D funding, it ranks third in SBIR funding. However, the level of SBIR funding to San Diego County is not far off from that in Santa Clara and Los Angeles counties, and puts it well ahead of the other counties in the top eight list.

3. Santa Clara County

Santa Clara County encompasses the heart of Silicon Valley. Most analyses refer to Silicon Valley but don't really define its boundaries. By confining our discussion to Santa Clara County, we have defined Silicon Valley into an entity that can be compared with other regions in the state. So how has Santa Clara County fared in terms of research activity over the course of the 1990s? Although R&D funding increased during the earlier half of the decade, R&D funding has actually been flat since 1995. This plateau in research funding came in parallel with the "dot com" boom in venture funding. Hence, federal research investments did not keep pace with the phenomenal rise in private investments in new ventures.

Santa Clara County is home to Stanford University and NASA's Ames Research Center. The bulk of Santa Clara County's R&D funding derives primarily from DOD, NASA and HHS. Funding from DOD rose, then decreased over the time period studied (1993-99). At the same time, HHS and NASA funding rose and dipped in compensating fashion to give an overall aggregated funding pattern that is flat. Re-analyzing the data by technology sectors, the trends for aerospace, defense and life sciences paralleled the changes in agency funding.

Interestingly, there were dramatic increases in Santa Clara County's electronics and advanced computing research during this same time period. While identifiable funding to these two sectors is small, we believe that our methodology systematically understates the full extent of this sector's true research activity. If the trends in true funding to these sectors parallel results here, then growth in Santa Clara County's research investments in its two core technology strengths is much larger than its overall funding picture would show.

4. Orange County

Orange County's research activity is driven by aerospace and defense, with a large portion of its funding coming from NASA and DOD. Most of this research appears to be done by businesses. Unlike Los Angeles County, Orange County did not experience a decrease in funding in 1995. Hence, Orange County's R&D activity has been relatively stable over the time period studied (1993-99). DOD and NASA funding have been flat and this parallels the generally flat trends in R&D funding to the aerospace and defense technology sectors. Life sciences funding has been increasing slightly and reflects overall funding to UC Irvine rather than to individual businesses.

SBIR funding to Orange County rose steadily, doubling from $3.2 million annual funding in 1993 to $6.2 million annual funding in 1999. The agencies fueling this growth in SBIR funding are DOE and NSF. This is an early indicator that Orange County is growing new high tech ventures, on top of a relatively stable research funding base.

5. Alameda County

Alameda County is the home of UC Berkeley and two DOE National Labs, Lawrence Berkeley National Labs and Lawrence Livermore National Labs. While a large part of Alameda County's

funding derives from DOE, the technology sectors supported include both energy and defense research activities. Life sciences is also a major component of the technology sector mix funded.

Alameda County has experienced large swings in R&D funding during the time period studied (1993-99). These swings in funding are attributable to large swings in total DOE funding available, since DOE funds most of the research to this county. In order to confirm if these large swings are real or a data anomaly, one would have to investigate the nature of the funding shifts that occurred in Alameda County during the early to mid-1990s. Unfortunately, time limitations prevented an in-depth look at the root causes of these funding shifts. It is important to understand the reasons for these substantial shifts and consider their long-term consequences for the County's competitiveness.

In terms of funding to the various technology sectors, both the defense and energy sectors were affected by these large swings in funding. In fact, after an initial rapid rise between 1993 and 1994, R&D funding to the energy sector has been declining steadily over the second half of the 1990s. In light of the recent energy crisis, the consequences of this decrease in funding to a critical technology sector may need to be considered.

6. San Francisco County

San Francisco County is a national leader in life sciences/biotechnology research. It is home to UCSF, one of the leading medical schools in the nation and has an extensive network of medical centers located in the county. San Francisco County's R&D funding derives primarily from HHS. Since HHS funding has been increasing steadily throughout the time period studied, there are no unexpected findings to report about San Francisco County's funding trends over the time period studied (1993-99).

While San Francisco County ranks sixth in R&D funding, it ranks ninth in terms of SBIR funding. It is quite possible that this difference in ranking arises from San Francisco's geography. If land is expensive and not readily available, then emerging technology companies may chose to site themselves in the surrounding counties, rather than in San Francisco County itself. This would lead to increases in SBIR funding for San Mateo and Alameda counties at the expense of San Francisco County's total. This difference in levels of R&D and SBIR funding, as well as the economic development and policy consequences for San Francisco County, merits more analysis.

7. San Mateo County

San Mateo County is home to a DOE funded National Lab, the Stanford Linear Accelerator Center, so it is not surprising that its R&D funding profile is dominated by DOE. San Mateo County is also situated between Santa Clara and San Francisco County and its SBIR profile may be affected by spillover from both of these counties.

In terms of funding trends, San Mateo County experienced a dramatic drop in R&D funding in 1995. This drop derives primarily from the significant decrease in DOE funding in the course of one year. Hence, the remarks about Alameda County should be reiterated for this county as well. First, we need to take a closer look at DOE funding to make absolutely sure that this drop is real and not a data anomaly. If it is true, can we attribute this cut to a shift in funding priority at DOE resulting in a major research program being cut? Time limitations prevented an in-depth look at the data to determine which program was cut.

8. Santa Barbara County

Santa Barbara County's highly ranked and large R&D funding base was not initially expected. Like San Diego County, Santa Barbara is not a county that immediately comes to mind when one lists high technology meccas for the state of California. Nevertheless, Santa Barbara County received nearly one billion dollars in aggregated research funding over the time period studied (1993-99). It is home to UC Santa Barbara, a research university with a rising reputation among the nine campuses of UC, as well as companies, which develop technologies of value to DOD and NASA.

Santa Barbara County's R&D funding has been steady but relatively flat between 1993 and 1999. It ranks tenth in terms of SBIR funding and may be lagging somewhat in terms of receiving support for technology commercialization activities. Santa Barbara, like San Francisco, has little land available for new commercial or residential development. Santa Barbara County's research funding base comes from DOD and NASA funding, supplemented by NSF. HHS funding in the life sciences comes in a distant fourth place. This is understandable since UCSB does not have a Medical School.

In contrast, Santa Barbara County does have a considerable amount of funding for research in environmental technologies. Time limitations prevented us from probing further into the data to determine what types of environmental technologies are being researched. The emergence of an environmental industry cluster, for example, depends on the types of research funded. Some environmental research activities have promising applications and can yield new products, companies and jobs. Others may be more relevant to regional planning and public policy.

F. Extensions of This Work

This study is a first effort to provide regional level data about R&D funding to the state of California. Most of the effort in this project has been invested in raw data cleanup and preparation of a useable database of over 160,000 individual awards and tasks granted by the federal government to individual entities in the state. Funding for equipment and facilities currently is not included in the RaDiUS database so these numbers somewhat understate the total federal investment in California's R&D efforts. This report, therefore, is only a beginning. It outlines, *in very broad strokes,* the character of the research activities in the state of California

between the federal fiscal years of 1993 and 1999. If project time and scope were made available, we would propose the following extensions to our current work.

1. Incorporate data from FY2000 and later

RaDiUS data limitations prevent full analysis of FY2000 data. Rand is currently working with HHS to fix the "bug" that led to anomalous undercounts of HHS data in FY 2000. This bug was not fixed in time for inclusion into this report, hence FY2000 data is not included in certain sections of the report. Rand anticipates that this data will be available during the 2002 calendar year. An upgrade of the RaDiUS database is also underway so future reports will be both more comprehensive and more accurate.

2. County-By-County Reports on R&D Capacity

It also would be useful to develop a more detailed county-by-county report on the R&D activities of each of the top eight (possibly the top 13) regions of the state. These individual county reports would allow a fuller analysis of the R&D activities in each region, something not possible in the current statewide survey of regions. An expanded report could include such things as:

- funding trends to individual entities in a particular county
- funding trends to individual technology sectors within each county
- geographic maps of R&D and SBIR recipients by agency and technology sector in order to assess "clustering"
- probes of particular events in each county's history that might explain the large funding concentration and/or shifts over the years

County-by-county reports would assist the Division of Science, Technology and Innovation (DSTI) in identifying particular areas of opportunity or concern, in any one county. They would also aid in designing specific, targeted programs that would assist technology and innovation activities for that county.

In any broad statewide survey, there is the risk that top-ranking counties get spotlighted, while innovative but lower-ranked counties get ignored. Extending this study by producing county-level reports on a few key counties that are outpacing their lower ranked counterparts would overcome this. Working with DSTI staff to determine which counties are of interest and then producing reports based on that county's data may be useful. Criteria for determining key leading counties that may be of interest include:

- counties that have experienced the highest percentage increase in R&D funding over the time period 1993-99
- counties that have experienced the highest percentage increase in SBIR funding over the time period 1993-99
- perhaps using other data indicators (number of patents and licenses, venture capital funding, number of new business start-ups) to determine which counties would be of interest

3. Analysis of Clinical Trials Data in RaDiUS

Due to the objectives of the current project, this effort did not delve into a section of the RaDiUS database that contains detailed information about awards for clinical trial studies. In an extension of this work, it would be possible to map, on a regional (county) level, all federally funded clinical trials in the state of California. Biotechnology companies depend on clinical trials to validate the efficacy and safety of their products, prior to obtaining federal regulatory approval. Analyzing this clinical trials data may provide useful insights to state policymakers on how this interaction plays in the formation of local biotech clusters. Do companies site facilities in regions that facilitate clinical trial research? Are local biotech companies more likely to conduct trials in their home county or are they just as likely to go elsewhere? Is proximity to a clinical trials center a stronger determining factor to a company's decision to site near that center than to locate corporate lab headquarters near the university research lab from which the breakthrough technology arose? What fraction of a region's life sciences research funding goes into clinical trials? Do counties differ across the board on clinical trials funding? While this area is unexplored, analyzing the data now available through RaDiUS could yield interesting insights.