Appendix Five

MARINE SCIENCE AND TECHNOLOGY INDUSTRY IN NEW ENGLAND - ECONOMIC IMPACTS

EXECUTIVE SUMMARY

The purpose of this report is to estimate the effects on the Massachusetts and New England economies of the marine science and technology industry. The industry's economic impact is quantified in terms of output, employment, and income. The major finding of the economic impact analysis is that the marine science and technology cluster is a high wage industry in New England and Massachusetts that is highly integrated with other high wages sectors such as professional services, semiconductor and electronic components manufacturing, and scientific research and development. The employee payrolls generated by the marine science and technology cluster are substantially above the New England and Massachusetts average for all industries.

The key findings of the economic impact analysis for New England are:

1. The annual output (2004) sales of the marine science and technology cluster in New England is approximately $4.8 billion, which 0.80% of New England's combined gross state products:

   a. More than half (51.4%) of the cluster's annual output is concentrated in Massachusetts ($1.5 billion) and Rhode Island ($1 billion).

   b. Nearly three-quarters (74.4%) of the cluster's annual output is concentrated in and marine instruments and equipment (1.97 billion) and shipbuilding and design ($1.60 billion).

2. The marine science and technology cluster directly employs 38,906 persons (ES-202 basis) in New England:

   a. More than half (51.8%) of the cluster's total employment in New England is concentrated in Maine (10,773) and Connecticut (9,389).

   b. More than three-quarters (79.9%) of the cluster's total employment in New England is concentrated in shipbuilding and design (18,549) and marine instruments and equipment (12,496), followed by marine services (4,309), marine materials and supplies (2,095), and marine education (1,457).

3. The marine science and technology cluster in New England generates an annual payroll of approximately $2.7 billion in wages and benefits. The estimated average

annual wage of persons employed in the cluster is $51,363, which is 17.2% higher than New England's average wage for all industries of $43,827

4. The marine science and technology cluster in New England made nearly $1.4 billion in local purchases that indirectly generates an additional 9,679 jobs with $511.5 million in payroll and annual average wages of $39,635:

a. These local purchases were distributed across 343 sector's of the New England economy with the largest impacts occurring in the region's high technology, , professional services, distribution, and business travel sectors.

b. The cluster's indirect impacts are particularly notable in areas such as semiconductor and electronic components manufacturing, scientific research and development, wireless communications manufacturing, management consulting, computer system design services, architectural and engineering services, facilities support services, and legal and accounting services.

5. Consumer expenditures by employees of the marine science and technology cluster induced another 59,569 jobs in New England with a total payroll of $2.4 billion and an annual average wage of $30,421:

a. These consumer expenditures were distributed across 420 sector's of the New England economy with the largest impacts occurring in sectors providing consumer goods and services.

b. The cluster's induced impacts are particularly notable in areas such as residential real estate and construction, retail distribution, automotive sales and services, eating and drinking places, child care, health care, financial services, educational services, and state and local government.

6. The total annual economic impact of the marine science and technology cluster in New England, including direct, indirect, and induced impacts, is $12.0 billion in output and 108,154 jobs with an annual payroll of $5.6 billion:

a. The cluster's total economic impact is approximately 2.00% of the region's combined gross state products and 1.65% of the region's total ES-202 employment.

b. The cluster's employment multiplier effect on New England is 2.78, which means that for every 100 persons directly employed in marine science and technology an additional 178 jobs is created by other business establishments in the region as a result of the cluster's local purchases and its employees' consumer expenditures.

c. The cluster's payroll multiplier effect on New England is 2.10, which means that for every 100 persons directly employed in marine science and technology an additional $110 in wages, salaries, and benefits is created by other business establishments in the region as a result of the cluster's local purchases and its employees' consumer expenditures.

The key findings of the economic impact analysis for Massachusetts are:

1. The annual output (2004) sales of the marine science and technology cluster in Massachusetts is approximately $1.5 billion, which is 34.1% of the New England industry total and 0.52% of the state's gross state product:

2. The marine science and technology cluster directly employs 8,863 persons (ES-202 basis) in Massachusetts, which is 25.7% of the New England industry total and 0.28% of the state's total employment.

3. The marine science and technology cluster in Massachusetts generates an annual payroll of approximately $661 million in wages and benefits. The estimated average annual wage of persons employed in the state's marine science and technology cluster is $55,948, which is 20.8% higher than the Massachusetts average wage for all industries of $46,332.

4. The marine science and technology cluster in Massachusetts made approximately $328 million in local purchases that indirectly generates an additional 2,434 jobs with $131 million in payroll and annual average wages of $40,483, which is substantially higher than the cluster's indirect wage impacts for New England as a whole:

a. These local purchases were distributed across 253 sector's of the Massachusetts economy with the largest impacts occurring in the state's high technology, professional services, distribution, and real estate sectors.

b. The cluster's indirect impacts are particularly notable in areas such as semiconductor and electronic components manufacturing, scientific research and development, wireless communications manufacturing, architectural and engineering services, facilities support services, legal and accounting services, and advertising.

5. Consumer expenditures by employees of the marine science and technology cluster induced another 11,099 jobs in Massachusetts with a total payroll of $472 million and an annual average wage of $31,910:

a. These consumer expenditures were distributed across 353 sector's of the Massachusetts economy with the largest impacts occurring in sectors providing consumer goods and services.

b. The cluster's induced impacts are particularly notable in areas such as residential real estate and construction, retail distribution, automotive sales and services, eating and drinking places, health care, educational services, and state and local government.

6. The total annual economic impact of the marine science and technology cluster in Massachusetts, including direct, indirect, and induced impacts, is $2.9 billion in annual output and 22,393 jobs with an annual payroll of $1.3 billion:

a. The cluster's total economic impact is approximately 1.00% of Massachusetts' gross state product and 0.70% of the state's total ES-202 employment.

b. The cluster's employment multiplier effect on New England is 2.53, which means that for every 100 persons directly employed in marine science and technology an additional 153 jobs is created by other business establishments in the state as a result of the cluster's local purchases and its employees' consumer expenditures.

c. The cluster's payroll multiplier effect on New England is 2.23, which means that for every 100 persons directly employed in marine science and technology an additional $123 in wages, salaries, and benefits is created by other business establishments in the state as a result of the cluster's local purchases and its employees' consumer expenditures.

ECONOMIC IMPACTS OF MARINE SCIENCE & TECHNOLOGY

DIRECT ECONOMIC IMPACTS: NEW ENGLAND

The New England[1] marine science and technology cluster accounted for $4,868,900,000 in direct sales (output) in 2004 (see Table 1), which is 0.81% of New England's gross state product.[2] The cluster has 38,906 employees (see Table 2), which is 0.59% of the region's total employment. It is estimated that these employees earned $2,7 billion dollars in wages and

[1] For purposes of comparison, New England is defined as Connecticut, Massachusetts, Maine, New Hampshire, and Rhode Island, because no marine science and technology establishments were identified in Vermont.

[2] The direct output of a private sector business establishment is typically measured by the total value of goods and services produced annually on-site (i.e., annual sales). However, most public and non-profit establishments, such as the Naval Undersea Warfare Center, Woods Hole Oceanographic Institute, or a university do not have "sales" and, therefore, output is measured by total on-site expenditures, which consist mainly of employee payroll, local purchases, and contracts with consultants and private vendors. Due to the difficulty of obtaining information on the budgets of marine education programs, it is likely that industry output is underestimated by approximately $64,000,000, based on IMPlan generated estimates, and this figure does not include federal research funds awarded to those institutions.

benefits in 2004. The estimated annual average wage (ES-202 basis) of persons employed in the cluster is $51,363 or 17.2% higher than the New England average wage for all industries of $43,817.[3]

Table 1

Marine Science & Technology: Sales, 2004 (millions)				
State	**Core**	**Partial**	**Second Tier**	**Total**
CT	797.1	148.2	0.2	**945.4**
MA	374.1	1,161.4	5.3	**1,540.8**
ME	857.9	10.2	N/A	**868.1**
NH	121.8	381.0	0.5	**503.3**
RI	795.3	215.9	0.0	**1,011.3**
NE	**2,946.2**	**1,916.8**	**6.0**	**4,868.9**

Table 2

Marine Science & Technology: Direct Employment, 2004				
State	**Core**	**Partial**	**Second Tier**	**Total**
CT	8,437	949	2	**9,389**
MA	2,962	5,842	59	**8,863**
ME	10,683	90	N/A	**10,773**
NH	401	2,535	2	**2,938**
RI	5,394	1,546	4	**6,944**
NE	**27,877**	**10,963**	**66**	**38,906**

Distribution by state

The three largest employers in New England's marine science and technology cluster are Maine, Connecticut and Massachusetts with 27.7%, 24.1% and 22.8% of the cluster's total employment, respectively.

Distribution by Industry Sector

The two largest sectors of the marine science and technology cluster are shipbuilding and design (41% of employment), marine instruments and equipment manufacturing (36.2% of employment), and marine services (12.5% of employment).

Table 3

Marine Science & Technology Cluster: Sectors & Subsectors, 2004			
Marine Instruments and Equipment by Subsectors	**Employment**	**Sales**	**No. of Firms**
Acoustic	442	31	23
Diving and underwater work equipment	11	2	2
Floatation equipment	152	20	6
Oceanographic measuring instruments	962	152	28

[3] This estimate assumes that 25 percent of labor income is allocated to fringe benefits.

Remediation equipment	N/A	N/A	1
Underwater construction equipment	130	71	9
Underwater telecommunications systems	0	0	2
Underwater vehicles	118	22	5
Electronics for marine navigation and communications	3,058	525	31
Electronics for marine instruments and platforms	7,621	1,144	68
Sub-Total	**12,496**	**1,966**	**175**
Marine Materials and Supplies by Subsectors			
Assembly	16	1	1
Cables	866	80	15
Engines, components and equipment	522	246	22
Machining and fabrication	161	20	13
Materials	441	91	13
Packing and crating	90	19	2
Sub-Total	**2,095**	**457**	**66**
Marine Research and Education by Subsectors			
Industry and tech groups	8	0	9
Marine education	1437	4	48
Marine research and consulting	12	2	1
Sub-Total	**1,457**	**7**	**58**
Marine Services by Subsectors			
Boat facilities	6	0	5
Commerical marine research and consulting	2,200	248	90
Marine engineering	355	149	32
Marine surveying and exploration	137	22	5
Software and systems design for marine applications	1,611	423	42
Sub-Total	**4,309**	**842**	**174**
Ship Building and Design by Subsectors			
Shipbuilding and design, major operations	18,549	1,596	8
Sub-Total	**18,549**	**1,596**	**8**
TOTAL	**38,906**	**4,869**	**481**

INDIRECT, INDUCED & TOTAL ECONOMIC IMPACTS: NEW ENGLAND

The marine science and technology cluster also generates indirect and induced impacts in New England by purchasing goods and services from off-site vendors in other industries (inputs) and through the off-site consumer spending of the cluster's employees.

INDIRECT ECONOMIC IMPACTS

In 2004, the marine science and technology cluster made nearly $1.4 in local purchases that indirectly generated an additional 9,679jobs with $511.5 million in additional labor income and annual average wages of $39,635 (see Table 6). The IMPlan modeling system is able to specify the sectoral distribution of these induced impacts by calculating the regional effect of local purchases based on the BEA's input-output accounts for New England. The cluster's local purchases and indirect impacts were distributed among 343 of Implan's 538 sectors of the region's economy with the largest impacts occurring in region's high technology, professional services, distribution, and business-related travel sectors. The cluster's indirect impacts are particularly notable in areas such as semiconductor and electronic component manufacturing, scientific research and development, wireless communications manufacturing, management consulting, computer system design services, architectural and engineering services, facilities support services, and legal, accounting, and bookkeeping services (see Table 4):

Table 4

Sectoral Distribution of Indirect Employment Impacts: New England, 2004

Implan Code	Implan Description	Induced Employment
43	Maintenance & repair of nonresidential bldgs.	123
244	Turned product & screw - nut - and bolt	163
307	Broadcast & wireless communications	113
311	Semiconductor & related device manufacturing	119
312	Other electronic component manufacturing	432
390	Wholesale trade	1,040
394	Truck transportation	165
397	Scenic & sightseeing transportation	280
399	Couriers & messengers	116
400	Warehousing & storage	217
431	Real estate	196
437	Legal Services	159
438	Accounting & bookkeeping services	177
439	Architectural & engineering services	448
442	Computer systems design services	120
446	Scientific research & development	257
447	Advertising & related services	103
451	Management of companies & enterprises	474
454	Employment services	572
458	Services to buildings & dwellings	183
479	Hotels & motels	109
481	Food services & drinking places	116
483	Automotive repair & maintenance	154

Note: Table only includes sectors with induced employment impacts of 100+.

INDUCED ECONOMIC IMPACTS

Consumer expenditures by employees of the marine science and technology cluster sustain an additional $5.7 billion in annual output in New England, which supports another 59,569 jobs in New England with a total payroll of $2.4 billion and annual average wage of $30,421 (see Table 6). The IMPlan modeling system is able to specify the sectoral distribution of these induced impacts by calculating the regional effect of purchases made by these employees based on disposable income levels and the BEA's input-output accounts for New England. The model indicates that the induced impacts attributable to the Hanscom complex are widely distributed across the region's economy – some employment is supported in 420 of IMPlan's 538 sector codes – but the most significant induced impacts occur in sectors providing consumer goods and services, such as residential real estate and construction, retail distribution, automotive services, eating and drinking places, child care, health care, financial services, educational services, and state and local government (see Table 5):

Table 5

Sectoral Distribution of Induced Employment Impacts, New England, 2004

Implan Code	Implan Description	Induced Employment
33	New residential single family structures	675
35	New residential alterations & additions	614
38	Commercial and institutional building	1,076
41	Other new construction	780
390	Wholesale trade	1,644
394	Truck transportation	288
395	Transit & ground passenger transportation	317
401	Motor vehicle and parts dealers	977
402	Furniture & home furnishings stores	313
403	Electronics & appliance stores	251
404	Building materials & garden supply	547
405	Food & beverage stores	1,651
406	Health & personal care stores	570
407	Gasoline stations	370
408	Clothing & clothing accessories	742
409	Sporting goods, hobby, & book stores	440
410	General merchandise stores	1,114
411	Miscellaneous store retailers	766
412	Nonstore retailers	632
422	Telecommunications	342
426	Securities, commodity contracts, & investments	439
427	Insurance carriers	501
430	Monetary authorities & depository credit	435
431	Real estate	1,177
437	Legal Services	647

438	Accounting & bookkeeping services	314
439	Architectural & engineering services	594
441	Custom computer programming services	782
442	Computer systems design services	242
454	Employment services	1,014
458	Services to buildings & dwellings	600
462	Colleges, universities, & junior colleges	893
463	Other educational services	221
464	Home health care services	608
465	Offices of physicians & dentists	2,027
466	Other ambulatory health care services	517
467	Hospitals	2,483
468	Nursing & residential care facilities	1,275
469	Child day care services	540
470	Social assistance, except child day care	883
471	Performing arts companies	301
478	Other amusement, gambling, & recreation	510
479	Hotels, motels, including casino hotels	395
481	Food services & drinking places	4,855
483	Automotive repair & maintenance	784
487	Personal care services	360
492	Grantmaking and giving and social agencies	275
493	Civil, social, professional, & similar orgs.	741
499	Other state & local enterprises	281
503	State & local education	4,129
504	State & local education non-education	3,597
505	Federal military	844
506	Federal non-military	485

Note: Table only includes sectors with induced emp loyment impacts of 250+.

TOTAL ECONOMIC IMPACTS

The marine science and technology cluster's total annual economic impact, including direct, indirect, and induced impacts is $12.0 billion in annual output in New England and 108,154 jobs with an annual payroll of $5.6 billion (2004) (see Table 6). This is approximately 2.00% of the regional combined gross state product and 1.65% of the region's total ES-202 employment (2004).

Table 6

New England Marine Technology: Total Economic Impacts, 2004				
	Direct	**Indirect**	**Induced**	**Total**
Output/Sales	$4,868,760,105	$1,367,726,945	$5,724,595,037	$11,961,082,087
Employment	38,906	9,679	59,569	108,154
Payroll	$2,664,438,504	$511,486,168	$2,416,232,379	$5,592,157,051

The IMPlan model for New England calculates a multiplier effect of 2.78 for the marine science and technology cluster, which means that for every 100 persons directly employed in the cluster an additional 178 jobs is created by other business establishments elsewhere in the region as a result of the industry's local purchases and its employees' consumer expenditures.

The IMPlan model for New England calculates a multiplier effect of 2.10 for the marine science and technology cluster, which means that for every $100 in industry-generated payroll (direct and indirect) an additional $110 in wages and salaries is generated by other business establishments elsewhere in the region as a result of the industry's local purchases and its employees' consumer expenditures.

DIRECT ECONOMIC IMPACTS: MASSACHUSETTS

The Massachusetts marine science and technology cluster accounted for $1,540,400,000 in direct sales (output) in 2004 (see Table 9), which is 34.1% of the New England industry total and 0.52% of Massachusetts' gross state product. The cluster has 8,863 employees in Massachusetts (see Table 2), which is 25.7% of the New England industry total and 0.28% of the state's total employment. It is estimated that these employees earned $661005346 dollars in wages and benefits in 2004. The estimated annual average wage (ES-202 basis) of persons employed in the Massachusetts marine science and technology cluster is $55,948 or 20.8% higher than the Massachusetts average wage for all industries of $46,332.

INDIRECT, INDUCED, & TOTAL ECONOMIC IMPACTS: MASSACHUSETTS

The marine science and technology cluster also generates indirect and induced impacts in Massachusetts by purchasing goods and services from off-site vendors in other industries (inputs) and through the off-site consumer spending of the cluster's employees.

INDIRECT ECONOMIC IMPACTS

In 2004, the marine science and technology cluster made approximately $328 million in local purchases that indirectly generated an additional 2,434 jobs with $131 million in additional labor income and annual average wages of $40,483, which is substantially higher than the cluster's indirect wage impacts for New England as a whole (see Table 11).

The IMPlan modeling system is able to specify the sectoral distribution of these induced impacts by calculating the regional effect of local purchases based on the BEA's input-output accounts for Massachusetts. The cluster's local purchases and indirect impacts were distributed among 253 of Implan's 538 sectors of the state's economy with the largest impacts occuring in region's high technology, professional services, distribution, and real estate sectors, where annual average wages are generally above the state average. The cluster's indirect impacts are particularly notable in areas such as semiconductor and electronic component manufacturing, scientific research and development, wireless communications manufacturing, architectural and

engineering services, facilities support services, legal and accounting services, and advertising (see Table 7):

Table 7

Sectoral Distribution of Indirect Employment Impacts: Massachusetts, 2004		
Implan Code	**Implan Description**	**Induced Employment**
43	Maintenance & repair of nonresidential bldgs.	28
307	Broadcast & wireless communications	27
311	Semiconductor & related device manufacturing	52
312	Other electronic component manufacturing	153
390	Wholesale trade	254
395	Transit & ground passenger transportation	26
397	Scenic & sightseeing transportation	93
398	Postal service	25
399	Couriers & messengers	33
400	Warehousing & storage	40
431	Real estate	57
437	Legal Services	44
438	Accounting & bookkeeping services	45
439	Architectural & engineering services	79
446	Scientific research & development	47
447	Advertising & related services	30
451	Management of companies & enterprises	120
454	Employment services	175
457	Investigation & security services	25
458	Services to buildings & dwellings	55
463	Other educational services	49
481	Food services & drinking places	116
Note: Table only includes sectors with induced employment impacts of 25+.		

INDUCED ECONOMIC IMPACTS

Consumer expenditures by employees of the marine science and technology cluster sustain an additional $1.1 billion in annual output in Massachusetts, which supports another 11,099 jobs in the state with a total payroll of $472 million with an annual average wage of $31,910 (see Table 9).

The IMPlan modeling system is able to specify the sectoral distribution of these induced impacts by calculating the regional effect of purchases made by these employees based on disposable income levels and the BEA's input-output accounts for Massachusetts. The model indicates that the induced impacts attributable to the marine science and technology cluster are widely distributed across the region's economy – some employment is supported in 353 of IMPlan's 538 sector codes – but the most significant induced impacts occur in sectors providing consumer goods and services, such as residential real estate and construction, retail distribution, automotive services, eating and drinking places, health care, educational services, and state and local government (see Table 8):

Table 8

Sectoral Distribution of Induced Employment Impacts, Massachusetts, 2004		
Implan Code	**Implan Description**	**Induced Employment**
33	New residential single family structures	114
35	New residential alterations & additions	104
38	Commercial and institutional building	250
41	Other new construction	156
390	Wholesale trade	309
401	Motor vehicle and parts dealers	165
404	Building materials & garden supply	102
405	Food & beverage stores	324
406	Health & personal care stores	112
408	Clothing & clothing accessories	138
410	General merchandise stores	181
411	Miscellaneous store retailers	137
412	Nonstore retailers	129
431	Real estate	192
437	Legal Services	109
439	Architectural & engineering services	117
441	Custom computer programming services	182
454	Employment services	184
458	Services to buildings & dwellings	114
462	Colleges, universities, & junior colleges	178
464	Home health care services	114
465	Offices of physicians & dentists	397
467	Hospitals	481
468	Nursing & residential care facilities	242
470	Social assistance, except child day care	164
481	Food services & drinking places	927
483	Automotive repair & maintenance	136
487	Personal care services	105
493	Civil, social, professional, & similar orgs.	135
503	State & local education	767
504	State & local education non-education	720
505	Federal military	123
506	Federal non-military	114

Note: Table only includes sectors with induced employment impacts of 100+.

TOTAL ECONOMIC IMPACTS

The marine science and technology cluster's total annual economic impact, including direct, indirect, and induced impacts is $2.9 billion in annual output in New England and 22,396

jobs with an annual payroll of $1.3 billion (2004) (see Table 9). This is approximately 1.00% of Massachusetts' gross state product and 0.70% of the state's total ES-202 employment (2004).

Table 9

Massachusetts Marine Technology: Total Economic Impacts, 2004				
	Direct	**Indirect**	**Induced**	**Total**
Output/Sales	$1,540,400,000	$328,242,116	$1,092,392,268	$2,961,032,384
Employment	8,863	2,434	11,099	22,396
Payroll	$661,005,346	$131,401,451	$472,212,212	$1,264,619,009

The IMPlan model for Massachusetts calculates a multiplier effect of 2.53 for the marine science and technology cluster, which means that for every 100 persons directly employed in the cluster an additional 153 jobs are created by other business establishments elsewhere in the region as a result of the industry's local purchases and its employees' consumer expenditures.

The IMPlan model for Massachusetts calculates a multiplier effect of 2.23 for the marine science and technology cluster, which means that for every $100 in industry-generated payroll (direct and indirect) an additional $123 in wages and salaries is generated by other business establishments elsewhere in the region as a result of the industry's local purchases and its employees' consumer expenditures.

DATA SOURCES

There is no single source for reliable information on the marine science and technology industry. Consequently, researchers began by assembling a master list of companies involved in the marine science and technology industry. The first step in assembling this list was to aggregate company listings obtained from various organizations into one file. The initial Master Company List (listing Marine Science and Technology firms and educational institutions in coastal New England states) was developed using a variety of sources including:

- the 2004 Massachusetts Ocean Technology Network (MOTN) membership list,
- the Cape Cod Economic Development Council's 2003 map and company list of Oceanographic & Marine Technology Businesses,
- the University of Rhode Island's Marine Technology companies database,
- SBIR/STTR awards related to marine research from 1998 to 2003,
- the U.S. Department of Defense's Directorate for Information Operations and Reports (DIOR) for U.S. Navy and other federal contract awards to companies involved in marine technology related research, development, and production,
- a search of the world wide web for information on educational programs and institutions involved in marine science and technology or marine-related education and research,
- the University of Massachusetts Lowell's Tech Track data base,

The Master Company List served as the initial basis for a search of Dun & Bradstreet's IMarket database that was organized by geographical definition for Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island and by company name. If Dun & Bradstreet had a company in its database, the company's 8-digit Standard Industry Classification Code (SIC) and SIC description was added to the Marine database and served as the basis for a further search of the IMarket database. These searches yielded 344 New England based companies in the marine science and technology industry.

The Master Company List and database was then enhanced by a search for additional information about companies in the Corptech database. The search was organized by name of companies and later a query was saved and a file was exported from the Corptech database. The Corptech search yielded 138 New England based companies in the marine science and technology industry. The exported information included the company name, city, street address, zip code, actual sales, telephone number, year established, primary SIC Code, products by Major Codes and SIC Codes, description, sales qualifier, sales range, and Corptech URI. This information was added to the Master Company List and database, although the Dun & Bradstreet and Corptech searches produced some overlap in identified companies.

For companies on the master list that did not have information in the Corptech or Dun & Bradstreet database, a web search was conducted to identify those companies' primary business activities, locations, CEO/President's name, telephone number, etc. This information was also added to the master list and database. This information was supplemented by Dun &

Bradstreet's MP Target, which includes information on company addresses, employment, sales, telephone numbers, President/CEO names, etc.

ECONOMIC IMPACTS: DEFINITIONS

Economic impacts measure the importance of an economic activity primarily in terms of the output, employment, and personal (labor) income generated by that activity:

> *Output* is the value (sales) of goods and services produced by establishments in the marine science and technology industry.[4]
>
> *Employment* is the number of people employed by establishments in the marine science and technology industry, including wage and salary employees, full-time and part-time employees, and self-employed persons.
>
> *Labor income* is the wages, benefits, and proprietors' income derived from employment that is linked geographically to establishments in the marine science and technology industry.

Economic impacts consist of direct impacts, indirect impacts, induced impacts, and total impacts. *Direct impacts* are the economic activities carried out at a business establishment or construction project and are therefore an immediate consequence of the economic activity that would not have occurred in the absence of the business establishment or construction project.

Indirect impacts derive primarily from off-site economic activities that are attributable to the identified business establishment. These economic activities occur mainly as a result of *non-payroll expenditures* by the business within a defined local area (i.e., town, city, county, metropolitan statistical area). Local expenditures include a range of operating expenses such as construction materials, office supplies, motor transport, horticultural services, furniture, utilities, maintenance and repairs, business machines, and so forth. Indirect impacts differ from direct impacts insofar as they originate entirely off-site, although the indirect impacts would not have occurred in the absence of the identified business establishment. *Induced impacts* are the multiplier effects of the direct and indirect impacts created by successive rounds of spending by employees and proprietors.[5] *Total impacts* are the sum of the direct, indirect, and induced impacts.

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[4] The North American Industry Classification System (NAICS) defines an establishment as a "single physical location, where business is conducted or where services or industrial operations are performed (e.g., a factory, mill, store, hotel, movie theater, mine, farm, airline terminal, sales office, warehouse, or central administrative office." Both NAICS, and the former Standard Industry Classification (SIC) System, are establishment classification systems that classify establishments into "industries" when their "primary activity meets the definition for that industry," see, Executive Office of the President, *North American Industry Classification System: United States, 2002* (Washington, D.C.: Office of Management and Budget, 2002), pp. 21-24.

[5] Most of the take home-home income earned by project employees is spent locally. Some of this spending becomes income to local individuals who provide services to construction employees. Some the spending by construction employees goes to local businesses and becomes income to the business owners and their employees.

Economic impacts are often calculated separately for the *operations phase* and *construction phase* of an establishment. The operations phase of an establishment generates economic impacts that continue as long as the facility remains in existence. The economic impacts of construction and other capital expenditures are necessarily limited and temporary in duration and last only so long as construction and related capital purchases are underway. This economic impact analysis focuses exclusively on the economic impact of on-going operations, since data on capital expenditures and industry-related construction is not available.

The cluster's economic significance to the state economy is evaluated in three areas: (1) its quantitative contribution to employment and wages, (2) its multiplier effect on employment and income, and (3) the quality of job creation.

METHODOLOGY: THE IMPLAN MODELING SYSTEM

The indirect and induced economic impacts of the Hanscom Air Force Base complex are specified using IMPLAN (IMpact Analysis for PLANing), which is an econometric modeling system developed by applied economists at the University of Minnesota and the U.S. Forest Service. The IMPLAN modeling system has been in use since 1979 and is currently used by over 500 private consulting firms, university research centers, and government agencies. The Center for Policy Analysis has been a licensed IMPlan user since 1999 and regularly employs its econometric modeling system in conducting economic and fiscal impact analyses.

The IMPLAN modeling system uses combines the U.S. Bureau of Economic Analysis' Input-Output Benchmarks with other data to construct quantitative models of trade flow relationships between businesses and between businesses and final consumers. From this data, one can examine the effects of a change in one or several economic activities to predict its effect on a specific state, regional, or local economy (impact analysis). The IMPLAN input-output accounts capture all monetary market transactions for consumption in a given time period. The IMPLAN input-output accounts are based on industry survey data collected periodically by the U.S. Bureau of Economic Analysis and follow a balanced account format recommended by the United Nations.

IMPLAN also includes social accounting data (e.g., personal income and gross state product) that makes it possible to measure non-industrial transactions such as the payment of indirect taxes by businesses and households. The IMPLAN data base provides data coverage for the entire United States by county and has the ability to incorporate user-supplied data at each stage of the model building process to insure that estimates of economic impacts are both up-to-date and specific to an economic impact area.[6] IMPLAN can construct local input-output models in units as small as five-zip code clusters.

Subsequently, part of these second-round incomes are also spent locally and thus become income to another set of individuals. As successive rounds of spending occur, additional income is created in the local area, region, and state.

[6] The IMPLAN modeling system draws on a variety of statistical sources, including the Bureau of Labor Statistics Growth Model, Bureau of the Census, ES-202 employment and earnings data, the Regional Economic Information System (REIS), and the Bureau of Economic Analysis Gross State Product data.

IMPLAN's Regional Economic Accounts and the Social Accounting Matrices are used to construct local, county, or state-level multipliers specific to an impact area. Multipliers describe the response of an economy to a change in demand or production. The multipliers allow economic impact analysis to move from a descriptive input-outputs model to a predictive model. Each industry that produces goods or services generates demand for other goods and services and this demand is multiplied through a particular economy until it dissipates through "leakage" to economies outside the specified area. Thus, multipliers calculate the response of the economic impact area to a change in demand or production.

IMPLAN models *discern and calculate leakage* from local, regional, and state economic areas based on workforce configuration, the inputs required by specific types of businesses, and the availability of both inputs in the economic area. Consequently, *economic impacts that accrue to other regions or states as a consequence of a change in demand are not counted as impacts within the economic area*. The model accounts for substitution and displacement effects by deflating industry-specific multipliers to levels well below those recommended by the U.S. Bureau of Economic Analysis. In addition, multipliers are applied only to *personal disposable income* to obtain a more realistic estimate of the multiplier effects from increased demand. The reliability of these estimates has been proven through empirical testing (Department of Commerce 1981; Brucker et al 1990).

The Center for Policy Analysis built input-output models for the state of Massachusetts and New England using the IMPlan Professional 2.0 model building software and data packages. The data used in the model are for 2001, which is the latest available. Where necessary, all inputs were converted to 2001 dollars using appropriate deflators (producer price indices for industrial commodities and the personal consumption expenditure deflator for personal income). Model outputs are then converted back into 2004 dollars. A predictive model is constructed by specifying industry output for a specific economic area, which is then applied to the industry multipliers for that particular region. Based on these calculations, the model estimates final demand, which includes employment, employee compensation (excluding benefits), and point-of-work labor income (including benefits).

It is possible to estimate the total economic impact of the marine science and technology industry simply by entering the industry's direct output and employment in the econometric model. This method assumes that the production function is the same as the average of the various industry sectors in the state where it operates directly or through contractors. However, because data on the industry's different sectors is available, it was possible to use a more precise method for estimating the industry's economic impacts. Instead of specifying the output for a single industry (e.g., federal non-military), we instead specify a long list of output functions for each sector that is a part of the marine science and technology industry, which allows IMPlan to apply the appropriate regional purchase coefficient to each sector of industry to calculate an estimate of the indirect impacts generated by the industry's local purchases.

The model also applies the ratio of personal consumption expenditures to estimates of employee compensation in the industry to account for taxes and individual savings. The remaining disposable income is then distributed among IMPlan's 528 industrial sectors using the model's breakdown of personal consumption expenditures for all households, while also applying the appropriate regional purchase coefficient to each industry to estimate induced impacts generated by the industry in Massachusetts and New England.

Regional Purchases

The initial IMPlan data details all purchases in a given area, including imported goods and services. Importantly, however, IMPLAN's Regional Economic Accounts exclude imports to an economic area so the calculation of economic impacts identifies only those impacts specific to the designated economic impact area (e.g., Massachusetts, New England). IMPLAN calculates this distinction by applying Regional Purchase Coefficients (RPC) to predict regional purchases based on an economic area's particular characteristics.[7] The Regional Purchase Coefficient represents the proportion of goods and services that will be purchased regionally under normal circumstances, based on the area's economic characteristics described in terms of actual trade flows within the geographic area.[8]

Trade and Freight Margins

When establishments in the marine science and technology industry purchase goods or services, the expenditures cover at least the price of the goods or services, but it may also include the cost of shipping, insurance, wholesale margin, retail margin, and brokerage fees. IMPlan provides sector-specific margins to account for these "exported" expenditures, which are also subtracted from the regional impact.

Assignment to IMPlan Industry Sectors

The allocation of the marine science and technology industry's output among IMPlan's 528 industry sectors was conducted by staff at the Center for Policy Analysis. The *IMPlan User's Manual* includes a detailed data sectoring scheme that identifies the equivalent SIC and NAICS Codes for each of the model's 528 industry sectors. Since the marine science and technology cluster was initially defined at the 4-digit SIC level, it was possible to model the indirect and induced impacts of the industry with a high degree of detail.

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[7] The Regional Purchase Coefficient (RPC) was set at 100% for the New England regional model, because it is assumed that employment and income leakage is near 0% for the industry at that geographic level. In other words, it is not likely that many individuals employed in New England's marine science and technology industry are living in New York, Canada, or beyond.

[8] An inherent weakness of a single-region input-output model, such as IMPlan, is that it cannot capture the *feedback effects* that result when purchases from a supplier outside the region leads to additional purchases within the region by that supplier or suppliers. For example, a marine instruments manufacturer might purchase computers (office equipment) from Dell Computer in Austin, Texas, which would then purchase semiconductors from Intel Massachusetts. It is possible to construct a multi-region input-output model to capture feedback effects, but such a model requires a great deal of cost-intensive data collection and is not supported by the IMPlan software.