ECONOMIC AND EDUCATIONAL IMPACT OF BUILDING THE CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY*

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The Continuous Electron Beam Accelerator Facility (CEBAF) was built in Newport News, Virginia, between 1987 and 1995 and is a new basic research laboratory christened the Thomas Jefferson National Accelerator Facility (Jefferson Lab). Jefferson Lab's science and technology mission has major economic and educational benefits: basic research discoveries, improvement and application of key technologies associated with the accelerator and the experiments, extensive subcontracting with industry, and diverse employment and educational opportunities. The $600 million invested by federal, state, local, and international partners to build Jefferson Lab has had substantial economic and educational benefits locally, as well as significant benefits distributed among industries and universities throughout the United States.

1 Introduction

The Continuous Electron Beam Accelerator Facility (CEBAF) was built in Newport News, Virginia, between 1987 and 1995 and is a new basic research laboratory christened the Thomas Jefferson National Accelerator Facility (Jefferson Lab). The primary mission of Jefferson Lab is basic research into the quark structure of matter. A superconducting accelerator is the centerpiece of the facility. About 90% of these resources were provided by the U.S. Department of Energy (DOE), which owns the laboratory. The projected operating cost is about $70 million per year.[1] CEBAF is managed for DOE by the Southeastern Universities Research Association, a consortium of 41 universities in thirteen southeastern states and the District of Columbia.[2]

As a new accelerator-based research laboratory built in a geographic region where no major accelerators have existed previously, Jefferson Lab provides an example of the economic and educational impacts of such a project.

Figure 1 shows the location and site plan of CEBAF. Our accelerator is an underground, racetrack-shaped accelerator nearly one mile in circumference.

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It provides continuous electron beams at currents up to 200 μA and energies between 800 MeV and 4 GeV to nuclear physics spectrometers and detectors in three experiment areas.[3] Peak energies in the 4 to 6 GeV range will be available soon, with energies above 8 GeV foreseeable at the turn of the century. The potential for energy upgrade is an important factor for the continued vitality and international preeminence of the scientific program, which started in 1995. Already, a backlog of three years of experiments await scheduling in each of the halls, and the 1000-member user community has plans and proposals for an additional three years. Table 1 lists the main parameters of the accelerator.

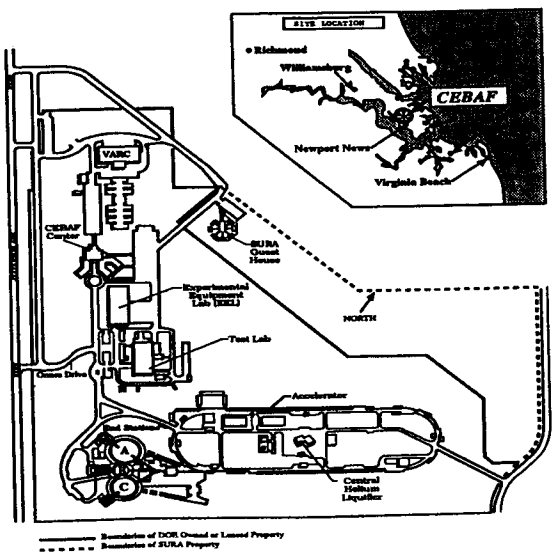

Figure 1: Site Plan

Table 1: Accelerator Parameters

Particle	Electron
Nominal Beam Energy	4 GeV
Maximum Current	200 μA
Nominal Beam Power	1 MW
Electric Power Installed	40 MW
Technology	superconducting rf
Accelerator Length	1.4 km (racetrack)
Radiofrequency (rf)	1497 MHz
Energy Spread	10^{-4}
Emittance (Beam Spread)	$<10^{-8}$ m

2 Overview of Economic and Educational Impacts

Jefferson Lab's science and technology mission has major economic and educational benefits. First, the basic research discoveries themselves will lay the groundwork for future technologies we are not creative enough to imagine today. There is no telling where the answers to fundamental questions about how quarks and gluons build matter, the nature of the nucleus, and the possible discovery of new nuclear phenomena may lead.

In addition, the act of building and operating the facility requires us to improve key technologies associated with the accelerator and the experiments. For example, the superconducting linear accelerator technology (Figure 2) at the heart of CEBAF may also be useful for an accelerator to produce tritium (APT). Already, this technology is finding application in a free electron laser with significant potential for manufacturing, industrial processing, and testing shipboard defense technologies. In addition, Jefferson Lab's detector technologies are finding uses in medical diagnostics and for non-destructive materials evaluation and testing.

Figure 2a: Superconducting RF Accelerator Cavity Pair

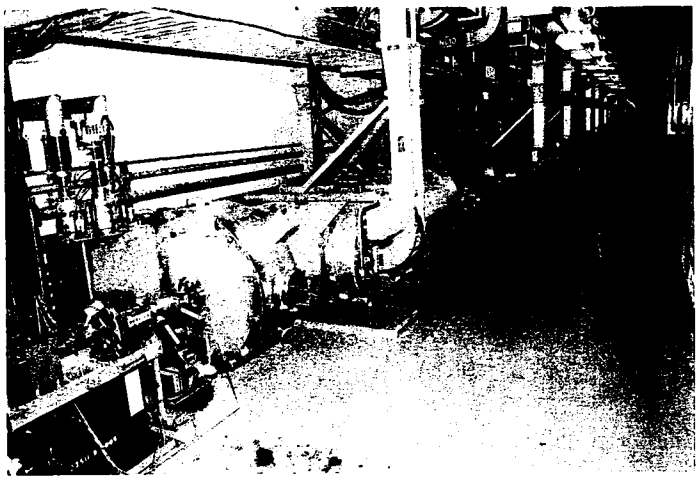

Figure 2b: North Linac

To build Jefferson Lab required extensive subcontracting with industry. About 70% of DOE funds provided for CEBAF development and construction were spent to obtain components, systems, or services from the private sector.

Finally, the process of building CEBAF and of exploring the nucleus to obtain new knowledge are intrinsically newsworthy, exciting, and motivational to students, faculty, and the public. The many interesting careers pursued by Jefferson Lab staff and its user community provide options for students to consider, and require skills and knowledge the students can acquire in school and through internships.

3 State and Local Participation

In the early 1980s when CEBAF was a concept and a plan, the Commonwealth of Virginia helped start the project, by providing funds for R&D and design long before any federal funds were made available. The city of Newport News aggressively recruited CEBAF to a former NASA site located in the city adjacent to land they hoped to develop into a profitable industrial park. The City leaders recognized CEBAF as environmentally-friendly and intellectually and technologically enriching to the community. They believed that the presence of this world-leading basic research laboratory would attract other high-technology companies. They also felt the high-technology character would be a major advantage to students at all levels and to local universities. Between 1985 and 1987 the City funded acquisition of the 200-acre site and built a "guest house" to lodge visiting scientists. In 1996, they broke ground on a

120,000 GSF building to provide space needed by the laboratory and its industrial and university partners. The new building is the flagship for the City's 200-acre high-technology park expected to attract many companies, among them ones applying or providing technologies and products related to Jefferson Lab.

During the past decade, Jefferson Lab has delivered handsomely on the state's and city's expectations for significant local and regional educational and economic benefits.

4 Educational and Community Benefits

In the educational arena, university faculty and students from around the country and world come to Jefferson Lab to do their experiments. In addition, the strength and quality of physics and engineering departments of nearby universities and colleges (even community colleges) have grown due to the Lab's influence. Jefferson Lab has been a catalyst for the formation of the Virginia Physics Consortium which links the physics departments of all Ph.D.-granting universities in the state into a collaborative network, wherein together, they could attain the status of a national "top-10" department. Finally, there are exciting and meaningful research opportunities for students from high school through graduate school.

In the local area, Jefferson Lab has provided major benefits to precollege education, where innovative partnerships involve approximately 10,000 students and 1,500 teachers per year. A major program called BEAMS (Becoming Enthusiastic About Math and Science) brings intact classes of 5th and 6th graders with their teachers to the Lab for a full school week of hands-on math and science activities, tours, and interactions with diverse career role models from the staff. [4]

As a result of these and other activities, the local public is quite enthusiastic about Jefferson Lab. We offer an annual site-wide public open house, provide speakers to civic groups, and send a participatory exhibit to the Virginia State Fair. Overall, the Lab receives favorable press coverage and maintains excellent community relations.

5 Employment

In the employment dimension, there are about 600 people employed on site (peak employment during construction was about 700). These represent NEW jobs, created since 1984, with about two-thirds of the people hired locally, and one-third recruited nationally. As an employer, Jefferson Lab is in the top 0.5% by size in the local area, the region, and the state.

The high technology nature of the work means that the workforce is highly skilled and well payed. The average 1996 salary is about $40,000, not including fringe benefits. We are a respected employer, and experience personnel turnover of only about 5% per year. In addition to the full-time staff on site, roughly 120 students from high schools, community colleges, and colleges have part-time jobs in engineering, scientific, technical, or administrative roles.

6 Contracting

About 70% of the $600 million investment in Jefferson Lab through 1995 was spent via subcontracts with manufacturing and service industries. Contracts have been awarded to firms in 49 of the 50 states (Figure 3), with about one-third of the procurement dollars awarded to Virginia firms (Figure 4). Over half of the money was spent in the southeastern states, and about one-quarter was spent locally. The vast majority of these contract dollars were awarded competitively on the basis of price or a combination of price and technical qualifications.

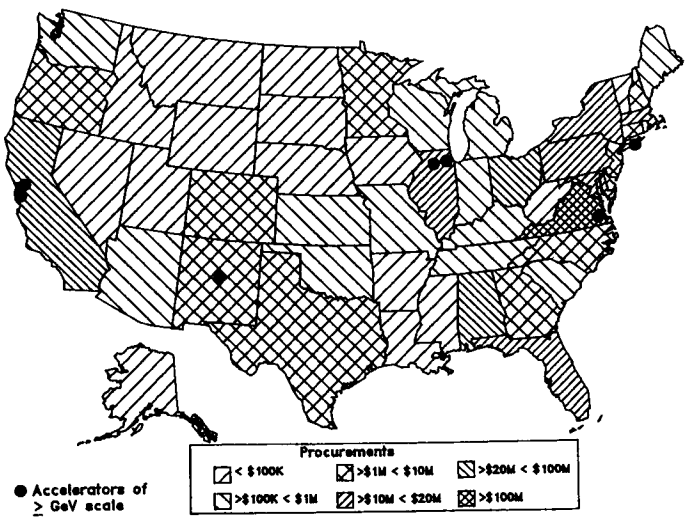

Figure 3: Subcontract Business

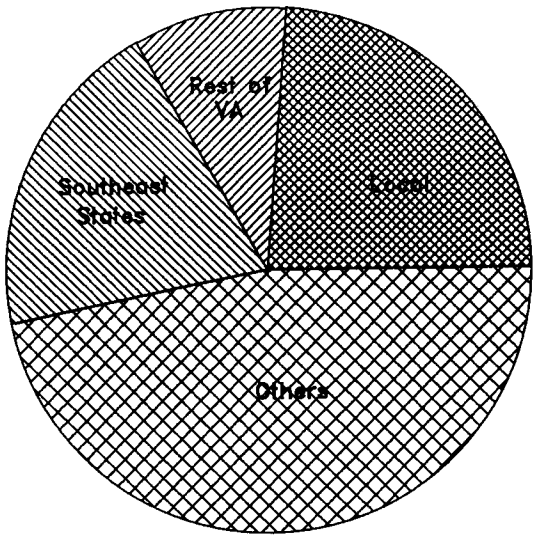

Figure 4: Geographic Distribution of Subcontracts By Cost

It is interesting to observe that states containing major accelerators (shown as dots on Figure 3) also received a substantial share of Jefferson Lab's business, regardless of their geographic distance. Companies in these states have already developed technical capabilities required to fabricate some of the specialized accelerator and detector components, due to previous experience they obtained working with their nearby accelerator laboratories.

Florida and Alabama received a large dollar volume of business, because they are each home to one of the two civil construction firms winning a major construction subcontract. Much of the money associated with these subcontracts was actually spent in Virginia, for hiring local construction workers and local subcontractors for cement work, steel work, plumbing, electrical work, etc.

The major European physics laboratory called CERN (European Center for Nuclear Research) in Geneva, Switzerland, has conducted two studies of the follow-on business to companies building seemingly esoteric parts for CERN accelerators and detectors. The most recent study was completed in 1984.[5] These companies estimated the financial value of markets developed for product lines based on or similar to components or devices first manufactured for CERN. For some technologies, the business volume for the firm averaged four times the value of the original CERN contract. We haven't made such a study for Jefferson Lab, but suspect that the experience would be similar.

7 Other Benefits

A final economic benefit locally is the flux of Jefferson Lab visitors. Some 600 people per year come to CEBAF for a few days to several months. They obtain temporary lodging in hotels and apartments, rent cars, eat in restaurants, and buy gifts, clothing, and supplies from local retail businesses. We estimate the visitor population on site averages about 100 people continuously. At the U.S. government per diem and lodging rate of ~ $80 per day, this represents an influx of nearly $3 million per year into the local economy. During the construction period the scientific visitor population was lower, but there were more subcontractor and supplier visitors. It would be surprising if this somewhat indirect local economic impact were less than $20 million, since 1985.

The existence and operation of CEBAF has other benefits as well. Our competencies and technologies are a resource to small businesses seeking technical advice, cooperative ventures, and those interested in Small Business Innovation Research (SBIR) and Small Business Technology Transfer Program (STTR) grants.

One very exciting spin-off of CEBAF is a free electron laser (FEL) based on the same accelerator technology. This technology has unique potential to provide high-average-power infrared and ultraviolet laser beams for low electric power use and cost. The Laser Processing Consortium, with industrial, university, and government member institutions, has formed to develop, test, and utilize a demonstration FEL. Funding for the first phase -- a 1 kilowatt infrared system -- has been provided in FY 1996 from the U.S. Navy and the Commonwealth of Virginia. A broad variety of exciting industrial and defense applications with markets worth billions of dollars have been proposed. Some of these products and processes are commercializable today, given a cost-effective, reliable source of laser light. Others are well along the development path; while some are prospective, based on preliminary results.

8 Summary

Jefferson Lab is a new accelerator-based laboratory with its primary mission to advance scientific knowledge. In many respects, Jefferson Lab is a typical model of the impact of a new accelerator facility technologically at the cutting edge. The $600 million invested in Jefferson Lab by federal, state, local, and international partners has had enormous economic and educational benefits locally, and substantial benefits distributed among industries and universities throughout the United States.

References

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