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ORNL FUSION PROGRAMS IN INDUSTRY*

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The Oak Ridge National Laboratory is operated by Union Carbide Corporation, with a budget of about $340 million per year and a staff of about 5,000, plus 700-800 staff from outside companies and universities, and from abroad. In addition, Union Carbide operates the Oak Ridge and Paducah Gaseous Diffusion Plants and the Y-12 Plant. There is a separate engineering organization and a separate computer sciences organization. The engineering organization has 1,300 staff members, which makes it among the largest in the world.

In recent years, Oak Ridge National Laboratory has changed from being largely a nuclear energy organization to one which is broadly involved in energy. Ten percent of our effort today is related to fossil energy, mostly coal. We have a very large energy conservation program. The fusion program accounts for nearly 20% of our effort. We continue to be heavily involved in fission energy, environmental and health research, and basic physical sciences.

Six years ago, we decided deliberately to increase our subcontracting. In 1974, we spent about $6 million on subcontracts; today we spend about $70 million, or 20% of our budget, on subcontracts. We expect the dollar amount will grow.

Our subcontracts generally fall into three categories. One is assistance to our study and analysis activities. The second is R&D by industry and universities to support our programs. Finally, we help "manage" a number of national programs as an "extension" of the Department of Energy, and in this capacity let many subcontracts in areas such as energy conservation and biomass. In these categories, we have approximately 1,000 subcontracts divided among 300 to 400 subcontracting organizations.

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We engage in the normal range of subcontracting options and have encountered the usual institutional problems of such procurement. In some cases, it has taken over a year to issue an RFP, engage subcontractors, and begin work. One of the tools we are using to speed up the process for studies or design support is the basic ordering agreement (BOA), in which we competitively select organizations to assist us in specified areas. Once agreements are in place, work can be authorized as needs arise without going through a formal selection process again. This arrangement is very convenient because it allows us to get help in a week or two rather than several months. Sometimes we use a "mini-RFP," which is an informal competitive process among several BOA contractors, but even this takes only a few weeks. For most R&D contracts, we use the normal competitive procedure which takes 2-1/2 to 6 months from RFP to the start of work if no difficulties are encountered.

Turning now to fusion, Oak Ridge's program is very broad. We work on tokamaks, EBT's, theory, technology and other areas, and the Fusion Engineering Design Center is at Oak Ridge. We have 61 fusion subcontracts at the moment with 28 separate organizations. Last year we subcontracted $16 million worth of work.

Figure 1 shows the distribution of subcontracted funds in major fusion research areas. About half of the money goes into the Large Coil Program, but substantial amounts go to the development of the gyrotrons and to the Design Center. We have the responsibility for developing the large superconducting coils that will be required for future toroidal devices. We are building a large test facility, costing over $30 million, which will be able to test a cluster of six coils weighing 40 to 45 tons each. Our subcontractors, General Electric, General Dynamics, and Westinghouse, are each building a coil to be included in the test. The remaining three coils will be supplied by Euratom, Japan, and Switzerland under the auspices of the International Energy Agency.

When the facility is fully operational, it will be capable of testing all of the coils simultaneously at liquid helium temperatures inside a large vessel. A special coil will provide magnetic pulses simulating the time dependent forces of a fusion device. Three coils should be ready to test in late 1981, and the others should come in within two years.

To start the Fusion Engineering Design Center, we selected three organizations by a competitive process to participate in the design studies for what is now the Fusion Engineering Device. The on-site staff consists of only six Oak Ridge professionals; four of the full-time participants are from the other fusion laboratories; and 20 are from the industrial subcontractors. Figure 2 shows how the Center is organized.

We turn now to our local product, the Elmo Bumpy Torus (EBT). An EBT is a toroidal device with some bumpiness. It's advantages are that it's modular; has an open, accessible center; and operates steady state. Operation of EBT-1 started in 1973, and someone has estimated that EBT has operated more hours than all the tokamaks in the world put together. It is driven by microwave power, recently increased in frequency to 28 GHz, and it's running well. There are only two EBT's in the world now, the one at Oak Ridge and one in Japan, which is a spin-off of the Oak Ridge technology.

The gyrotrons on the EBT produce power which is carried through waveguides into the plasma. There they heat the electrons which serve a couple of functions: they form rings around each cell that create magnetic fields of their own, and they also heat the plasma in the middle. Varian developed the 28 GHz continuous gyrotron under a subcontract to us, and Varian and Hughes are now at work on 60 GHz systems. Varian is also producing pulse devices that are beginning to be used in tokamaks.

A number of subcontractors participate in the EBT experimental program. McDonnell Douglas has a subcontract for developing and applying ion cyclotron resonance heating. They will develop, design, build and install these devices on the machine, working with us on the operation and analysis. Westinghouse is similarly developing a divertor for the EBT. We also have some university contracts. This program allows people to participate directly in the full range of tasks involved with operation of the machine.

About two years ago, we reached agreement with the Department of Energy on the planning for the design and construction of a larger EBT called the EBT Proof-of-Principle device, EBT-P, which will carry the EBT program roughly to the point that the PLT has carried the tokamak program; i.e., to establishing that it is a feasible concept. In the EBT program, we first requested proposals for Phase I design studies and we received proposals from a very substantial number of American industries. We were impressed with the quality of the organizations which were willing to participate. There were four teams led by Ebasco, Grumman, McDonnell Douglas, and Westinghouse. Each received $200,000 to develop design concepts, which was probably only a small fraction of what they spent. After the initial studies were completed, all of the organizations got together with us to develop a single reference design. Then we turned to the same contractors and asked them to submit proposals for the actual design and construction of EBT-P. On September 10, 1980, McDonnell Douglas was selected to build the plant. The device will cost $80-90 million, and will be in operation by 1985. General Dynamics will provide the superconducting magnets as a subcontractor to McDonnell Douglas, and Gilbert Commonwealth is their architect/engineer.

In summary, we decided six years ago to take advantage of what industry could provide by expanding our use of subcontractors. Our experience is that this subcontracting helps us in three ways. First, it provides assistance where we are short-handed. Second, industry often can do things we can't do. Third,

it helps to build the industrial expertise needed to create the next generation of fusion devices; for example, there is now a worldwide market for gyrotrons, and our subcontractors are prepared to supply its needs.

On the whole, we believe that the disadvantages sometimes encountered in subcontracting - red tape, delay, cost, and some inefficiency - are far outweighed by the advantages. Consequently we intend to continue and to do more if circumstances permit.

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FIGURE 1

MAJOR FUSION SUBCONTRACT AREAS

	FY-1980 EXPENDITURES (thousands of dollars)
LARGE COIL PROGRAM	8,000
GYROTRON DEVELOPMENT	3,400
FUSION ENGINEERING DESIGN CENTER	2,500
ISX-B	700
EBT-P	700
EBT-S	600

FED/VU 80-326R

A UNIQUE FUSION RESOURCE HAS BEEN IMPLEMENTED WITH THE ESTABLISHMENT OF A CENTRALIZED LABORATORY/INDUSTRY DESIGN TEAM

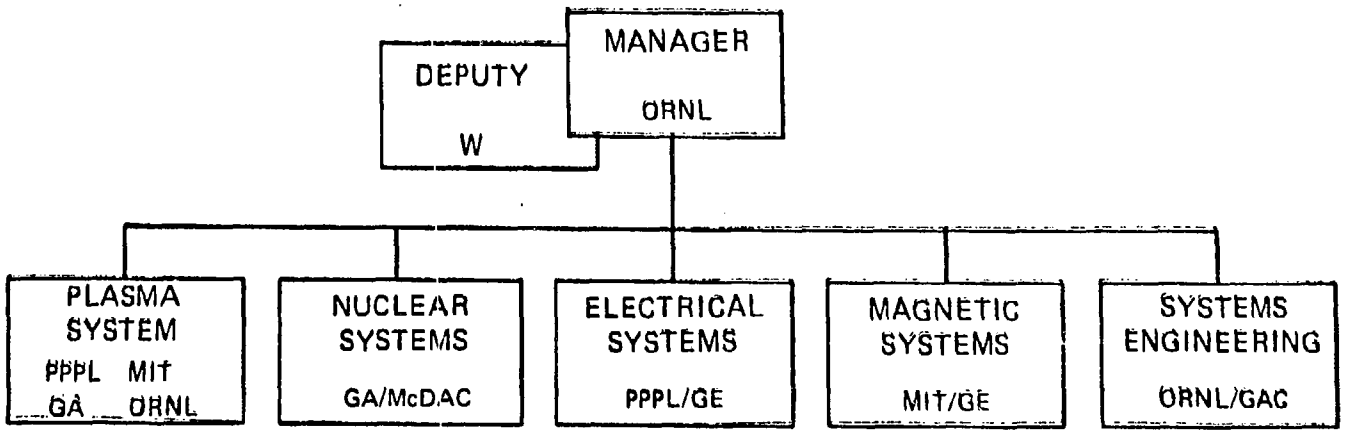

FIGURE 2