Summary of Technology Partnership Activities

BACKGROUND

Oak Ridge National Laboratory (ORNL) is a key participant in DOE's national effort on electric power applications of high temperature superconductivity (HTS). ORNL has formed effective teams that combine the resources of the Laboratory with the entrepreneurial drive of private companies. New technology partnership mechanisms, a feature of the ORNL Superconducting Technology Program for Electric Power Systems since its inception in 1988, have resulted in 39 superconductivity "pilot center" cooperative agreements and 6 cooperative research and development agreements (CRADAs), an increase of 7 in the total number of agreements. In addition, licensing agreements, joint inventions, and joint publications with the private industry partners have ensured that there is technology transfer throughout the program.

Technology partnering on Laboratory–industry teams may occur in several ways. Spinoff technology partnering involves the licensing of patentable Laboratory inventions to industry, continued product or process development to the point of demonstration of precommercial viability, or both. In the ORNL program the cooperative development level of technology partnering is emphasized: joint Laboratory–industry teams work on a problem that (1) requires combined resources and expertise and (2) has a clear objective of precompetitive research and technology development. For the project to succeed, each partner depends on the success of the other.

Most of the cooperative projects with private industry and the Laboratory precompetitive research and development projects are developing key technology in which commercialization of the results is expected to occur after a minimum of 3 to 5 years. Some activities are also of a higher-risk, longer-term nature for which new markets, or a shift of markets, to embrace HTS are expected if the project succeeds. For example, the ORNL rolling-assisted biaxially textured substrates (RABiTS™) process represents a new way to produce strongly linked YBCO wires using an industry-scalable process. This wire may still be the only option for practical performance levels in high magnetic fields at liquid nitrogen temperatures (65–77 K).

RELATIONSHIP TO THE DOE MISSION

The ORNL program mission is that of its program sponsor, DOE's Office of Utility Technologies, Superconductivity Program: to develop the technology base necessary for industry to proceed to commercialization of electric energy applications of HTS. HTS will enable new energy-efficient motors, transformers, and transmission lines and will also provide electric power equipment manufacturers with strategic technology for global competitiveness. Electric utilities can defer acquisition of new transmission rights-of-way with successful introduction of superconducting cables. System stability and protection will be enhanced with the introduction of fault current limiters. Distributed utility systems in the future, which will include distributed generation systems, will benefit from the small size and weight of the next generation of electric power equipment.

FUNDING

DOE funding for the program, subcontracting activities in 1997, and a summary of funds-out cooperative agreements are shown in Tables 3.1 and 3.2.

Table 3.1. Superconducting Technology Program funding: authorization and outlay by fiscal year

	New budget authorization/outlay ($ × 1000)				
	1989–1993	1994	1995	1996	1997
Direct scientific and technical[a]	11,942	3,334	3,434	2,995	3,046
Management and outreach	1,023	298	300	310	310
Subtotal—ORNL	12,965	3,632	3,734	3,305	3,356
Subcontracts[a]	1,021	496	198	1,290	1,021
Funds-out cooperative agreements	3,688	821	611	286	789
Total program	17,674	4,949	4,543	4,881	5,166

[a]Details are provided in separate table. Funds-out cooperative agreements provide partial financial support to U.S. industry for cost-shared cooperative research and development.

TECHNOLOGY PARTNERSHIP APPROACH

Our interdisciplinary approach uses all resources available at ORNL to meet the program goals for joint Laboratory–industry development of HTS technology for electric power applications. Our superconductivity agreement mechanism interlinks research and development projects with industry and universities that optimize utilization of facilities, expertise, and program resources for the benefit of all participants. This program also coordinates the ORNL activities with the other national laboratories, government agencies, university centers, and industry groups.

Cooperative agreements ensure that technology development is industry-driven. The Office of Science and Technology Partnerships and patent counsel work together to place these agreements. Where appropriate, these efforts are coordinated with projects within ORNL that are funded by the DOE Office of Energy Research, as well as Work for Others and ORNL Director's Research and Development Fund projects. Effective funds-out to industry is used to supplement industry cost share. In FY 1997, $1.8 million in funds-out to industry and universities was provided through cooperative agreements and subcontracts. To keep industry involved from the start of the program and to ensure commercialization potential, these technology partnering mechanisms are augmented by CRADAs, user agreements, and licensing activities.

Responsiveness to American industry has high priority in this program. An ORNL ad hoc technical review committee, consisting of a project manager, a scientific coordinator, a manager for conductor development, and a manager for applications development, reviews all inquiries from industry and recommends a project for possible funding. This review ensures that (1) the proposed work fits the program mission, (2) the work is collaborative, (3) there is legitimate commercial interest, and (4) the work is feasible. Substantial private-sector cost share is required on cooperative agreements.

ORNL provides support to the DOE Headquarters (DOE-HQ) Superconductivity

Table 3.2 Superconductivity Program
Summary of Cooperative Agreements as of September 30, 1997

Participant	Approved term	Type[a]	Total agreement cost share ($ × 1000)			Technology area
			By DOE		By Industry	
			To ORNL	To Industry		
Advanced Fuel Research (complete)	2/1/90–9/30/92	NFE	230	0	442	In situ HTS film deposition monitor
American Magnetics (complete)	8/10/89–8/9/92	NFE	100	0	480	Characterize MOCVD multifilament conductors
American Magnetics	10/1/96–10/1/97	C	0	0	82.4	Development, design, and fabrication of hybrid HTS leads
American Superconductor	9/1/96–8/31/98	FI	150	0	165	
American Superconductor (complete)	9/1/91–11/15/96	FO	1439	800	862	Coil fabrication, technical development, and testing
American Superconductor (complete)	4/1/89–11/15/96	FI	2090	0	1705.4	Fabrication of powder-in-tube wire and tape
Astronautics (complete)	9/1/91–2/28/95	FO	600	450	820	Magnetic refrigeration
CeraNova Corporation (complete)	8/1/93–1/31/95	FO	90	25	75	Melt-processed YBCO wire for leads and coils
Consultec Scientific (complete)	6/1/89–12/31/90	FO	38	45	64	Deposition target device
Corning (complete)	6/1/89–12/31/93	FO	325	275	316	Deposition on flexible ceramic substrates
CPS Superconductor (complete)	4/1/91–3/31/93	NFE	80	0	50	Conductor fabrication—continuous-filament melt-textured YBCO
Dow Corning (I-IIa) (complete)	7/1/90–9/31/91	FO	110	50	67	Thick film deposition
DuPont (complete)	7/1/89–3/31/91	NFE	225	0	250	Thin film devices and bulk applications
Edison Materials Technology Center (complete)	1/2/96–1/1/97	NFE	60	0	100	Develop coil winding technology
Electric Power Research Institute (complete)	7/13/93–7/12/96	C	26	0	215	Variable speed superconducting motors, power electronics, and superconducting magnetic energy storage
Energy Conversion Devices (complete)	5/1/91–3/31/93	NFE	90	0	90	Deposition of conductors
General Electric (A1) (complete)	12/15/88–2/28/89	FI	5	0	45	Thallium HTSc material processing
General Electric (SPI) (complete)	12/1/93–11/30/95	NFE	400	0	1173	Thallium wire development and generator design

Table 3.2 (continued)

Participant	Approved term	Type[a]	Total agreement cost share ($ × 1000)			Technology area
			By DOE		By Industry	
			To ORNL	To Industry		
General Electric (B1) (complete)	10/1/89–6/30/96	FO	895	520	614	Laser deposition of conductors; thallium-deposited conductors
General Electric (C1) (complete)	4/1/90–12/31/90	NFE	135	0	140	Thallium HTSc material processing
HiTc Superconco (complete)	3/1/90–4/30/91	NFE	40	0	50	Magnetic bearings
Innovative Materials Technology (complete)	10/1/89–3/31/90	FI	50	0	50	Composite tape fabrication
Intermagnetics General Corporation	6/15/97–6/14/98	FO	117	125	125	HTS transformer
Intermagnetics General Corporation	10/1/91–9/30/97	FO	1452	965	731	HTS transformer; BSCCO 2212 tape development
Intermagnetics General Corporation (complete)	9/1/91–8/31/94	NFE	100	0	100	Thallium powder-in-tube conductor
IBM (complete)	2/1/90–1/31/93	NFE	255	0	673	Optimize flux pinning via ion-induced defects
IBM (complete)	2/1/90–5/31/95	FO	201	389	186	Optimize flux pinning via ion-induced defects
MicroCoating Technologies	9/15/97–9/14/98	FI	0	0	150	Develop coated-conductor technology
Midwest Superconductivity/ Westinghouse Electric	6/25/96–6/24/98	C	300	0	980 160 1140	Develop coated-conductor technology
Neocera (complete)	2/1/91–1/31/93	FO	80	111.6	95.7	Laser ablation multi-target deposition
Oxford Instruments	1/94–1/31/99	C	275	0	475	Develop technology for dip-coated BSCCO-2212 wire
Plastronic, Inc. (complete)	10/22/93–9/30/95	NFE	165	0	225	Apply wire-forming technology to produce BSCCO wire
Plastronic, Inc.	5/1/97–7/1/98	FI	0	0	120	High-strength, low-ac loss high-temperature superconductor
Saphikon (complete)	2/1/92–4/30/94	NFE	50	0	492	Deposited conductor fabrication
Southwire Company	10/3/95–10/5/97	C	201	0	1249.2	Transmission cable

Table 3.2 (continued)

Participant	Approved term	Type[a]	Total agreement cost share ($ × 1000) By DOE To ORNL	Total agreement cost share ($ × 1000) By DOE To Industry	Total agreement cost share ($ × 1000) By Industry	Technology area
Southwire Company	2/1/97–1/31/1998	FO	550	500	973	3-phase, 100-ft demonstration cable made with HTS materials
SUNY-Buffalo (complete)	7/1/89–10/30/92	FO	165	250	255	Laser deposition of conductors
Stevens Institute of Technology (complete)	1/1/90–5/31/92	FO	90	105	100	MOCVD for electronic devices
Superconductive Components, Inc. (complete)	3/15/95–3/14/97	NFE	25	0	25	Scale-up of the production of superconducting and precursor powders synthesized by aerosol decomposition method
Superconductivity, Inc. (complete)	10/1/89–3/31/93	NFE	180	0	133	Magnetic energy storage for end-use applications
Textron Specialty Materials (complete)	8/1/89–3/31/91	NFE	60	0	45	Deposition of conductors
3M-Southwire-LANL-ORNL	4/3/97–4/99	C				Development of HTS wire using coated conductor technologies
3M					1375	
Southwire					324	
LANL					1699	
ORNL			600	960 [b]		
University of Wisconsin—Madison (complete)	8/1/92–3/31/96	FO	110	60	150	Aerosol powder synthesis
Waukesha Electric Systems	6/15/97–6/14/98	FO	117	125	148	HTS transformer
Westinghouse Electric (complete)	4/1/89–12/31/93	FO	1200	750	800	Powder scale-up, BSCCO wire fabrication, and leads
FY 1997 active subcontracts						
Imtech	10/3/94–12/31/97			271		Superconducting powder synthesis/scale-up
Massachusetts Institute of Technology	4/29/96–3/31/98			215		Stability of HTS conductors and coils
Oak Ridge Institute for Science and Education	Ongoing			360		Postdoctoral research fellowships (4.5)

Table 3.2 (continued)

Participant	Approved term	Type[a]	Total agreement cost share ($ × 1000)			Technology area
			By DOE		By Industry	
			To ORNL	To Industry		
State University of New York at Buffalo	11/1/95–5/31/96 10/1/96–10/31/97			25 30		Supply epitaxial films of thallium-based high-temperature superconducting materials
Texas Center for Superconductivity at the University of Houston	5/15/95–12/31/97			98		Processing YBCO and BSCCO superconductors for high-current leads and conductors (two students)
University of Tennessee	Ongoing			80		Students (3) - Deposited conductor development
National Institute of Standards and Technology (Interagency Agreement)	9/22/93–11/30/98			515		BSCCO and TBCCO phase diagram support
Energetics, Inc.	4/96–7/96 8/96–7/97 8/97–7/98			70 450 350		Technical and analytical support
Bob Lawrence & Associates	2/17/97–2/16/98			155		Technical and economic benefits assessment and market study
University of Wisconsin	5/1/97–4/30/99			100		TEM and magneto-optic imaging studies on RABiTS™
Marshall O. Pace	4/97–9/97			10		High-voltage breakdown studies on cryogenic insulation
Horatio Rodrigo	5/97–9/97			37		Set up impulse high-voltage generator and conduct vacuum and cryogenic breakdown measurements
Capital equipment	FY 1997			283		Deposited conductor development

[a]NFE = no-funds-exchange; FO = funds-out; FI = funds-in; I-informal; and C = CRADA.
[b]DOE to LANL.

Program for Electric Power Systems by identifying, guiding, and monitoring research and development at ORNL and ORNL subcontractor sites and by performing coordination, analysis, and planning of activities related to the national program.

Some of the various activities performed as part of this task include the following:

- technical, project, and budget guidance;
- project identification and development;
- exploratory research and development;
- support of consultants and subcontracts providing technical, program, or technology partnering support;
- identification, placement, and technical monitoring of subcontractors, review committee members, and workshop guests;
- guidance and support on technology partnering;
- publication of reports and proceedings from workshops;
- identification and initiation of cooperative agreements, interagency agreements (i.e., National Institute of Standards and Technology), and memoranda of understanding;
- distribution of reports to program managers;
- coordination of the Laboratory's Industrial Overview Committee;
- preparation of assessments to address technical, economic, regulatory, and institutional issues in the DOE program;
- coordination of interlaboratory technical team meetings;
- assistance to the DOE-HQ program manager in preparation of the Superconducting Technology Program Annual Operating Plan;
- collection and dissemination of programmatic information and program-wide assessments;
- assistance in organizing the HTS Wire Development Workshop (in partnership with ANL and LANL); and
- review of industrial collaboration opportunities through multilaboratory meetings and conference calls.

ORNL works with the other program laboratories to address such issues as communication among program participants, workshop and meeting implementation, planned competitive solicitations and superconductivity agreements, and coordination of technical and economic assessments.

An Industrial Overview Committee is charged with reviewing program activities and advising Laboratory management as to program progress, policy, and direction. The committee consists of representatives of electric utilities, original equipment manufacturers, and HTS wire manufacturers. This committee meets once a year at ORNL, Argonne National Laboratory (ANL), or Los Alamos National Laboratory (LANL).

PROGRAM MEASURES

Four new cooperative agreements were executed during FY 1997: American Superconductor Corp., Southwire Company, American Magnetics, and Midwest Superconductivity/Westinghouse. New Statements of Work were negotiated, and agreements were extended with IGC and Oxford Instruments. Ten new invention disclosures were submitted by ORNL or industrial principal investigators. These are listed in Table 3.3.

Table 3.3. Superconducting Technology Program invention disclosures
(FY 1997)

ERID No.	Subject	Submitted by
312	Rolling Methods of Forming Biaxially Textured Articles	A. Goyal
316	Powder Metallurgical Methods of Forming Biaxially Textured Articles	A. Goyal
330	Encapsulated High Temperature Superconductor Bundle	J. W. Lue and M. S. Lubell (ORNL), M. Tomsic (Plastronic)
334	Strengthening High Temperature Superconducting Tapes with Diffusion Bonded Backing	J. W. Lue and M. S. Lubell (ORNL), M. Tomsic (Plastronic)
363	Method of Forming Biaxially Textured Articles	A. Goyal and D. M. Kroeger
366	Method of Forming Biaxially Textured Articles Having Reduced Magnetism	A. Goyal and D. M. Kroeger
367	Method of Forming Biaxially Textured Articles	A. Goyal, D. M. Kroeger, and M. Paranthaman
368	Method of Forming Biaxially Textured Articles	A. Goyal
374	Method of Forming Biaxially Textured Articles by Physical Vapor Deposition	A. Goyal and D. M. Kroeger
375	Biaxially Textured Articles Having Metal Nitride Buffer Layers	A. Goyal and D. M. Kroeger