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Central Intelligence Agency

Washington, D.C. 20505

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MEMORANDUM FOR: See Distribution Attached

SUBJECT: Foreign Centers of Technical Excellence: Prospects for Collaboration [redacted] 25X1

Attached for your information is a copy of a report we have just prepared on foreign centers of technical excellence. I hope you find it useful. If you would be interested in having a fuller briefing on this subject, please contact [redacted] 25X1 Chief of our Technology and Industrial Competitiveness Division, [redacted] 25X1

[redacted] 25X1
Director of Global Issues

Attachment:
Foreign Centers of Technical Excellence: Prospects for Collaboration [redacted] 25X1
GI M 87-20095, May 1987, [redacted] 25X1

[redacted] 25X1

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DIRECTORATE OF INTELLIGENCE

27 May 1987

Foreign Centers of Technical Excellence: Prospects for Collaboration [redacted] 25X1

Summary

While the global dispersion of advanced technologies appears to be accelerating, only the United States and Japan have the range of scientific and industrial capabilities to advance simultaneously on all technical fronts. Centers of leadership, often focused on a relatively narrow range of technologies, do exist in other countries -- for example, French and West German strengths in advanced manufacturing technologies and British capabilities in airframe composites probably lead the rest of the world. Similar patterns of concentration appear to be taking hold in parts of the the Third World, but LDC contenders have not yet significantly approached the technological levels of the major industrial countries. Given the dictates of national pride and proprietary interest, major collaborative efforts among foreign technical centers have been relatively rare. We believe, however, that market forces will encourage more future collaboration among facilities with "niche" capabilities, as innovative firms in different countries seek to commercialize complementary technologies. For many, the alternative to collaboration -- via go-it-alone strategies -- is likely to be technological and industrial stagnation. [redacted] 25X1

This memorandum was prepared by [redacted] Office of Global Issues, with contributions from analysts in the Offices of Global Issues and European Analysis. Comments may be directed to [redacted] Chief, Technology and Industrial Competitiveness Division, [redacted] 25X1 25X1 25X1

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Foreign Centers of Technical Excellence: Prospects for Collaboration

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Foreign Centers of Technical Excellence: Prospects for Collaboration

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In recent years, centers of technical strength in research and development (R&D) and production have emerged in a number of firms and laboratories throughout the Free World. While these organizations and facilities possess impressive capabilities for technological innovation, individually very few of them have attained levels of achievement on a par with leading US institutions. By far the lion's share of foreign R&D and production advances has been accounted for by Japan and Western Europe. Local producers in advanced-technology "niches" are emerging in some Third World countries, although these efforts have often consisted of purchasing and integrating proven subsystems from the United States and Western Europe.

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Centers of Foreign Technical Excellence

World-class **research and development** facilities abound in the Free World (see Appendices A and B). Indeed, the recent series of superconductor achievements by dozens of organizations -- a chance discovery in a Swiss laboratory followed rapidly by breakthrough advances around the world (figure 1) -- illustrates the globally dispersed nature of R&D leadership. Foreign facilities with exceptional R&D capabilities now exist in several areas with important commercial and defense applications. For example:

- The French consortium SNECMA has sharply accelerated its advanced propulsion research, building on French Government support as well as the market success of the CFM56 engine developed jointly with General Electric.

- A number of Japanese firms took an early lead in worldwide basic research on intermetallics, which are generally considered the most promising materials to outperform superalloys.

- Although heavily dependent on US and Japanese computer technology, West Europeans have been doing world-class basic research on new architectures for high-performance systems and optical disk units.

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Leading-edge **production** capabilities are also spread throughout the major industrial countries (Appendix C). Japanese advances in microelectronics and European strengths in advanced machine tools are well-documented examples. Other instances of world-class production capabilities in key technology areas include the following:

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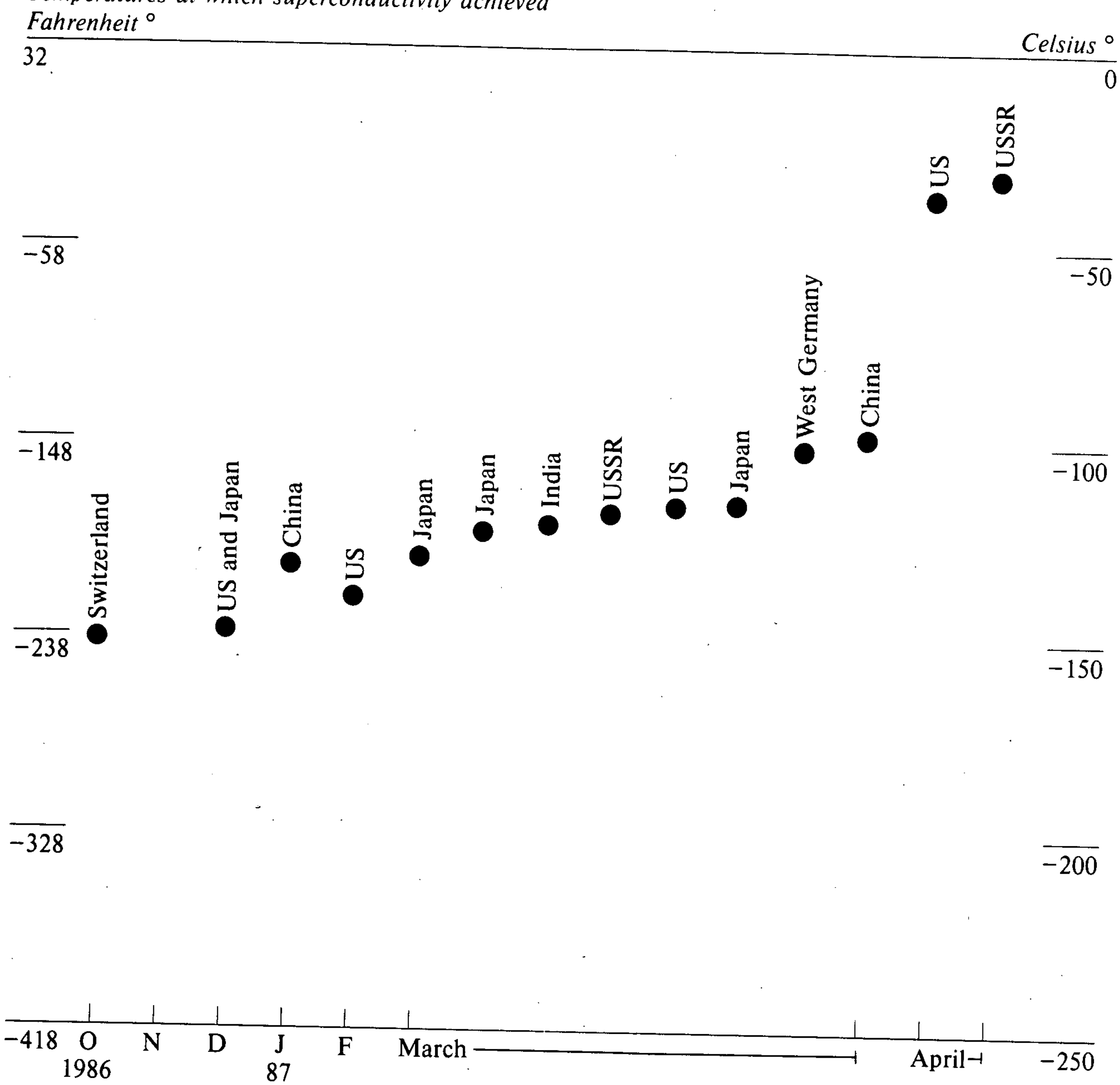
Figure 1
Breakthroughs in Superconductors, Fall 1986-Spring 1987

Temperatures at which superconductivity achieved



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- Japan is currently almost equal with the United States in biotechnology overall, and in some important areas -- especially fermentation technology, a key to large-scale production -- appears to be ahead of all other nations.

- In advanced telecommunications equipment technology, the world leaders in producing digital local switching systems include Northern Telecom of Canada, Ericsson of Sweden, and CIT Alcatel of France.

- West German equipment for electron-beam melting of superalloys, filament winding of advanced composite materials, and cold forging of steel is rated by US industry experts as the best in the world.

- Despite weaknesses in factory automation software development, Japanese firms now produce computer numerical controls for machine tools that are at least as sophisticated as the most advanced US products.

Among smaller industrial countries, Switzerland, the Netherlands and Denmark have made significant achievements in such areas as optoelectronics and biotechnology. Figure 2 summarizes how Western Europe and Japan currently stand relative to the United States in key technology production areas. [redacted] 25X1

While the technological gap between the major industrial countries and the developing countries remains very wide, "niche" capabilities are beginning to take root in parts of the Third World (see Appendix D). Most collaborative efforts involving these countries have been in defense-related technologies. Nevertheless, some Third World facilities are developing capabilites on their own in civilian areas. For example:

- Brazil has made major contributions to international technology in alcohol fuels, shale oil recovery and utilization, and deepwater oil production techniques. Brazilian nonconventional energy research has been recognized as world-class since about 1980.

- Taiwan and South Korea have been developing manufacturing know-how for advanced composite materials. While both Taipei and Seoul are pushing plans to establish domestic capacity for making military-grade composites, industry in Taiwan has thus far emphasized applications for commercial products such as sporting goods.

- India has advanced significantly in many areas of science and technology, and its work in agrotechnology, medicine, theoretical physics and mathematics has high potential for contributing to world knowledge in those fields. [redacted] 25X1

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Figure 2
Free World Activities in Key Technologies: Current Status Relative to the United States

Japan/**Europe**

▶ Improving
● Maintaining
◀ Declining

	Lag: Sub-stantial	Lag: Clear	Lag: Slight	Parity With US	Lead: Slight	Lead: Clear	Lead: Sub-stantial
Semiconductors							
Silicon devices/materials		●		▶			
Nonsilicon devices/materials			●		▶		
Fabrication equipment		●	▶				
Data processing							
Supercomputers		◀	▶				
General purpose mainframes		◀	◀				
Peripherals		●	▶				
Telecommunications							
Transmission		●	▶				
Switching	▶		●				
Terminals		▶	▶				
Advanced structural materials							
Ceramics				●	▶		
Composites			▶	●			
Metals		▶	●				
Manufacturing							
Machine tools				●			
Robotics				●	●		
Aircraft							
Propulsion	▶			●			
Avionics		●	▶				
Aerodynamics/structures	●		●				
Space							
Launch vehicles	▶	▶					
Remote sensing			▶	●			
Ground stations			▶		◀		
Comsats	▶		●				
Nuclear							
Reactors			▶		▶		
Fuel cycle		▶		▶			
Fusion power		●	●				
Biotechnology							
Genetic engineering		●	▶				
Bioprocess industry		●			●		

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Vehicles of Technology Collaboration

Aside from international cooperation on basic research in high energy physics -- such as CERN, the European Nuclear Research Center -- collaborative R&D efforts have had only modest support to date (see Appendix E). The most impressive attempt is EUREKA, the European response to the US SDI research program. Since its initiation by President Mitterrand in 1985, 19 European governments and several hundred firms have joined this program for pooling R&D resources in electronics, transportation, manufacturing, and biotechnology. With a projected budget of $4 billion over the next 4-5 years, EUREKA plans to capitalize on current European strengths -- in software, machine tools, and niche areas such as application-specific integrated circuits -- as well as to infuse new technologies into ailing industries. 25X1

The MEGA project is a prime example of cooperative R&D between European firms. Through this effort, Siemens (West Germany) and Philips (Netherlands) hope to recapture a large part of the European semiconductor market from US and Japanese suppliers. Another example of corporate collaboration is the defense-related sensor technology project involving Telefunken (West Germany), Mullard (UK), and SAT (France) aimed at developing next-generation tactical weapons. 25X1

Japan's approach to R&D collaboration is generally focused inward rather than internationally. Joint research ventures are common among government, industry, and university laboratories in Japan. The most ambitious projects include TRON (a microprocessor standard for Japanese language applications) and SOR-Tech (a new approach for using X-rays to manufacture high-density semiconductor chips). The Japanese are aware of foreign criticism that their pattern of technology transfer has been decidedly one-way. We believe one solution Tokyo is stressing is the promotion of international cooperation in areas of less commercial consequence, including space, medicine, and environmental protection. A current example of this approach is Japan's proposed "Human Frontiers" program aimed at global problems such as tropical diseases and pollution. 25X1

The most significant results of international technology collaboration have occurred in production rather than in R&D (see Appendix F). Airbus Industrie -- the French, German, British and Spanish aerospace consortium -- has fielded a family of sophisticated airliners over the last 15 years. Aside from the government subsidy/price-cutting issue that will continue to be a source of trade friction, Airbus demonstrates technology collaboration at its best. The requirement for an advanced European military fighter for the 1990s may also motivate close collaboration, with temporary submergence of differing national priorities and military missions (see Box). 25X1

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Advanced Military Fighter: European Technological Strengths and Conflicting National Priorities

The West Europeans' combined technological strengths would, in principle, enable them to produce an indigenous fighter superior in performance to the primary Soviet fighter threat of the late 1990s and more advanced than the current frontline US fighters such as the F-15 and F-16:

- **The United Kingdom** may be the world leader in airframe composites, in addition to its strength in airborne attack radar and sensors.

- **France** is probably ahead of the United States in computer aided design and manufacturing, and excels in the application of advanced airframe metals.

- **Italy** has emerged as the world leader in engine gearboxes and a strong player in airframe composites.

- **West Germany** excels in advanced manufacturing technologies.

However, West European aerospace firms lack the Stealth technologies that will be incorporated in the next-generation US Advanced Tactical Fighter (ATF) of the mid-1990s, and possibly in a limited number of Soviet Stealth fighters. 25X1

European technological strengths also tend to be limited by conflicting national priorities:

- The United Kingdom has diverse mission requirements of long-range island defense, strike/interdiction in Central Europe, and out-of-area contingencies.

- France couples insistence on indigenous design and production with a strong emphasis on export sales.

- Italy is increasingly more concerned over threats from the Mediterranean region -- including Libya -- than a Warsaw Pact incursion.

- West Germany is wary of capabilities threatening Soviet territory and supportive of joint ventures.

Despite differences in national priorities, we believe the West Europeans will be compelled to rely on multinational development and production -- as they have with Tornado, Alpha Jet, Jaguar, Transall, Airbus, and ATR -- in order to amortize R&D costs and improve export sales. 25X1

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European collaboration on high-technology arms production extends to Third World participants. Israel-West Germany (tank cannon, armor, and propulsion); Brazil-Italy (AMX multirole fighter); Brazil-UK-France-West Germany (Osorio main battle tank); Argentina-Italy-France-West Germany (CONDOR ballistic missile); and South Korea-West Germany (K-1 main battle tank) are among the recent linkages formed in this area. 25X1

Common Themes and Motivations

Although there are unique historical forces driving specific examples of technical collaboration, competition with the United States has been a recurring theme in such efforts. This competition encompasses technology, international trade, and political influence/autonomy considerations:

- **Keeping Pace with US Technology.** In virtually all areas of advanced technology, absolute market size will continue to be a critical factor shaping the growth and survival prospects of foreign producers. The size of the US market, and the technological leads traditionally enjoyed by US producers, generally oblige foreign high-technology firms to keep pace with the United States or withdraw from the world market entirely. The Europeans and others are aware that development of advanced technical capabilities -- via collaborative efforts such as Airbus, the MEGA Project, and EUREKA -- may serve as broad-based technology drivers, producing spinoff technologies that will position them to participate in other high-technology areas.

- **Global Competition.** The internationalization of high-technology industries offers foreign companies an effective means of competing in the world market against the United States through consortiums and other interfirm link-ups. By joining forces to produce and integrate an entire high-technology system, contributing firms are able to better target their R&D resources and quicken the pace of advances in subsystems and component developments. European and Japanese willingness to sell advanced-technology products and systems to certain customers refused by the United States, and the reluctance of many Third World countries to become dependent on US systems, will likely boost other countries' high-technology export sales. Moreover, Japanese and European component manufacturers will probably become more aggressive in foreign markets once dominated by American suppliers as they convert laboratory technologies to marketable products.

- **Minimizing Dependence.** The need for foreign governments to justify major R&D programs or weapons expenditures by pointing to economic benefits at home -- especially higher employment levels and the promotion of local high-technology capabilities -- will make it difficult to abandon advanced-technology efforts even if cost effectiveness and military requirements should argue

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otherwise. For example, we believe West European motivations for limiting US participation in the European Fighter Aircraft (EFA) are driven by desires to maximize European technological development and employment and to avoid export restrictions accompanying US technology. Nonetheless, [redacted] the Europeans may buy a US radar or engine in order to reduce the EFA's development risks, time, and costs. [redacted] 25X1 25X1 25X1

Outlook

Given the nature and pace of high-technology innovation, we believe that governments will see their abilities to direct technical collaboration increasingly eroded by market forces. Although many governments encourage certain forms of cooperation, the emphasis has been on protecting national economic and security interests rather than making the fullest use of international scientific and industrial strengths. Most foreign governments appear to prefer some variation of the Japanese approach of exploiting technologies developed elsewhere while preserving domestic employment and production. West European and some Third World countries, lacking Japan's broad industrial and technological base, are trying to reach Japanese-type objectives through limited bilateral and multilateral collaborative arrangements such as EUREKA, in hopes of maintaining a measure of technological independence from the major powers. [redacted] 25X1

High-technology firms and their customers hold a different set of priorities, however. These firms know that -- without access to the full range of technical inputs in both basic research and production engineering -- their products would quickly become uncompetitive. Even if protected domestically, they could rapidly lose major shares of world markets. Ultimately, domestic sales also would suffer as prices rise and performance deteriorates relative to leading-edge products made in other countries. [redacted] 25X1

In our judgment, national strategies to steer development of high-technology industry -- including Japan's -- will be subject to erosion as individual firms seek out foreign sources of complementary technical inputs. Many pan-European efforts will likely prove to be inadequate without US or Japanese links, especially in electronics. Japan eventually will be compelled to change its inward-looking strategy or risk losing its access to US and West European markets and scientific expertise. In the Third World, nationalistic stands on technology transfer, patents, and foreign investment will be undermined as LDC firms with specialized technical capabilities seek developed-country partners. To the extent that foreign governments manage to forestall these trends -- and many will try, possibly for the best of short-term reasons -- we believe that they will be opting out of the new technological age. [redacted] 25X1

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Appendix A

FOREIGN CENTERS OF TECHNICAL EXCELLENCE: LEADING RESEARCH AND DEVELOPMENT FACILITIES

Technology	Facility
Biotechnology	University of Leeds (UK)
	Company for Biotechnology Research (W. Germany)
	European Molecular Biology Laboratory (W. Germany)
	Institute for Fermentation and Biotechnology (W. Germany)
	Carlsberg Institute (Denmark)
Computers	NEC Scientific Computing Center (Japan)
	NEC C&C Systems Research Lab (Japan)
	NEC Software Project Engineering Laboratory (Japan)
	Hitachi Central Research Laboratory (Japan) -- fundamental and applied computer technologies
	Hitachi Systems Development Laboratory (Japan)
	Fujitsu Kawasaki Works (Japan) -- systems and software
	Fujitsu Kansai Information Processing Laboratory (Japan) -- software
	Korea Institute of Electronics Technology (S. Korea) -- computers, semiconductors
Materials	Kyocera (Japan) -- ceramics for auto engines, gas turbines, and armor
	SEP (France) -- advanced carbon-carbon materials and derivative work on ceramic-matrix composites
	Aerospatiale (France) -- composites and aluminum-lithium in airframes

Technology	Facility
Materials (continued)	Messerschmitt-Bolkow-Blohm (W. Germany) -- composites and aluminum-lithium in airframes
	National Institute for Research in Inorganic Materials (Japan) -- ceramics research and materials properties under extreme conditions
	National Research Institute for Metals (Japan) -- leading metallurgy center; will soon occupy a new facility devoted to cryogenics
	Korea Institute of Machinery and Metals (S. Korea) -- machinery, metals, shipbuilding, and precision instruments
	Korea Institute of Energy and Resources (S. Korea) -- energy technology and economics, mining and materials
Optoelectronics	Thomson-CSF (France) -- fiber-optic gyroscope; halide compounds for infrared optical fibers; InGaAsP, a semiconductor laser compound; integrated optics
	Optoelectronic Technology Research Corp. (Japan) -- optoelectronic integrated circuits
	NEC Optoelectronics Basic Research Laboratory (Japan) -- fiber-optic communications transmission techniques, including coherent transmission
	NEC Optoelectronics Applications Research Laboratory (Japan) -- integrated optics; optoelectronic devices*
	Fujitsu (Japan) -- optoelectronic integrated circuits and devices; optical transmission systems and switching
	Toshiba (Japan) -- laser diodes
	Hitachi (Japan) -- laser diodes

* Optoelectronic devices include laser diodes, optoelectronic materials (III-V) and device production, material and device physics.

Technology	Facility
Optoelectronics (continued)	Sumitomo Electric (Japan) -- optical fibers
	Furukawa (Japan) -- halide fibers; integrated optics
	KDD (Japan) -- fiber optics, halide fibers, laser diodes
	Siemens (W. Germany) -- integrated optics; fiber-optic transmission; components and systems
	Standard Electrik Lorenz (W. Germany) -- fiber-optic gyroscope
	MITI Electrotechnical Laboratory (Japan) -- optoelectronic integrated circuits and devices; fiber optics
	Sony (Japan) -- laser diodes
Microelectronics	Fujitsu Kawasaki Works (Japan) -- communications and electronic equipment, software, computers, integrated circuits
	Fujitsu VLSI Sekkei (Japan) -- very large-scale integrated circuit (VLSI) designs
	NEC Fundamental Research Laboratories [Kiso Kenkyujo] (Japan) -- semiconductors, ceramics
	NEC Microelectronics Research Laboratories [Microelectronics Kenkyujo] (Japan) -- VLSIs, high speed devices, recording materials, sensors
	Mitsubishi Materials Engineering Laboratory [Zairyo Kenkyujo] (Japan) -- materials, electronic devices
	Hitachi Central Research Laboratory [Chuo Kenkyujo] (Japan) -- fundamental and applied technologies
	Hitachi Device Development Center [Device Kaihatsu Center] (Japan) -- VLSIs
	Toshiba Semiconductor Device Engineering Laboratory [Handotai Gijutsu Kenkyujo] (Japan)

Technology	Facility
Telecommunications	NTT Electrical Communication Laboratories (Atsugi, Japan) -- integrated circuit design, development, and production process development; GaAs single-crystal growth; laser diodes
	NTT Electrical Communication Laboratories (Musashino, Japan) -- oversees all NTT research: III-V materials characterization; laser diode superlattice structures; switching technology and systems development
	NTT Electrical Communication Laboratories (Ibaraki, Japan) -- fiber-optic waveguides; optical fiber production
	NTT Electrical Communication Laboratories (Yokosuka, Japan) -- systems integration; transmission, data processing, and customer-premises equipment; visual media, speech processing, and character-recognition equipment; coherent communication systems operating in the mid-infrared range
	NTT Software Production Technology Laboratory & Central Software Center (Japan) -- software for advanced network services; information network systems
	Korea Electrotechnology and Telecommunications Research Institute (S. Korea)
Aerospace	Airbus Industrie (France, UK, W. Germany, Spain)
	SNECMA (France)
	SEP [Societe Europenne de Propulsion, a division of SNECMA] (France)
	National Aerospace Lab (Japan) -- may be shifting toward concentration on computer simulation and materials
Defense Industries Technology	Technologie Zentrum Nord (W. Germany) -- control technology, sensors, microelectronics, and lasers. Projects include: ZEPL explosively-formed penetrator submunition; EPH RAM terminally guided tube-artillery round; EPHAG terminally guided tank round

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Technology	Facility
Defense Industries (continued)	Royal Armament Research and Development Estalishment (UK) -- conventional weapons, armor arrays, liquid propellants, electromagnetic gun
	GIAT/Satory, ISL (France) -- conventional weapons, armored vehicle technology, anti-armor munitions
	Technical Research and Development Institute (TRDI) of the Japanese Defense Agency -- general-purpose weapons technology development
Other	Korea Advanced Institute of Science and Technology (S. Korea) -- integrated industrial technology

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Appendix B

FOREIGN CENTERS OF TECHNICAL EXCELLENCE: LEADING FACILITIES IN SDI-RELATED TECHNOLOGIES

Technology	Facility
Algorithms	Johannes Kepler Universitat (Austria) Laboratorie de l'Utilisation du Rayonnement Electromagnetique (France) Universita degli Studi di Milano (Italy) Universita degli Studi di Napoli (Italy) Imperial College of Science and Technology (UK) University of Edinburgh (UK)
Radar Antennas	Thomson CSF-Avionics Division (France) Selenia-Industrie Elettroniche Associate SpA (Italy) Hollandse Signaalapparaten (Netherlands) Ericsson Radio Systems (Sweden) Plessey Electronic Systems (UK) Marconi Radar Systems, Ltd. (UK)
Optical Coatings	Balzers AG (Liechtenstein)
Composites	Thomson CSF Avionics Division (France) Centro Ricerche Fiat SpA (Italy) Oto Melera SpA (Italy) Agusta SpA (Italy) Battelle Institute (W. Germany) Fraunhofer-Gesellschaft Forderung Angewandten Forschung (W. Germany) MBB-ERNO Raumfahrttechnik (W. Germany)
Hardening Systems	Erkzeugmachinenfabrik Erlikon-Buehrie (Switzerland)
Gyroscopes	Thomson CSF-Electron Tube Division (France) British Aerospace Electronic Systems Division (UK) Teldix (W. Germany) Bodenseewerk Geratetechnik (W. Germany) Standard Electrik Lorenz AG Forschungszentrum (W. Germany)

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Technology	Facility
Inertial Measuring Units	Societe Francaise d'Equipements pour la Navigation Aerienne (France) Thomson CSF-Avionics Division (France) Marconi Radar Systems, Ltd. (UK) British Aerospace Electronic Systems Division (UK) Teldix (W. Germany) Bodenseewerk Geratetechnik (W. Germany)
Free Electron Lasers	Laboratorie de l'Utilisation du Rayonnement Electromagnetique (France) Comitato Nazionale Ricerca Sviluppo Energia Nucleare (Italy)
Space-Based Optics	Schotte Glaswerke (W. Germany)
Ground-Based Mirrors	Schotte Glaswerke (W. Germany)
Adaptive Optics	Heriot-Watt University, Computer Applications Services (UK) Cambridge Consultants, Ltd. (UK)
Power Conditioning	Siemens AG Radio and Radar Systems Division (W. Germany)
Spacecraft Prime Power	Dornier System (W. Germany) Deutsche Forschungs und Versuchsanstalt fur Luft und Raufahrt (W. Germany)
Axial Propulsion	Rheinmetall (W. Germany) Dornier System (W. Germany)
Optical Seekers	Hollandse Signaalapparaten (Netherlands)
Infrared Sensors	Thomson CSF-Electron Tube Division (France) Instrument Technology, Ltd. (UK) Mullard, Ltd. (UK)

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Technology	Facility
Structures	Erkzeugmachinenfabrik Erlikon-Beuhrie (Switzerland) Dornier System (W. Germany) Deutsche Forschungs und Versuchsanstalt fur Luft und Raufahrt (W. Germany)
Radar Transmit-Receive Modules	Thomson CSF-Electron Tube Division (France) Marconi Electronic Devices, Ltd. (UK) Microwave Associates, Ltd. (UK) Siemens Radio and Radar Systems Division (W. Germany)
Warheads (non-nuclear)	Erkzeugmachinenfabrik Erlikon-Buehrie (Switzerland) Rheinmetall (W. Germany) Diehl (W. Germany)

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Appendix C

FOREIGN CENTERS OF TECHNICAL EXCELLENCE: LEADING PRODUCTION FACILITIES

Technology	Facility
Semiconductors	
DRAMS	Toshiba (Japan) Hitachi (Japan) Fujitsu (Japan) NEC (Japan)
SRAMS	Fujitsu (Japan) Hitachi (Japan) NEC (Japan) Toshiba (Japan)
Standard Logic	Fujitsu (Japan) Hitachi (Japan) NEC (Japan)
Silicon Materials	Sumitomo Electric (Japan) Wacker (W. Germany)
Gallium Arsenide Devices	Fujitsu (Japan) NEC (Japan) Toshiba (Japan)
Gallium Arsenide Material	Sumitomo Electric (Japan) Mitsubishi-Monsanto (Japan)
Optical Lithography	Canon (Japan) Nikon (Japan)
Packaging	Kyocera (Japan) NTK (Japan)
Test Equipment	Advantest (Japan)
Computers	
Optical Storage	Matsushita (Japan) Hitachi (Japan) Sony (Japan) Toshiba (Japan)

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Technology	Facility
Telecommunications	
Switching Systems	Northern Telecom (Canada) Ericsson (Sweden) CIT Alcatel (France)
Local Switching Centers	CGE (France) Northern Telecom (Canada)
Satellite Earth Stations	NEC (Japan)
Advanced Structural Materials	
Composites:	
Carbon Fibers	Toray Industries (Japan) Kashima Oil (Japan)
Thermoplastic Composites	Imperial Chemical Industries (UK)
Thermoplastic Matrix Material	Ciba-Geigy (Switzerland)
Carbon-Carbon Composites	Societe Europeane de Propulsion (France)
Filament Winding Equipment	Baer (W. Germany)
Weaving Equipment	Brochier et Fils (France)
Ceramics:	
Silicon Nitride Material	Kyocera (Japan)
Hot Isostatic Presses	ASEA (Sweden)
Diamond Finishing Equipment	Toshiba (Japan)
Metals:	
Electron-Beam Melting Equipment	Leybold-Heraeus (W. Germany)

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Technology	Facility
Optoelectronics	
Polarization-Preserving Optical Fiber	Hitachi (Japan)
1.3-1.55 Laser Diodes	NEC, Hitachi, Fujitsu (Japan)
Germanium Avalanche Photodiodes	NEC, Fujitsu (Japan)
Biotechnology	
Bioreactors	Toyo Soda Manufacturing (Japan)
Fermentation	Mitsui Bioengineering Corp. (Japan)
Industrial Enzymes	Novo (Denmark)
Aerospace	
Airframes:	
Composites	British Aerospace (UK) Aeritalia (Italy) Dassault (France)
Advanced Metals	Dassault (France) British Aerospace (UK)
Computer Aided Design	Dassault (France)
Automated Production	Dassault (France) British Aerospace (UK) Messerschmitt-Bolkow-Blohm (MBB) (West Germany)
Advanced Aerodynamics	Dassault/Office National d'Etudes et de Recherches Aerospatiales (France) British Aerospace/Royal Aircraft Establishment (UK) MBB/Deutsche Forshungs und Versuchsanstalt fur Luft und Raumfahrt (W. Germany)

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Technology	Facility
Avionics:	
Attack Radar	GEC (UK) Ferranti (UK) Electronique Serge Dassault (France) Fabbrica Italiana Apparecchiature Radioelecttriche SpA (Italy) Mitsubishi Electric Corp. (Japan)
Advanced Controls	Dassault (France) British Aerospace (UK) MBB (W. Germany)
Advanced Gyroscopes	British Aerospace (UK) Thomson-CSF (France) Societe Francaise d'Equipements pour la Navigation Aerienne (France)
Cockpit Displays	Thomson-CSF (France)
Stealth Technology	Marconi (UK) Plessey (UK) Dornier (W. Germany)
Propulsion:	
Hot Section	Rolls-Royce (UK) SNECMA(France)
Manufacturing	SNECMA (France) Rolls-Royce (UK) Motoren- und Turbinen-Union (MTU) (W. Germany)
Land Armaments	
Systems Integration	Mitsubishi Heavy Industries (Japan) Vickers (UK) Krauss Maffie (W. Germany) Thyssen Henschel (W. Germany) GIAT (France) Oto Melara (Italy) Rafael (Israel) Engesa (Brazil) Avibras (Brazil) Hyundai (S. Korea) Armscor (S. Africa)

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Technology	Facility
Land Armaments (continued)	
Gun Systems	Rheinmetall (W. Germany) Bofors (Sweden) Royal Ordnance (UK) Cockerill (Belgium) NORINC (Austria) Engesa (Brazil) Fuicine Breda (Italy)
Precision-Guided Munitions	British Aerospace (UK) Aerospatiale (France) Diehl (W. Germany)
Propulsion	Rolls-Royce (UK) Unidiesel (France) MTU (W. Germany)
Transmissions	David Brown (UK) Renk (W. Germany) Zahnradfabrik Friedrichshafen (W. Germany)
Armor Arrays	Vickers (UK) GIAT (France) Blohm & Voss (W. Germany) Thyssen Henschel (W. Germany) Georg Fischer (Switzerland)
Defense Electro-Optics	GEC (UK) Marconi (UK) Barr & Stroud (UK) Plessey (UK) Ferranti (UK) Thomson-CSF (France) SFENA (France) ESD (France) Eltro (W. Germany) Seimens (W. Germany) AEG (W. Germany) FIAR (Italy) SABCA (Belgium) Philips (Netherlands) ELOP (Israel)

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Appendix D

THIRD WORLD RESEARCH CENTERS: OVERVIEW

The R&D capabilities of Third World countries range from a handful of isolated and poorly funded facilities in Jordan to hundreds of active groups in India and Brazil. We have little information with which to assess the quality of the R&D work performed at most LDC research institutes. In our judgment, however, most of the facilities are inadequately staffed, funded and equipped to carry out significant R&D programs. In addition, we believe that in many cases the research they perform is theoretical in nature and may have little applicability to economic development goals. 25X1

Much of the research being carried out in the Third World is agriculture-related. A number of developing countries have at least one institution -- and some can count dozens -- working on improving and utilizing important local crops. Resources are often wasted by redundant research carried out in rival institutes, sometimes attached to the same government ministry. Nevertheless, significant agricultural R&D has been conducted in some of these facilities. For example, Malaysia has a solid group of institutes focusing on specific agrotechnologies including fisheries, palm oil, rubber, and forestry, and some Malaysian scientists are recognized as international experts in these fields. Nigeria appears to have an even more extensive group of agriculture-related R&D facilities, although we have little information on their activities. 25X1

Third World countries are engaged in research in a wide range of other fields, including:

- Earth sciences, remote sensing and meteorology.
- Oceanography and marine resources.
- Medicine, including disease control and eradication.
- Microelectronics.
- Nonconventional energy resource development.

Although many Third World R&D programs are just getting underway, we believe a number of LDCs have at least some potential for limited progress in these fields. Brazil's nonconventional energy research is currently recognized as world-class. Egyptian medical scientists have made important contributions to the study and control of bilharzia, a debilitating parasitic disease. Broad-ranging Indian medical research -- particularly in leprosy and tropical diseases -- is expected by experts in the field to yield promising results. Brazilian and Indian microelectronics research has proceeded slowly, and we believe significant technological advances are unlikely even over the medium term; other LDC efforts in this area, such as Malaysia's, are too new to assess at present. 25X1

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Because of data limitations, it is not possible to compile a comprehensive listing of all LDC research facilities doing significant R&D, or having the capability to do so in the near-term future. Nevertheless, a partial listing of centers of technical strength in the Third World highlights their diversity and future potential:

- The National Institute for Space Research (INPE) is **Brazil's** primary civilian space research organization. INPE scientists are designing four weather data collection and remote sensing satellites that are planned for launch by 1993. The institute is currently working on infrared lasers and detectors, and solar cells for applications in satellite control systems. INPE also undertakes basic space research and mathematical modelling for agricultural productivity forecasting.

- The International Rice Research Institute (IRRI) in the **Philippines** is the acknowledged world leader in developing high-yielding rice varieties that have driven the "green revolution" throughout Southeast Asia. Originally funded by the Ford and Rockefeller Foundations, IRRI now is staffed primarily by non-US personnel.

- The Research and Training Center for Vectors of Diseases at Ain Shams University in **Egypt** is probably the foremost regional center doing R&D on arthropod-borne diseases such as leishmaniasis. We believe this organization is capable of achieving significant research results.

- The Central Research Institute (CRI) in Kasauli, **India** is the country's most important researcher and producer of immunologicals such as diptheria, tetanus, typhoid, rabies, and cholera vaccines. CRI is the only producer of yellow fever vaccine in South Asia and is a training center for vaccine and sera production.

- The Rubber Research Institute of **Malaysia** (RRIM) has over 200 senior staff members engaged in R&D on nitrogen-fixing ground covers, propagation by budgrafting and tissue culture, and the processing of natural rubber and natural/synthetic blends. RRIM and its sister institute in London recently announced the development of epoxidized natural rubber -- a product that outperforms both natural and synthetic rubber -- which is expected to come onto the market later this year.

Important R&D facilities in other developing countries are currently in the planning or construction stages. For example, Indonesia's National Scientific and Technological Research Center (PUSPIPTEK)-- scheduled for completion in the 1990s -- will include energy and nuclear labs as well as another nine planned laboratories. 25X1

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Appendix E

COLLABORATIVE EFFORTS IN RESEARCH AND DEVELOPMENT: SELECTED EXAMPLES

- **EUREKA.** Initiated by President Mitterrand of France in 1985, Eureka is a West European-wide cooperative program targeting the development of advanced technologies with near-term commercial applications. The program is concentrating over half of its cooperative efforts on areas where Europe is relatively weak, especially electronics R&D. EUREKA participants hope to bring together the traditional research sector -- universities and research institutes -- and the private sector, in order to raise the productivity and international competitiveness of European industry. As of early this year, the program had enlisted 19 European governments as members and attracted the participation of several hundred European companies as well as a few US firms. A total of 109 projects, with a combined business/government budget of $4 billion over the next 4-5 years, are now included. Other areas of development under EUREKA sponsorship include factory automation and manufacturing, data processing, materials, and biotechnology. European Silicon Structures, one of EUREKA's key programs, aims to create a center for R&D and production excellence in application-specific integrated circuits. The consortium includes financial contributions from Olivetti, Philips, Saab, Telefonica, Bull, Brown-Boveri, Bosch, and British Aerospace, combined with technical know-how from the United States and skilled labor from France. [redacted] 25X1

- **MEGA Project.** A cooperative R&D project combining the resources of Siemens (West Germany) and Philips (Netherlands), the MEGA Project is intended to develop the next generations of 1 megabit and 4 megabit integrated circuits and, jointly with Thomson (France), the 64 megabit chip. The agreement was formed in 1984 and includes support from both the West German and Dutch governments, contributing $100 million and $67 million, respectively. It will be funded a total of $667 million over four years. In addition, the two principals will each spend $500 million on separate production facilities. The goal of the project is to recapture a large part of the European semiconductor market from US and Japanese suppliers. [redacted] 25X1 25X1

[redacted] the 64 megabit chip project is being proposed under the EUREKA program. The firms hope to supply the West European market with 1 megabit chips by 1988. [redacted] 25X1 25X1

- **Sensor Research.** Another collaborative basic research effort within Western Europe is a joint venture formed by Telefunken (West Germany), Mullard (UK), and SAT (France). [redacted] the joint venture is working on 25X1

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several sensor technologies for use in a wide range of conventional weapons. These technologies include new infra-red detectors, gallium aluminum arsenide substrates, and charge coupled devices. The joint venture probably grew out of a requirement to defray the expenses involved with extensive testing of alternative materials and manufacturing processes. [redacted] 25X1

● **Inter-Firm Cooperation in Japan.** Five Japanese firms are funding university research on a new microprocessor standard known as TRON (The Real-time Operating-system Nucleus), with a group at Tokyo University currently receiving about $75 million per year. The five firms and others -- including NTT, according to the project leader -- are conducting parallel internal development efforts. [redacted] 25X6 [redacted] 25X6 In October 1986, Fujitsu and Hitachi agreed to develop jointly a family of products, including state-of-the-art 32-bit microprocessor units (MPUs), based on TRON. Toshiba, a member of the TRON council with excellent manufacturing capability but little success in MPUs, has also sought US designs. In December 1986, Toshiba agreed with Motorola to set up a 50/50 joint venture in Japan to provide Motorola-designed MPUs to Toshiba, and memories requiring Toshiba's manufacturing know-how to Motorola. [redacted] 25X1

Thirteen Japanese firms are cooperating with MITI laboratories in SOR-Tech, developing equipment for using X-rays to manufacture chips. With 70 percent of its 15 billion yen capital to be provided by Tokyo over ten years, SOR-Tech is focusing on producing small, superconducting synchrotron orbital radiation sources of X-rays. Some researchers believe that such equipment will be necessary for making the high-density semiconductors of the 1990s. [redacted] 25X1

● **"Human Frontiers."** After months of consultations, Tokyo appears to be ready to launch an international cooperative research program tentatively named the "Human Frontiers Science Program." [redacted] 25X1 Prime Minister Nakasone will propose a one-year international feasibility study at the June 1987 economic summit. MITI hopes that this study will yield, in time for the 1988 Ottawa summit, a concrete proposal of an international basic research program aimed at global problems such as tropical diseases and pollution. [redacted] 25X1

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Appendix F

COLLABORATIVE EFFORTS IN PRODUCTION: SELECTED EXAMPLES

• **Airbus.** Airbus Industrie, a four-nation commercial aircraft consortium led by France, is a leading example of successful collaboration in key technology areas among the major West European countries. From a fledgling operation with a limited product line in the early 1970s, Airbus has matured into a potent competitive force challenging the leading US aerospace firms with a family of advanced aircraft designs. The technological and marketing success of Airbus Industrie's product line is attributable to Western Europe's capability to draw from significant centers of excellence among individual members of the consortium. Several companies in the major participating countries -- France, West Germany, and the United Kingdom -- have expertise in airframe and avionics technologies which were demonstrated in previous military and commercial programs, including the Concorde. France's Aerospatiale, in addition to its overall capabilities, was able to bring to bear its extensive experience in aircraft assembly. Thomson-CSF provides an expanding range of advanced electronics and avionics capabilities for new Airbus designs. Messerschmitt-Bolkow-Blohm (MBB) of West Germany provides modern and highly efficient production facilities for the manufacture of major airframe components. In addition, some West German electronics firms have provided advances in equipment found in the cockpit of the new Airbus A320 design, as well as experience in composite materials. The British, drawing on the research of British Aerospace, have become specialists in designing and building the wings for Airbus aircraft, while UK electronics firms including Lucas and Plessey have provided modern operational controls such as flight management systems. [redacted] 25X1

• **West European Military Aircraft.** At present, West European firms are at least roughly equivalent to their US counterparts in most of the 12 critical advanced military aircraft technologies we have identified. European aerospace firms have achieved this level of technical excellence by conducting applied research independently. Some firms like Thomson-CSF (France), which draw upon a large product base, invest up to $1 billion annually on broad-based research. In advanced aerodynamic technologies, European firms typically team with their respective government aerospace laboratories, such as France's ONERA. [redacted] 25X1

Eurofighter, the consortium formed in 1986 to design and build the European Fighter Aircraft of the 1990s, has the technological capability to build an aircraft superior to the US F-15 of F-16. Eurofighter includes firms in the United Kingdom (British Aerospace, GEC, Ferranti, Rolls-Royce); West Germany (MBB, AEG-Telefunken); Italy (Aeritalia, FIAR); and Spain (CASA, Sener). [redacted] 25X1

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• **Foreign Defense Industries.** Outside of NATO, there are a number of collaborative production arrangements that facilitate the development and flow of defense technologies among developed and developing countries. For conventional weapons -- especially main battle tanks -- Israel is looked upon as a rich resource for applied technology expertise, particularly by the United States and West Germany. Israel currently supplies West Germany with kinetic energy ammunition for the 120mm tank cannon. At the same time West Germany is providing some technical assistance to Rafael, Israel's tank producer, for its development of the 120mm smooth-bore cannon for the Merkava tank. In the past, MBB (West Germany) has collaborated with Israel on the development of reactive armor. 25X1

• **Brazilian-Italian Fighter Aircraft.** The AMX subsonic, multirole fighter was developed jointly by the Italian firms Aeritalia (fuselage center section, radome, fin, and control surfaces) and Aermacchi (forward fuselage, avionics integration, canopy, and tail cone) and the Brazilian firm EMBRAER (wings, intakes, pylons, and fuel tanks). The division of funding was roughly 70 percent Italian and 30 percent Brazilian. The AMX incorporates relatively unsophisticated technologies -- a conventional aluminum airframe and a basic avionics suite with a limited-capability radar. The British firms Rolls-Royce and GEC Avionics provided some of the AMX's most advanced systems, including the turbofan engine and flight control computers. The AMX program will provide critical design, integration, and manufacturing experience to Brazil's young aircraft industry. The Brazilian air force is scheduled to buy 79 of the 266 AMXs to be produced. The AMX is currently in flight testing and is expected to enter service in 1988. 25X1

• **Armored Vehicle Technologies.** Several Third World firms have demonstrated armored vehicle systems integration capabilities. Although they often do not possess the necessary technology or industrial base to design and produce all of the required subsystems, they have demonstrated the ability to purchase proven subsystems from the United States and Western Europe and effectively integrate them. 25X1

An example of Third World integration capabilities is ENGESA, a Brazilian arms producer that produced at least two prototypes of a main battle tank, the Osorio, by acquiring subsystems from West European firms regarded as leaders in their respective fields. European suppliers have included GIAT and SFIM (France), Vickers and Marconi (UK), and Philips (Netherlands). The Osorio is scheduled to participate in a main battle tank competition with Saudi Arabia later this year. It will be the first Third World-produced main battle tank to participate in a competition of this magnitude. 25X1

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Similarly, Hyundai is producing the South Korean K-1 main battle tank by assembling components from the United States, West Germany, and other countries. The US-supplied fire control system is one of the most advanced systems available. The South Koreans, we believe, are currently attempting to Europeanize the tank to circumvent US restrictions which would limit the export of the K-1. Among the West European firms that may become alternatives to current US suppliers of components for the K-1 are the British firms Vickers, Pilkington P.E., and Marconi; Diehl, Zeiss, and Krupp of West Germany; and GIAT of France. 25X1

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