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The European Science Notes Information Bulletin (ESNIB) 91-06 is a compilation of reports on recent developments in European science of specific interest to the U.S. research and development community, and is issued in support of the mission of the Office of Naval Research European Office (ONR Europe). Issue Number 91-06 in addition to European area news, notes, and abstracts, contains reports in the fields of Computer Science, Materials, and Oceanography. The value of the ESNIB to Americans is to call attention to current activity in European science and technology and to identify the institutions and people responsible for these efforts. The ESNIB authors are primarily ONR Europe staff members; other reports are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the U.S. Army Research, Development and Standardization Group. Scientists from the U.S. who are traveling in Europe may also be invited to submit reports.

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COMPUTER SCIENCE

MATERIALS

OCEANOGRAPHY

NEWS, NOTES, AND ABSTRACTS

NATIONAL SCIENCE FOUNDATION CONTRIBUTIONS

COMPUTER SCIENCE

Computer-Aided Design and Manufacturing at the University of Leeds

by C. Chryssostomidis, Professor of Naval Architecture, Director of Sea Grant College Program, Massachusetts Institute of Technology, Cambridge, Massachusetts

Introduction

During this visit, I focused primarily on issues of computational geometry and manufacturing process simulation. My host at the University of Leeds was Professor Alan de Pennington of the Department of Mechanical Engineering. Professor de Pennington is a widely known leader in the computer-aided design/computer-aided manufacture (CAD/CAM) disciplines and heads a large group of researchers. For about 2 years, Professor de Pennington was Program Director of the Computer-Integrated Engineering Division at the National Science Foundation, Washington, D.C. The general objectives of his team at the University of Leeds are the integration of design, manufacture, and life-cycle support of engineering products. To achieve this objective, his team has concentrated on:

- Building and experimenting with a product description system
- Automating the machining manufacturing processes
- Developing their own database schemas and communications capabilities; i.e. sharing data
- Developing application programming interfaces giving access to this shared data; i.e. sharing software
- Developing appropriate common user interfaces
- Developing an interworking capability with existing CAD/CAM systems.

Examples of this work in novel product description systems are two recent Ph.D. dissertations from this group by Dr. Anthony Saia (June 1989) and Dr. David R. Dunnington (September 1989), and several related articles and reports. Both dissertations address aspects of the problem of integration of sculptured or free-form surfaces in a Constructive Solid Geometry (CSG) scheme for describing complex objects. Towards this objective, the team has developed a novel approach called the Inner Set Outer Set (ISOS) method. This method allows introduction of recursive subdivision techniques commonly associated with surface modeling methods into a solid modeling framework. This is an important development because it allows extension of CSG systems describing mechanical objects bounded by classical algebraic surfaces to include parts bounded by sculptured surfaces. The methods they developed using recursive subdivision have been applied to a very rich class of sculptured surfaces representable in terms of B-splines. Consequently, most of the various surfaces and objects used in mechanical design and fabrication can be now represented in a common framework. This framework enhances our ability to automate and streamline the design and analysis process.

To cover the entire spectrum of surfaces encountered in ship design and fabrication, methods need to be developed to allow us to handle more general surfaces such as offsets of rational B-splines, generalized cylinders (or sweeps), medial surfaces, and surfaces arising from the solution of partial differential equations. Robust boundary evaluation for objects bounded by such surfaces is still a major outstanding intellectual problem that needs to be studied.

Automated Finite Element Processing

Under the direction of Professor de Pennington, Dr. M.S. Bloor, Dr. D.C. Barton and Mr. N.K. Shaw, this is an important new research area for the CAD community with substantial intellectual content. The goal is to establish a generic capability for preprocessing geometric models for analysis. This would increase the efficiency of the analysis cycle, which is hampered now because human intervention is necessary. Several scientists are pursuing the medial axis and other related transforms as a way to abstract geometric models for automated idealization and discretization (e.g., Professor Christoph Hoffmann, Purdue University,

Lafayette, Indiana; Professor Nicholas Patrikalakis, MIT; Dr. Cecil Armstrong, Queen's University, Northern Ireland; and Professor Michael Brady, Oxford University). The team at Leeds has identified and started work in several important problems needed towards the achievement of their goals:

- Remove superfluous detail of geometric models unimportant in analysis, symmetry recognition, reduction of problem dimensionality
- Construct appropriate abstractions useful in analysis
- Design data structures appropriate for load and constraint specification for analysis.

Parallel Algorithms and Architectures for Display of Solid Objects

Under the direction of Professor de Pennington and Professor P.M. Dew, Computer Studies Department, the emphasis is on developing a powerful imaging facility for rapid visualization of geometric models of a product during design. Their work exploits recent advances in parallel computer architectures brought about by the advent of Very Large Scale Integrated (VLSI) circuitry. A range of parallel algorithms and architectures are being studied with the objective of reducing the rendering time for complex solid objects to allow interactive design in realistic time scales. This is part of a longer term goal to design a computational geometry engine that can provide the geometric information required by advanced information support systems (ISS). Because of time limitations, I did not see the current developments in this area.

Automation of Inspection

Supervised by Professor de Pennington and Dr. N.P. Juster, the objective of this report is to expand the range of capabilities of solid modeling systems to manufacturing and inspection by providing an appropriate mathematical formalism for dimensions and tolerances. The underlying theory in this area is based on interrogation of distance functions on point sets. Software, based on this formalism, is being developed that will automatically analyze the data obtained from a coordinate measuring machine. This would lead to a quick evaluation of a manufactured object from the point of view of dimensional accuracy and would be particularly important in objects with very high accuracy requirements. Because of its importance and wide application, several scientists are studying the inspection problem (i.e., Professor Aristides Requicha, University of Southern California; Professor Andre Clement, University of Paris; Professor Nicholas Patrikalakis, MIT; and Professor Leonidas Bardis, National Technical University of Athens).

Information Support Systems for Design and Manufacture

This project is supervised by Dr. M.S. Bloor, Professor de Pennington, Dr. Juster, Dr. Saia, and Mr. Shaw. Beyond purely geometric data, designing, manufacturing, and maintaining a product requires the representation of additional information. Developing such an ISS to assist robotic assembly, tool selection, process planning, NC programming, and verification and inspection is the focus of the team's activities. The principal intellectual challenge is to develop standards to represent all aspects of designing and manufacturing mechanical objects. The team is a leader in this area in the U.K.

The following typical references describe much of Professor de Pennington's team in the CAD/CAM areas.

Dunnington, D.R. 1989. A recursive subdivision strategy for solid modeling with sculptured surfaces. Ph.D. diss. University of Leeds.

Saia, A. 1989. A study of the integration of B-spline bounded primitives in constructive solid geometry, Ph.D diss. University of Leeds.

Beacon, G.R. et al. 1989. Boundary evaluating using inner and outer sets: the ISOS method. *IEEE Computer Graphics and Applications* 9.

Davy, J.R. Davy et al. Towards a software architecture for solid modelling systems on processor networks. In *Proceedings of the IIth Technical Meeting, Occam User Group*, September 1989.

D.R. Dunnington, A. Saia, A. de Pennington, and G.L. Smith. 1989. *Constructive solid geometry with sculptured primitives using inner and outer sets, Theory and practice of geometric modelling*. Berlin. Springer Verlag.

A. Saia, M.S. Bloor, and A. de Pennington. September 1987. *Sculptured solids in a CSG based geometric modelling system. The mathematics of surfaces*. Vol. II, IMA Conference Series. Oxford, Oxford University Press.

A. Saia, S.E. Howe, M.S. Bloor, and A. de Pennington. September 1989. *Sculptured solid shapes using inner and outer bounded models. The mathematics of surfaces*. Vol. III, IMA Conference Series. Oxford, Oxford University Press.

T. David, P.H. Gaskell, A. Saia. 1989. *Integrating sculptured surface design with the panel method for flow visualization. The mathematics of surfaces*. Edited by D.C. Handscomb. Vol. III, IMA Conference Series, Oxford, Oxford University Press.

Dunnington, D.R. et al. 1989. Boolean operations on sculptured primitives using ISOS techniques. In *Procceedings of International Conference on Theory and Practice of Geometric Modelling*. Tubingen.

Geometric Modeling of Complex Sculptured Surfaces

I also visited Dr. Malcolm I.G. Bloor and Dr. Michael J. Wilson in the Department of Applied Mathematics who are also working in the CAD area. Both Bloor and Wilson have been focusing on geometric modeling of complex sculptured surfaces using partial differential equation (PDE) methods.

Their initial work focused on the solution of the blending or filleting problems between two or more general surfaces. The basic idea is to regard the unknown

surface as the solution of an elliptic or biharmonic partial differential equation in the parameters, u, v, of the surface. The solution of these PDEs, subject to certain boundary conditions prescribing the position and partial derivatives of the surface, is computed using analytic or numerical techniques. The free parameters of the problem include the coefficients of the partial differential equations and the form and particular values of the boundary conditions. Bloor and Wilson have shown that these parameters provide enough flexibility to define complex sculptured blending surfaces. A significant advantage of these methods is that they allow the generation of multi-sided blending surface patches without a specialized methodology as with earlier methods. Since the shape of the blend depends on just a few parameters, it becomes feasible to invoke optimization procedures to achieve a certain objective by allowing variation of these free parameters. More recently, Bloor and Wilson have suggested and begun exploring application of their methodology in design of functional sculptured or free-form surfaces such as ship hulls and propellers. This study will investigate the extent to which physical considerations can be integrated with the PDE method to produce objects whose geometrical properties are adapted to their functionality in appropriate ways. Joint research between Professor Horst Nowacki, Technical University of Berlin, Federal Republic of Germany, and Dr. Bloor's group is currently underway. The study focuses on incorporating hydrodynamic functional considerations (such as those encountered in ship hull and marine propeller design) in geometric modeling of sculptured surfaces via the PDE method.

Additional applications of the method currently under study include an extension from surfaces to solids to allow appropriate parametrization of volumes for discretization and finite element analysis. Such solid meshing is essential, for example, in simulating manufacturing processes; e.g., casting and molding.

To allow integration of their methods with other CAD system formulations, Bloor and Wilson have also investigated the approximation of surfaces arising from the solution of PDEs using B-spline bases with collocation and finite element solution techniques. Such approximation in terms of B-splines also provide the necessary handles to fine-tune the design shape using the local control properties of the B-spline basis.

Professors Dimitri Terzopoulos, University of Toronto, (formerly at Schlumberger and MIT) and David Gossard, MIT, are both studying generation of surfaces by solution of partial differential equations. Terzopoulos is studying in the context of computer vision and animation, and Gossard is studying in the context of preliminary design of complex mechanical systems.

The following typical references describe much of the work on the PDE method:

Bloor, M.I.G. and M.J. Wilson. 1989. Generating blend surfaces using partial differential equations, *CAD 21*, No. 3: 165-171.

Bloor, M.I.G. and M.J. Wilson. 1989. *Generating N-sided patches with partial differential equations*. Edited by R.A. Earnshaw & B. Wyvill B. *New advances in computer graphics*, Springer-Verlag, Berlin, 129-145.

Bloor, M.I.G. and M.J. Wilson. May 1990. Using partial differential equations to generate free-form surfaces, *CAD 22*, No. 4: 202-212.

Bloor, M.I.G. and M.J. Wilson. July/August 1990. Representing PDE surfaces in terms of B-splines. *CAD 22*, No. 6: 324-331.

Lowe, T. et al. October 1990. Functionality in blend design, *CAD 22*.

Bloor, M.I.G. and M.J. Wilson. 1990. Generating free-form surfaces using partial differential equations, in curve and surface modelling. *SIAM Frontiers in Applied Mathematics*.

Bloor, M.I.G. and M.J. Wilson. 1990. Geometric design of hull forms using partial differential equations. *International Symposium MARIN Wageningen CFD and CAD in Ship Design*.

Lowe, T.W. et al. 1990. Functionality in surface design. In *Proceedings of the 16th ASME design and automation conference, held in Chicago*. New York.

Computer-Aided Design and Manufacturing in Greece

by C. Chryssostomidis

Introduction

While in Greece, I visited Professor Vassilios Papazoglou, Director of the Shipbuilding Technology Laboratory, and Professor Leonidas Bardis, of the Department of Naval Architecture and Marine Engineering of the National Technical University of Athens (NTUA). Both are well known internationally for their work in computer-aided design and fabrication of ship structures. They have established effective research cooperation with other universities, research institutions, and industry in Greece, as well as other European Community (EC) countries and the U.S.

Shipbuilding Technology Laboratory

Professor Papazoglou and his students have been focusing their activities in three major areas:

1. Welding fabrication
2. Composite materials
3. Ocean engineering problems.

Their work includes theoretical, numerical, and experimental studies. Typical examples include the papers identified in the list of references below. This laboratory has modern facilities, instrumentation, and welding machines able to simulate most welding processes commonly encountered in shipbuilding.

In the welding fabrication area, Professor Papazoglou and his students have focused on

- Prediction of distortion of simple welded structures (as T-beams and panels)
- Real-time distortion control of welded structures for flexible automated welding systems
- Knowledge-based welding design systems for nonconventional materials
- Expert systems for laser surface treatments of light alloys.

His work is funded by the General Secretariat for Research and Technology in Greece, the EC, and industry.

Because of my interest in welding fabrication as applied in shipbuilding, my visit focused in particular on the issues of welding distortion and its control. Welding distortion is undoubtedly one of the most troublesome problems facing shipbuilding and, more generally, the metal construction industries. Distortion has severe impact on cost and productivity of ship structures. The approach that Professor Papazoglou is following is based on appropriate adjustment of critical welding parameters being sensed in real time. These parameters include, for example, the temperature distribution and transient metal movements. Following sensing of major welding parameters, algorithms are being developed for efficient real-time evaluation of the magnitude and character of distortion. Artificial intelligence techniques are then being applied for the development of real-time control methods capitalizing on actual measurements, semianalytic/numerical models, previous experimental studies, and the experience of welding engineers. Tables 1 and 2 list researchers involved in the welding distortion and control problem and weld defect assessment methods, respectively.

Table 1. Welding Distortion and Control Researchers

- Professors Stuart Brown, Thomas Eagar, David Hardt, and Koichi Masubuchi - MIT
- Dr. Amiram Moshaiov - Tel-Aviv University, Israel
- Dr. C.F.G. Baxter - British Maritime Technology Laboratories, Bedford, U.K.
- Dr. H.B. Smartt - Idaho National Engineering Laboratory.

Table 2. Weld Defect Assessment Method Researchers

- Dr. John Agapakis - Automatix, Bedford, Massachusetts
- Dr. L. Dorn and Dr. S. Majumder - Technical University of Berlin, Federal Republic of Germany (FRG).

In the composite materials area, Professor Papazoglou's laboratory has focused on static and dynamic buckling problems of composite laminated plates under various in-plane loads and on structural reliability analyses of composite laminated structures. The EC funds this work. The principal aim of these projects is the development of rational criteria and data for designing structures made from composite materials taking into account the various failure modes of the structures. The principal contributions that have already resulted from these projects include:

- Design curves for static bucking of composite laminated plates for all possible combinations of in-plane loads with and without shear effects
- Study of all possible modes of dynamic buckling of symmetric and unsymmetrical laminates.

The field of composites is a very active area of research (see Table 3).

Table 3. Composites Researchers

- Professors J. Reddy and L. Librescu - Virginia Polytechnical Institute, Blacksburg
- Professors P. Lagace and T. Gutowski - MIT
- Professor G. Simitses - Cincinnati University
- Professor C. Bert - University of Oklahoma, Norman
- Professor V. Birman - University of New Orleans
- Dr. A.H. Noor - NASA Langley Center, Virginia
- Dr. C. Smith - the Admiralty Establishment in the U.K.
- Professor I. Elishahoff - Technion Israeli University, Haifa Israel.

In ocean engineering, Professor Papazoglou's laboratory focuses on the design of mooring systems for deep sea applications and on innovative open-sea fish farming systems. EC and industry fund this work. In mooring systems, Professor Papazoglou is collaborating with Professor Spyros Mavrakos, NTUA, and Professor Michael Triantafyllou, MIT. Their objective is to reduce dynamic tension through optimization of the number, size, and location of submerged buoys attached to the mooring lines. Their approach includes theoretical, numerical, and experimental studies.

The following articles and reports describe some of the work by Professor Papazoglou's research team within the last few years.

Papazoglou, V.J. Welding as part of a CAD/CAM system. *Proceedings ESPRIT CIM-Europe Workshop on Automation and Robotics in Manufacturing and CIM in Shipbuilding and Allied Industries* June 1987. Bilbao, Spain.

Papazoglou, V.J., and J.M. Kalogerakis. Solving welding distortion in flexible automated welding systems-a strategy for implementation. *Proceeding, 5th IMAEM International Congress on Marine Technology*. May 1990. Athens, Greece.

Papazoglou, V.J., and I. Papaioannou. 1989. Development of fast methods for computation of deformation of welded structures with the use of computers. *Report No. STL 009-I-89*. National Technical University of Athens, Department of Naval Architecture and Marine Engineering, Naval Technology Laboratory.

Papazoglou, V.J., and N. Tsuvalis. 1987. Towards computer-aided design of FRP hulls. *Proceedings, IVth IMAEM Conference. Varna, Bulgaria. Vol. 2:45.1-45.7.*

Tsuvalis, N., and V.J. Papazoglou. Theories for bending and static buckling of laminated anisotropic rectangular plates, a survey. *Proceedings, Composites 88 International Symposium.* August 1987. Patras, Greece.

Papazoglou, V.J., and N.G. Tsuvalis. 1991. Mechanical behavior of biomodulus laminated plates. *Composite Structures.* Vol. 17, No. 1:1-22.

Papazoglou, V.J., J.V. Sanoudos, and N.G. Tsuvalis. Methodologies for the structural analysis and design of F.R.P. hulls. *Proceedings, 5th AMAEM International Congress on Marine Technology.* May 1990. Athens, Greece.

Tsuvalis, N.G., and V.J. Papazoglou. Bending of bimodulus specially orthotropic laminated plates. *Proceedings, COMP '90 Symposium.* Patras, Greece. August 1990.

Papazoglou, V.J., and J.V. Sanoudos. Introducing structural reliability concepts into laminate analysis. *Proceedings, COMP '90 Symposium.* Patras, Greece. August 1990.

Papazoglou, V.J., N.G. Tsuvalis, and G.D. Kyriakopoulos. Buckling of unsymmetric laminates under linearly varying biaxial, in-plane loads, combined with shear. *Composite Structures.* (submitted for publication).

Sanoudos, J.V., and V.J. Papazoglou. Reliability analysis of composite laminated structures:a systems' approach. *Structural Safety.* (submitted for publication).

Mavrakos, S., V.J. Papazoglou, and M. Triantafyllou. An investigation into the feasibility of deep water anchoring Systems. *Proceedings OMAE 89 Europe Conference.* March 1989. The Hague, the Netherlands.

Mavrakos, S., L. Neos, V.J. Papazoglou, and M. Triantafyllou. Systematic evaluation of the effect of submerged buoys size and location on deep water mooring dynamics. *Proceedings, PRADS 89 Symposium.* October 1989. Varna, Bulgaria.

Papazoglou, V.J., S. Mavrakos, and M. Triantafyllou. 1990. nonlinear cable response and model testing in water. *Journal of Sound and Vibration.* Vol. 140, No. 1.

Papazoglou, V.J., S.A. Mavrakos, M.S. Triantafyllou, and P. Brando. A scaling procedure for mooring experiments. *Proceedings, EUROMS '90 Symposium.* August 1990. Trondheim, Norway.

Gounaris, G., and V.J. Papazoglou. Three-dimensional effects on the natural vibrations of uniform timoshenko and ship-like beams in fluid. *International Shipbuilding Progress.* (submitted for publication).

Mavrakos, S.A., V.J. Papazoglou, M.S. Triantafyllou, and P. Brando. Experimental and numerical study of the effect of buoys on deep water mooring dynamics. *Proceeding of the 1st International Offshore and Polar Engineering Conference.* August 1991. Edinburgh, U.K.

Papazoglou, V.J., G.M. Katsaounis, and J.D. Papaioannou. Elastic static analysis of chain links in tension and bending. *Proceedings of the 1st International Offshore and Polar Engineering Conference.* August 1991. Edinburgh, U.K.

National Technical University of Athens, Department of Naval Architecture and Marine Engineering

Professor Leonidas Bardis focuses his research in computer-aided design with emphasis in knowledge-based systems for ship operations and in computational geometry for nonlinear surfaces.

Professor Bardis' work in knowledge-based systems centers on an EC-funded project conducted jointly with universities, research institutions, and industry from Denmark, FRG, U.K., Portugal, and Greece. The overall objective is to develop an integrated shipboard-installed, knowledge-based system for ship operations supporting communication and cooperation of several subsystems, each dealing with a specific task. The emphasis in Professor Bardis' work is on developing an expert loading system and an expert voyage pilot.

The loading system is oriented to chemical product tankers and combines algorithms performing all necessary tasks of an ordinary loadmaster with high-level reasoning. This is focused on producing a near optimal loading plan while satisfying strength, stability, and cargo handling constraints. The encoding of the domain knowledge necessary is the subject of joint work with the Institute of Informatics and Telecommunications of the National Research Center "Democritos," in Greece.

The expert voyage pilot system is an advanced ship routing system based on detailed knowledge of the propulsive and seakeeping performance of the ship. The approach followed is based on the definition of "forbidden" regions. This is based on the actual weather, seakeeping, and propulsion characteristics of the ship. Detailed knowledge of ship performance further allows accurate computation of fuel consumption and arrival times. An instrumentation system integrated with on-board digital computation and an appropriate graphics interface is being designed to support this task.

In computational geometry, Professor Bardis and his students have focused on problems of ship hull surface definition and fairing, automatic mesh generation for hydrodynamics, development of topological models for the internal subdivision of ships, and their interrogation to support automated design and analysis. Professor Bardis has also carried out extensive joint research with Professor Nicholas Patrikalakis of MIT on several related problems. These include high-accuracy approximation of B-spline surfaces, offsets, blending and generalized cylinder surfaces, localization of parametric surfaces and interrogation and ray tracing of offset surfaces, and the development of generalized boundary representations for ship design, analysis, and manufacture.

The U.S. Navy has provided support for the above joint research activities with MIT via Naval Sea Systems Command. The fundamental work necessary in pursuing these projects was made possible by grants from the Office of Naval Research, the National Science Foundation, and the Sea Grant College Program of the Department of Commerce. Table 4 lists researchers who are conducting work on the problem of ship hull surface definition and fairing.

Table 4. Researchers on Ship Hull Surface Definition and Fairing

- Professor Horst Nowacki - Technical University of Berlin, FRG
- Dr. Malcolm Bloor - University of Leeds, U.K.
- Dr. Nickolas Sapidis - General Motors
- Professor Helmut Pottmann - Purdue University

The following articles and reports describe some of Professor Bardis' research:

Bardis, L., T.A. Loukakis, and G.A. Vouros. An expert loading system for chemical and product carriers. *Proceedings of the STAB '90 Conference.* September 1990. Naples, Italy.

Loukakis, T.A., L. Bardis, and G. Gelegenis. The design of an expert voyage pilot. *Proceedings of the IMAEM '90 Conference.* May 1990. Piraeus, Greece.

Bardis, L., and M. Vafiadou. 1991. Ship hull geometry representation using B-spline surface patches. *Computer-Aided Design.* Submitted.

Bardis, L., R. Jinkerson, and N.M. Patrikalakis. 1991. Localization for automated inspection of curved surfaces. *International Journal of Offshore and Polar Engineering.* Golden, Colorado:ISOPE. Vol. 1, No. 3:228-231.

Patrikalakis, N.M., and L. Bardis. 1990. Localization of rational B-spline surfaces. *Engineering with Computers.* Vol. 6, No 4:223-235.

Patrikalakis, N.M., L. Bardis, and G.A. Kriezis. 1990. Approximation of B-spline geometries with lower degree representation. *Journal of Offshore Mechanics and Arctic Engineering.* ASME Trans. Vol. 112, No. 3:192-198.

Bardis, L., and N.M. Patrikalakis. 1989. Approximate conversion of rational B-spline patches. *Computer-Aided Geometric Design.* Vol. 6, No. 3:189-204.

Vafiadou, M.E., and N.M. Patrikalakis. 1991. Interrogation of Offsets of Polynomial Surface Patches. *Eurographics '91, European Computer Graphics Conference and Exhibition, Vienna, Austria, September 1991.* Post, F.H. and W. Barth, editors. Amsterdam: Elsevier, pp. 247-259 and 538.

Bardis, L., and N.M. Patrikalakis. Blending rational B-spline surfaces. *Eurographics '89, European Computer Graphics Conference and Exhibition, Hamburg, FRG, September 1989.* Amsterdam: North-Holland.

Patrikalakis, N.M., and L. Bardis. September 1990. Revised July 1991 Feature extraction from B-spline marine propeller representations. *Cambridge, Massachusetts, MIT Ocean Engineering Design Laboratory Memorandum 90-12.*

I also visited Professor Theodore Loukakis, Director of the Naval Architecture Laboratory, internationally known naval architect and scholar, and former colleague at MIT. Professor Loukakis' activities are primarily in the area of theoretical, applied, and experimental hydrodynamics for ship design, therefore, are beyond the scope of this report. The laboratory that Professor Loukakis directs has excellent experimental facilities including a major modern towing tank, wind tunnels, and other experimental fluid mechanics testing capabilities.

Computer-Aided Design and Graphics in the Federal Republic of Germany

by C. Chryssostomidis

Introduction

These visits focused primarily on issues of computational geometry and computer graphics to support the design, analysis, and manufacture of large and complex systems primarily encountered in shipbuilding. During my stay in the Federal Republic of Germany (FRG), I visited the Technical Universities of Berlin and Darmstadt and the University of Hamburg.

Technical University of Berlin

Professor Horst Nowacki, Institute of Ship and Ocean Technology, was my host. Professor Nowacki is an internationally known scholar in computer-aided design (CAD). The overall objective of Professor Nowacki's laboratory is the integration of design, analysis, and fabrication of complex ocean platforms. To achieve this very general objective, his research team has concentrated on:

- Developing computer-aided ship design methods and tools
- Developing the methods for the programming of robots applied in shipbuilding
- Geometric modeling of sculptured surfaces
- Developing a generic visualization system for design, analysis, and scientific data interpretation
- Developing systems for electronic communication of computer models of complex objects within modern information networks
- Conceptualizing and developing neutral product definition databases for large multifunctional systems such as ship structures
- Developing CAD and analysis tools for specialized ocean vehicles.

Because of my interest in computational geometry, my visit focused on Professor Nowacki's research in geometric modeling of sculptured surfaces. Typical examples from Professor Nowacki's laboratory work include the papers identified in the list of references below.

The creation of mathematical curves and surfaces for the representation of objects with sculptured external geometry is formulated as an optimization problem with design-driven constraints. The overall objective of such formulations is to development fair shapes with superior aesthetic and functional characteristics that meet certain engineering design conditions. Fairness is defined indirectly in terms of optimizing an objective function. The properties of various objective functions have been studied. By analogy to structural mechanics, objective functions modeling certain physical quantities, such as bending energy and shear, have been investigated.

To achieve shape with appropriate functional characteristics, various engineering constraints must be imposed in the optimization process. Several such applicable constraints have been studied; e.g., ship design process. They include interpolation or nearness constraints of curves or surfaces to lower-dimension data, boundary conditions, and integral and form parameter constraints of various types, including equality and inequality constraints.

More recently, Professor Nowacki's group has started a collaboration program with Dr. Malcolm Bloor, University of Leeds, U.K., who is conducting research on the generation of surfaces as solutions to partial differential equations. The development of such surfaces obeying certain fairness criteria and subject to engineering constraints is an interesting topic of current research within the two groups. The problem of shape creation in the computer obeying certain fairness criteria and various constraints is also being studied by Professor Gerald Farin (Arizona State University), Dr. Nickolas Sapidis (University of Rochester), Professor Josef Hoschek, (Technical University of Darmstadt), and Dr. Helmut Pottmann, (Technical University of Vienna and, recently, Purdue University).

The following articles and reports describe some of the work by Professor Nowacki's research team within the last few years.

Kaklis, P.D. 1990. The curve-mesh concept in reconstructing smooth surfaces from noisy data. In *Proceedings of the 16th ASME design automation conference, held in Chicago, Illinois*, September 1990, edited by B. Ravani, Vol. 1., 51-58. NY:ASME.

Kaklis, P.D. and H. Nowacki. 1990. Experiences in curve and surface fairing. In *Proceedings of the symposium on computer geometrie, held in Technische Universitaet Dresden, Sektion Mathematik, Gaussig, Dresden, FRG, April 1990.*

Nowacki, H. 1990. *Mathematische Verfahren zum Glaetten von Kurven and Flaechen. Geometrische Verfahren der Graphischen Datenverarbeitung.* Edited by J. L. Encarnacao, J. Hoschek, and J. Rix. Berlin, Springer Verlag.

Weber, J. 1989. Constructing a boolean-sum curvature-continuous surface in dvanced geometric modelling for engineering applications. In *Proceedings of the International GI-IFIP Symposium 89, F.-L. Krause, H. Jansen, eds., held in Berlin, FRG November 1989.*

Nowacki, H., D. Liu, and X. Lue. 1989. *Mesh fairing GCI surface generation method, theory and practice of geometric modelling.* Edited by W. Strasser and H.P. Seidel. Berlin, Springer Verlag.

Standerski, N. 1989. *The generation of ship hulls with given design parameters using tensor product surfaces, theory, and practice of geometric modelling.* Edited by W. Strasser and H.P. Seidel. Berlin, Springer Verlag.

Nowacki, H. Klement, K. 1988. *Exchange of model presentation information between CAD systems. Computers and graphics.* Vol. 2, No. 2. Oxford, Pergamon Press.

Nowacki, H. 1988. *System-Architekturen und Schnittstellen fuer den schiffstechnischen Konstruktionsprozess. Jahrbuch der Schiffbautechnischen Gesellschaft*, Vol. 82. Hamburg, FRG.

Meier, H. and H. Nowacki. 1987. Interpolating curves with gradual changes in curvature. *Computer Aided Geometric Design*, 4:297-305.

Dannenberg, L. and H. Nowacki. 1985. Approximate conversion of surface representation with polynomial bases. *Computer-Aided Geometric Design*, Vol. 2:123-131.

University of Hamburg

My host in the University of Hamburg was Dr. Werner Hansmann of the Department of Informatics. Dr. Hansmann is well known for his research in the geometric modeling area. He is particularly known for his research work in blending surface generation. The blending surface creation problem is important in the complete specification of solid models of complex objects in the computer. To my knowledge, Dr. Hansmann was the first to provide a satisfactory solution for the representation of curvature continuous sculptured blending surfaces. He wrote a doctoral thesis on his findings (published in 1985). More recently, Dr. Hansmann has been involved in scientific and engineering visualization problems. In particular, he has started exploring ray-tracing algorithms on transputer architectures.

The blending surface generation problem has also been studied by Professor Christoph Hoffmann (Purdue University), Dr. Jaroslaw Rossignac (IBM), Professor Joseph Pegna (RPI), Dr. Franz-Erich Wolter (MIT), Professor Joseph Hoschek and Dr. Erich Hartmann (the Technical University of Darmstadt).

I present here some typical references from Dr. Hansmann's work in blending surface representations.

Hansmann, W. 1990. Knickfreie verbindung awischen freiformfLaechen und/oder algebraischen flaechen, Schriftenreihe des WBZ. Dresden, FRG: Technische Universitaet Dresden.

Hansmann, W. 1987. Interactive design and geometric description of smooth transitions between curved surfaces. In *Proceedings of the 6th ASME computers in offshore and arctic engineering conference held in Houston, Texas.* 19-26. NY:ASME.

Hansmann, W. November. 1985. Interactiver entwurf und geometrische beschreibung glatter uebergaenge zwischen raeumlich gekruemmten flaechenstrukturen. Ph.D. thesis, University of Hamburg, Department of Informatics.

Technical University of Darmstadt

My host, Professor Jose L. Encarnacao, is a well-known leader in computer graphics. Dr. Encarnacao is the founder and director of three major computer graphics-related institutes, located at the House of Computer Graphics in the Technical University of Darmstadt (TUD). The three institutes are:

- Department of Interactive Graphic Systems (GRIS) at the Computer Science Faculty of TUD
- Computer Graphics Center (known in German as the Zentrum fuer Graphische Datenverarbeitung e.V. or ZGDV)
- Fraunhofer Computer Graphics Research Group (Fraunhofer-Arbeitsgruppe Graphische Datenverarbeitung or FhG-AGD).

Their activities range from basic research and scientific education to more applied research and development and training of professionals from all branches of government organizations and industry. I noticed a deep commitment to technology transfer from academia to industry in all of Professor Encarnacao's activities. This committment could form an example for other countries and institutions as they attempt to expedite the application of basic research in industry. The three institutes support and enhance each other. This synergy provides important reciprocal incentives and creates the critical mass necessary for the undertaking of major projects. Here are some typical research and development projects from the three groups.

The Interactive Graphics Systems Group has or is conducting research in:

- Algorithms - Projects in geometric modeling, three-dimensional model reconstruction, rendering, texture synthesis, image processing, and distributed computing

- Graphics Software - Graphical Kernel System (GKS--the international graphics standard), raster drivers, user interfaces
- Graphics Hardware - GKS chip, geometry processors, transputer systems, and optical disc processors
- Applications - CAD/CAE, robot simulation and programming, VLSI design, simulators, and office support systems.

The Computer Graphics Center, founded by TUD and several major industries is a nonprofit organization that attempts to closely link academic research and industry in computer graphics. To achieve this goal, the ZGDV has, for example, undertaken:

- Education and training for academics and industry and government sponsors
- Industrial support activities involving computer graphics
- Graphics-related applied research and development; e.g., networking for graphics systems, user interfaces, graphics systems for CAD/CAM, graphics systems for education and training.

The Fraunhofer Computer Graphics Research Group (FhG-AGD) focuses on assisting

- Manufacturers in keeping up with the rapid computer graphics evolution
- Companies in planning, intergrating, and managing graphics systems
- Computer industry in integrating graphics into their systems
- Industry in improving product quality and reducing costs via computer graphics systems.

Typical specific projects of the FhG-AGD include integration of graphics in documents, industrial applications for CAD/CAM/CIM, industrial simulation, computer animation (to support design, advertising, film and television industries, visualization for product development, quality assurance), user interfaces for specific industries, and microelectronics (VLSI) for computer graphics.

It is hard to draw parallels with Professor Encarnacao's institutes both abroad and in the U.S. in graphics and CAD. The closest parallel (on a larger scale) is at the Center of Production Technology (Produktionstechnisches Zentrum Berlin) of the Technical University of Berlin in manufacturing and production systems under the leadership of Professor G. Spur. In Japan, Professor Tosiyasu Kunii, Chair, Department of Informatics, University of Tokyo, has spearheaded efforts to transfer fundamental research from academia to industry in computer graphics.

In the U.S., three organizations are similar to Professor Encarnacao's institutes. First, Media Laboratory at MIT, Professor Nicholas Negroponte, director, is well known internationally for its research in the application of computers in media technology, including computer graphics. The Engineering Design Research Centers at the Rensselaer Polytechnic Institute and Carnegie Mellon University, Professor Michael Wozny and Professor Friedrich Prinz, respective directors, are also well-known internationally for their work in the graphics and CAD and manufacturing.

Geometric Modeling--A Seminar at the Internationales Begegnungs-und Forschungszentrum für Informatik

by Richard Franke. Dr. Franke is a Professor of Mathematics at the Naval Postgraduate School, Monterey, California.

Introduction

The Internationales Begegnungs-und Forschungszentrum für Informatik (International Conference and Research Center for Computer Science [Center]) at Schloss Dagstuhl, near Saarbrücken, Federal Republic of Germany (FRG) is devoted to the stimulation of research in computer science. Using the Mathematisches Forschungsinstitut Oberwolfach as a model (see *ESNIB* 89-09:31), the Center organizes high-quality scientific workshops called Dagstuhl Seminars. The first Dagstuhl Seminars were held in summer 1990. The 1-week seminars are designed to bring together scientists of international rank and young scholars in one particular area of computer science. The structure of the meetings is informal and contributes to the presentation of new ideas, discussion of problems, and the possible trends in future developments.

The Center can accommodate (private and twin rooms and dining facilities) only about 40 persons, so the meetings tend to be quite small. Participation is by invitation only. In addition to accommodations, there are meeting rooms and a library (very small). There are several Sun workstations connected to the Internet, allowing communication by E-mail as well as direct connection to one's own machine connected to the Internet. The Center is being expanded so that by 1994, space will be available for about 60 participants. In addition, there will be some apartments for scientists making longer stays for research purposes. A new library is also planned with substantial funds being supplied by the Volkswagen Foundation.

Meetings are initiated by two or three prominent scientists in a particular field who apply for a Dagstuhl Seminar. An independent scientific Directorate is responsible for reviewing these proposals and for composing the list of participants. Proposals may be subjected to outside refereeing. The Center has complete control over all aspects of the seminar, and may modify the proposed topic, organizers, and participants.

The Center is a nonprofit institution, and is financed by the states Saarland and Rheinland-Pfalz in partnership with the Gesellschaft für Informatik and the Universities of Saarbrücken, Kaiserslautern, and Karlsruhe.

Dagstuhl Seminar: Geometric Modeling

On July 1-5, 1991, Geometric Modeling was held at Dagstuhl. The meeting was organized by Gerald Farin (Arizona State University, Tempe), Hans Hagen (Kaiserslautern University, FRG), and Hartmut Noltemeier (Würzburg University, FRG). Of the 40 participants from eight countries, 30 gave presentations. Topics included solid modeling and form feature recognition, geometry processing, and curve and surface definition. Also included were presentations on esoteric topics down to details about how geometric modeling programs are designed. I could not attend all the lectures. Therefore, I will give either the author's abstract (A) or my synopsis of lectures in which I was particularly interested. Many presentations were reports on joint work. However, I have not always included the joint attributions. For want of a better algorithm, I list the papers in the order they were presented.

Shape Information in Industry-Specific Product Data Model - Dieter Roller, Hewlett-Packard, GmbH, FRG (A). In this presentation, first some insight in the overall goal of the project is given. This is essentially the development of a CIM (corporate information management) solution portfolio for the European automatic industry. An architectural approach is described that is based on industry-specific, enterprise-wide information models. The product data model is then presented as one of them. In particular, the representation of shape information within the product data model is given in more detail. Eventually, some gained experiences from this project are given.

A Practical Classification Scheme for Form Features of Machined Parts - Michael Pratt, Cranfield Institute, United Kingdom (U.K.) (A). The concept of form features on local geometric configurations on the surface of an object is reviewed. The importance in computer-aided design, computer-aided manufacture (CAD/CAM), and other automated engineering application is then explained. The origin of feature data in product models may be either through the use of a feature-based design interface or through automated feature recognition from a pure geometric model. The

former does not provide for all engineering needs during the life-cycle of a product, since the designer's features are related to functionality. Generally, this not true of features required for other applications downstream of design. Automated recognition will therefore always be a necessity in an integrated system for design, analysis, manufacturing, and quality control.

Methods for the purpose are reviewed. Moreover, the recognition process can be simplified if the product model contains not only geometric information but also details of the designer's feature view of the product. Also discussed is the need for feature recognition techniques in validity checking throughout the design process. The paper concludes with suggestions for further work in the development of a formal language for defining features, having use for both creating and recognizing features. This will permit an integrated system to be configured to meet the precise requirements and modes of operation of diverse engineering organizations.

Feature Modeling with an Object-Oriented Approach - Wilhelm Brandenburg, Hella KG Hueck & Co., FRG (A). The notion of *features* is an integral part of the design methodology for vehicle lights at Hella and the system implementation supporting it. Object-oriented mechanisms are used to define part structure and behavior models. The mechanism is part of an *application-specific modeling platform* or *framework*, which allows application software to interact with the CAD/CAM system on a high level and capture, evaluate, and store the design intent.

The paper describes the modeling approach that led to the use of features. It outlines the implementation of features in an existing CAD/CAM system using an object-oriented paradigm. The paper finally illustrates feature-based modeling techniques in industrial application and lists practical advantages.

A Modeling Scheme for the Approximate Representation of Oriented Surfaces - Pere Brunet, Polytechnical University of Catalonia, Spain (A). An approximate octree representation for closed surfaces is presented--namely, the face octrees. Face octrees are based on a hierarchical representation of the subdivision of the space, until either homogeneous or face nodes are reached. Face nodes contain a connected, sufficiently planar partition of the surface within a tolerance $\in$. The representation $FO_{\in}(S)$ of a surface S depends on $\in$ and can be refined, $\{S, FO_{\in}(S)\} \rightarrow FO_{\in'}(S)$, $\in' < \in$. The face octree $FO_{\in}(S)$ of S defines a thick surface TS(S), union of all bands defined by the face nodes; a band in a face nodes spans $\in$ to both sides of the plane π approximating S in the node. The region TS(S) contains S, $S \subset TS(S)$. The face octree representation can be generated through a recursive algorithm based on a clipping of the surface patches and a planarity test. When used as an auxiliary model together with S, it can be used efficiently for a number of interrogations and geometric operations. Besides the algorithm for generation of $FE\text{-}\in(S)$, algorithms are proposed for point-sided classification, line and plane intersection tests, and interference detection. Space complexity of the proposed model is discussed, and some bounds are presented.

Geometry Processing - Robert E. Barnhill, Arizona State University, Tempe (A). Geometry processing is the determination of geometric aspects of curves, surfaces, and volumes. We discuss two principal topics in geometry processing: surface/surface intersections (SSI) and offset surfaces. Our SSI algorithm draws on several years of experience and currently includes flatness criteria, edge linearity measures, and adaptive marching, with modern computer science data management. We treat general parametric surfaces, both for SSI and for offsets. In our offset surface work we devise approximate offset surfaces of two types: (1) rectangular-based on Farouki's (1986) publication in computer-aided geometric design (CAGD) and (2) triangular- based on extensions of Piper's (1987) publication in Farin's Geometric Modeling (SIAM [1987]). We conclude with pointers to another topic--multidimensional interpolation, continued by Tom Foley. We use isophotes as an interrogation tool--a technique learned from earlier meetings here.

Cross Boundary Derivatives for the Side-Vertex Triangular Patch - Tom Foley, Arizona State University. Foley discussed the side vertex transfinite triangular interpolant (in this case, the version that interpolates to value and normal derivative around the boundary). The interpolant is a weighted combination of three functions, each interpolating data on one side of the triangle and the opposite vertex. These are constructed from univariate *radial* interpolants through the given vertex and a point (and slope) on the opposite side. This interpolant is often discretized to a 9-parameter patch (value and partial derivatives at the vertices) by assuming a cubic variation of the value along each edge, and a linear variation of the normal derivative. Foley showed shaded surfaces illustrating that the linear variation of the normal derivative can lead to *ridges* on the surface (interestingly, these never showed up previously on many wire-frame plots of such surfaces). Foley gave a representation of the function as a triangular Bézier patch. Since the function is not a cubic, the center Bézier point was a generalized one whose location depended on the data. Foley suggested a quadratic fit across convex quadrilaterals to determine the normal derivative at a point on the interior of the triangle edge (diagonal of the convex quadrilateral) to obtain a quadratically varying normal derivative, a scheme which also preserves cubic precision. Examples showed improved results.

Interactive Design Using the Partial Differential Equations Method and Functionality in Geometric Design - Michael J. Wilson, University of Leeds, U.K. Wilson made the presentation and showed videos of surface design using the partial differential equations (PDE) method. The original impetus was to construct fillets between two objects so the transition was smooth. This was achieved by solving the biharmonic equation in parameter space (with a scaling parameter in one direction for flexibility) with boundary conditions that assured a smooth contact with the objects. Both explicit solutions and finite-element solutions using a B-spline basis have been explored. Wilson showed videos that presented the effects of varying the scaling parameter and magnitude of the derivatives, tending to have predictable tightening or other effects on the surface. The process works as well on any object that has two boundaries. Several objects have been modeled, including a boat. The results of designing the shape to optimize on various criteria (e.g., drag in water) were shown. One of the amusing vignettes showed the sequence of designs obtained when optimizing for viscous drag (sailing though a sea of treacle).

Algorithmic Blending - Hartmut Prautzsch, Karlsruhe University, FRG (A). Prautzsch presented a simple procedure produces a four-sided piecewise bicubic C^1 patch with prescribed boundaries and cross-boundary derivatives.

Triangular B-splines - Hans-Peter Seidel, University of Waterloo, Canada. Seidel reviewed polar forms and multiaffine maps for Bézier curves and surfaces. He then discussed construction of a multivariate B-spline basis using polar forms. Basis sets for multivariate B-splines have been constructed previously, but they did not have satisfactory properties (e.g., didn't sum to one; the set was not independent). The basis set discussed here are independent, sum to one, and reproduce polynomials; the coefficients for representation are values of the polar form of the polynomial. In addition, they are affine invariant, have the convex hull property, are local, have maximum smoothness (C^{n-1} for degree n), and reproduce piecewise polynomials. In cases where knots occur along a line, a lower order of continuity occurs, and multiple knot behavior can be used to advantage.

Interpolation and Approximation with Exponential B-splines in Tension - Tom Lyche, University of Oslo, Norway. Lyche discussed further results with exponential B-splines reported on previously (see *ESNIB* 90-09:36). In particular, some convergence results were that the error in function approximation is $O(h^2)$ and that convergence to the Bézier control points is $O(r^{-2})$, where r is the tension parameter.

High Order Continuous Polygonal Patches - John Gregory, Brunel University, Uxbridge, U.K. Gregory discussed polygonal patches to fill polygonal holes (e.g., such as occurs at suitcase corner or at the wing-fuselage join of an aircraft). He reported that his previous work on blending function polygonal patches was not satisfactory to British Aerospace (one of the sponsors) since it did not use rectangular patches and was not easy to incorporate into their present design system. In this talk, Gregory discussed a method that involved dividing the polygonal patch into rectangles, which can then be handled by the existing system. There are constraints on the derivatives at the central vertex (*ESNIB* 89-04:26, reference to a paper by Renner).

Properties of Local Coordinates Based on Dirichlet Tesselations - Bruce Piper, Rensselaer Polytechnic Institute (RPI), Troy, New York. The coordinates discussed by Piper were developed by Sibson (1981) and used in an interpolation scheme for scattered data. The coordinate functions are piecewise rational functions with the pieces being defined on intersections of circular disks. Piper showed that the interpolation constructed by Sibson is C^1 continuous, gave a gradient formula, and then a new proof of linear precision of the scheme by using Stokes' theorem.

Generalized Weighted Splines - Richard Franke, Naval Postgraduate School. My talk about interpolation of scattered data by conditionally positive definite radial basis functions was concerned with the variational characterization (in the Fourier transform space) of the interpolation function. The result is because of Madych and Nelson and shows that a pseudonorm that is the integral of a weight function times the magnitude squared of the Fourier transform is minimized over all functions that interpolate the data in a certain Hilbert space. The weight function is the reciprocal of the generalized Fourier transform of the conditionally positive definite basis function (on $R^d\backslash\{0\}$). In this context, I discussed the family of interpolation functions containing thin plate splines, thin plate splines with tension, multiquadrics, and other more esoteric conditionally positive definite radial basis functions. Plots of basis functions, weight functions, and interpolation functions were shown to illustrate the effects on the interpolant of the rate at which the weight function in the pseudonorm becomes large.

Using Parameterizations with Base Points in CAGD - Joe Warren, Rice University, Houston, Texas (A). Given a rational surface, $x = X(s,t)$, $y = Y(s,t)$, $z = Z(s,t)$, $w = W(s,t)$, a base point is a parameter value (a,b) such that $X(a,b) = Y(a,b) = Z(a,b) = W(a,b) = 0$. This talk discussed several applications of base point to topics in CAGD. These applications include multi-sided patches, incompatible edge twist surfaces, and higher dimensional generalizations of the Bernstein-Bézier method.

Conference on Curves, Surfaces, CAGD, and Image Processing - Tom Lyche, University of Oslo, Norway. Lyche recalled the highlights of the meeting held in Biri, Norway, June 20-25, 1991, and supported under the

Conference Support Program by the Office of Naval Research European Office (ONR Europe). The first day of the meeting was devoted almost entirely to wavelets and applications, with more traditional topics being treated during the week-long meeting.

A special highlight was the first attendance at a meeting of Pierre de Faget de Casteljau, one of the early contributors to CAGD (long before it was called CAGD, in fact). The de Casteljau algorithm was the first linear combination algorithm for evaluation of what have become known as Bezier curves. This curious circumstance was a consequence of the fact that de Castlejau, an employee of Citroen, was unable to publish his work in a timely fashion.

Differential Geometric Methods in CAGD - Franz-Erich Wolter, Massachusetts Institute of Technology, Cambridge (A). The first part of this talk reports an necessary and sufficient criteria for second-(and higher) order contact between two surfaces. Those criteria employ few one-dimensional contacts, or curvature conditions (e.g., prescribing normal curvatures) to control all curvatures, or (more generally) to control higher-order contact between two surfaces. One of the theorems treats the case where the surfaces have contact along a curve. The other theorem treats the case where the surfaces have contact in a single point. The order two case of both theorems is joint work with Joe Pegna at RPI. It is shown how the point contact theorem can be applied to compute the curvatures for surfaces that are defined by a degenerate representation.

The second part of the talk reports on how methods from local and global differential geometry can be combined to develop efficient methods for distance computations; e.g., to trace points nearest on a surface to points on a space curve. Those methods employ:

- Tensorial differential equations for orthogonal projections (joint work with Pegna)
- Approximation of the inverse of the normal map
- Elimination of search areas using Taylor estimates
- Topological vector field index methods
- Global differential geometric methods employing the Cut Locus.

Finally, several applications for distance computations are given. Those applications include; e.g., medial curve and Cut Locus computations. The Cut Locus can be used as a tool for shape classification.

Fair NURBS (nonuniform rational B-splines) - Gerald Farin, Arizona State University. One of the properties of rational curves is that they can be reparameterized without changing the curve if different weights are used for the denominator. Choice of weights is a problem for the designer since the denominator weights do not have as nice a geometric analog as the numerator weights (control polygon). Farin suggested that an appropriate way of choosing weights was to take the end weights each as one and determine the others by making the curve segment as close to a circle as possible, subject to the smoothness constraints. As a way to smooth a curve by obtaining smoother curvature plots, Farin reported on an algorithm that goes from a cubic curve to a quadratic using the above criteria, and then lifts the curve back to a cubic by knot insertion, resulting in the Bézier B-spline representation. Farin showed examples that resulted in noticeably smoother curvature plots while having a negligible effect on the curve itself.

Variational Design of NURBS Curves and Surfaces - Hans Hagen, Kaiserslautern University, FRG. Hagen reported on efforts to choose parameters available in the representation of curves and surfaces using NURBS through minimization of a smoothness measure. Hagen was especially interested in quintic splines. He reported on results of minimizing the integral of a linear combination of curvature (norm of second derivative as the approximation) and jerk (or third derivative). The integrals were approximated using the trapezoidal rule. Because of the rational function, a nonlinear system resulted which was solved using a standard nonlinear equation solver. Existing curves can be fit using an objective function that is a combination of smoothness and fidelity to the data. Surfaces are smoothed using either the integral of curvature or using the above smoothness measure along parameter lines. Using optimization techniques to determine the weights in NURBS seems to be a viable technique, although the usual tradeoff between terms in the smoothness criteria is still an open question.

Composition of Tensor Product Bézier Representations - Dieter Lasser, Kaiserslautern University, FRG. Lasser discussed the exact representation of rational Bézier curves on a rational Bézier surface and (correspondingly) rational Bézier surfaces on rational Bézier volume. Such curves and surfaces might represent trimlines and are in general of high degree. He gave theorems on the composition of polynomial and tensor product Bézier representations and B-spine representations.

Best Approximations of Curves with Respect to the Hausdorff Distance - Wendelin Degen, Stuttgart University, FRG (A). To measure the distance between two parametric curves $t \mapsto x(t) \in \mathbb{R}^2$, $t \in [a,b]$ and $s \mapsto y(s) \in \mathbb{R}^2$, $s \in [c,d]$ we require that there is a reparametrization σ: $[a,b] \to [c,d]$ (a diffeomorphism) and a distance function ρ: $[a,b] \to \mathbb{R}$, such that

(i) the approximation can be represented as $y(\sigma(t)) = x(t) + \rho(t)\vec{n}(t)$, where $\vec{n}(t)$ is the unit normal vector of x at $t \in [a,b]$

(ii) $\mathrm{Det}(y'(\sigma(t)), \vec{n}(t)) \neq o$ for $t \in [a,b]$

Then the normal distance

$d_N(x,y) := \max_{t\in[a,b]} : \rho(t) := |\rho|_\infty$

can be used as a distance between the two curves x and y. In the case of "same end points" (x(a) = y(c), x(b) = y(d)), it turns out, that the distance is exactly the Hausdorff distance.

Now we apply the nonlinear approximation theory of Meinardus/Schwedt to determine the best approximation and a certain n-dimensional differentiable manifold M of Bézier curves $y \in M$, there must be proved:

- Differentiability of the distance function ρ with respect to the n parameters of M
- Local Haar condition of the tangent manifold T_yM
- Global Haar condition for each pair $y,y \in M$.

It is shown that all those conditions are satisfied for different settings:

- Cubic Bézier curves with equal endpoints and equal tangents as the given curve at the endpoints
- General Bézier curves of degree n with the same endpoints.

Therefore, the theory can be applied.

To calculate the best approximations explicitly, an algorithm was developed based on the fact that the best approximation contains an alternant. The algorithm starts with a calculation of the n + 1 extremal points of ρ; then the n parameters of M are varied, and a quasi-Newton's method to solve the nonlinear system $\rho_1 + \rho_2 = 0,\ldots,\rho_n + \rho_{n+1} = 0$ can be used.

Several examples are given.

Multisurface - Working with Large Surface Areas - Peter Schramm, Mercedes Benz, Sindelfingen, FRG (A). In current CAD systems, surface models are quite generally represented in terms of (trimmed) tensor product spline surfaces. Now, a multisurface is an assembly of several freeform surfaces with the capacity to describe the geometric shape of a complex part. In addition to the single surfaces, it contains topological information; i.e., neighboring relations.

The talk summarizes the main features of a multisurface as well as describing how it can be generated automatically--starting from a given set of surfaces. Further, special functionality for multisurfaces employed in the CAD-system SYRKO is presented, illuminating the advantages of having a superimposed means of order. Special attention is given to the problem of filleting a surface model which contains various edges and corners.

C^1 Smoothing of Multipatch Bézier Surfaces - Wolfgang Schwarz, EDS GmbH, FRG (A). Handling and modeling multipatch tensor product Bézier surfaces often causes continuity problems. Schwarz describes how to approximate a given surface in such a way that C^1 continuity at the crossing point of four surface patches can be obtained. The approximated surface uses a Bézier representation with the same orders as before.

Reconstruction of C^1 Closed Surface from Two-Dimensional (2-D), Cross-Sectional Data - Keith Unsworth, University of Dundee, U.K. (A). Unsworth describes a method for reconstructing a closed C^1 surface from given cross-sectional data. Each set of cross-sectional data is interpolated using a parametric shape preserving curve interpolation scheme. Also, adjacent interpolating curves are blended using Hermite interpolation. The surface is closed by defining a crown point and a base point, each of which is then used in the generation of the crown and base surface section. Consideration is also given to branching, which is catered for by including a saddle surface between the contours where branching occurs.

Partitioning Large Scenes of Geometric Objects - Christian Zirkelbach, Würzburg University, FRG (A). We are faced with the problem of representing proximity information in large scenes of geometric objects. We present a data structure called "Monotonous Bisector* Tree" and analyze some structural properties, showing that a Monotonous Bisector* Tree is a proper tool for supporting neighborhood queries, even in general metric spaces. Let S be a scene of convex objects in R^d. We show that a Monotonous Bisector* Tree can be generated in O(nlog n) time using O(n) space, which is optimal.

Development Towards Product Modeling - Joachim Rix, Fraunhofer Institute, Darmstadt, FRG (A). A concept of a product model was presented. This is based on the parameters of product life cycle, application areas, properties, and product presentation. The relation of these aspects points out the need for an integration of the different data models into one product model. The development of the CAD Reference Model (GI-FG.4.2.1) and the Standard for Exchange of Product Model Data (STEP) were described. The necessary work of integration of the given interdisciplinary activities in a new CAD environment architecture was shown.

Fairing of Point Sets - Matthias Eck, Darmstadt University, FRG (A). Given a set of N data points P_i, i = 1, ... ,N, we derive a method based on geometry of differences (Sauer 1971) to smooth them. Therefore, we use the discrete curvatures and torsions in the points to define local and global fairness criteria. The proper fairing procedure then works iteratively as the method of Sapidis and Farin 1989. Their method smoothes cubic B-Spline curves by knot removal and knot reinsertion.

Curvature Approximation and Knot Removal for Scattered Data - Bernd Hamman, Arizona State University (A). Given a 2-D triangulation of some surface in E^3, a method is presented for approximating the principal curvatures for the points in the triangulation. The method is based on constructing a local (least squares) approximation to the triangulated surface. The technique can easily be extended to

higher-dimensional surfaces. Further, an iterative algorithm is discussed for removing points from a point set in $\mathbf{E}^3$ constituting a 2-D triangulation. Weights are associated with each triangle determining whether or not it is to be removed. The weight for a single triangle is based on the curvature approximations at its vertices.

Free Form Curves Based on Normal Curves - Helmut Pottman, Vienna University, Austria (visiting at University of Hamburg, FRG) (A). The talk describes joint work with Tony DeRose. Stone and DeRose recently presented an analysis of planar cubic Bézier curves for the presence of shape characteristics (loops, inflections,...). Now we use the classical notion of a normal curve to rederive these results in a more direct geometric way. This approach has the advantage that it extends to higher degree curves as well as to rationals.

Simplification of Piecewise Linear Curves - Morton Dæhlen, Center for Industrial Research, Oslo, Norway (A). Given a piecewise linear curve **P** and a tolerance $\in > 0$, we find a new curve **Q**, with as few linear segments as possible, so the Hausdorff distance between **P** and **Q** is less than $\in$. The main applications of the simplification algorithm are data reduction and scaling of parametric curves for graphical display.

Conditions and Constructions for Geometric Continuity of Adjacent Surface Patches - Peter Wassum, Darmstadt University, FRG (A). The geometrically continuous joint between adjacent patches is widely regarded as the appropriate way to fit together surface patches when building up the surface. Because of the representation of surface patches in affine coordinates, the geometric continuity constraints of arbitrary order are developed using a recurrence formula derived from the concept of reparametrization. When formulating continuity constraints of arbitrary order, the possibility of rescaling linked to surface patch representations in homogeneous coordinates has additionally to be taken into account. Necessary and sufficient conditions are obtained for the geometrically continuous joint of integral or rational parametrized Bézier patches.

A Voronoi Diagram Based Clustering Algorithm - Thomas Schreiber, Kaiserslautern University, FRG (A). This paper describes a solution to the following problem: given a set of weighted multidimensional data points, find the cluster center points, which minimize the sum of the squared distances between each data point and its nearest cluster point. Because this problem is np-complete, we search for a good local minimum and apply a k-means-type algorithm by using multidimensional Voronoi diagrams. The Voronoi diagrams are created by an adaptive insertion of new cluster points in those areas where the largest error occurs. At the same time, this method produces a hierarchical Delaunay triangulation of the data points at different degrees of accuracy.

Conclusions

This was the first meeting concerned with CAGD to be held at the Dagstuhl Castle. The isolated location and the small number of participants are very conducive to intensive interchange of ideas. The participants made favorable comparisons with the Mathematical Research Institute at Oberwolfach, from which the institute at Dagstuhl drew its inspiration. It is hoped that the seminar will be a regular meeting, perhaps on a 2-year cycle.

The papers were predominantly related to curves and surfaces. Such topics as representation, creation, modification, and data reduction were treated. Papers on data fitting versus design aspects were somewhat more common than usual. Geometric continuity and related aspects were well represented. Several papers were interesting from the point of view of actual implementations of CAD systems. Other topics were of interest to industrial users. As always, several papers fell into the miscellaneous category.

From my perspective, the mathematics of CAGD has matured to the point that many of the practical aspects are now pretty well understood (not to say they are implemented in user-friendly systems, though). There are still many interesting, unsolved problems. At the same time, certain aspects of the theory of curves and surfaces still need to be unified.

Although many of the papers were in the nature of reports of work in progress (entirely appropriate at this kind of meeting), a Proceedings is planned with papers due for refereeing about 2 months after the meeting. The Proceedings will appear either as a special issue of *Computer-Aided Geometric Design* or as a book.

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Responsive Computer Systems: A Challenge for this Decade

by Miroslaw Malek, the Liaison Scientist for Computer Science and Computer Engineering in the Office of Naval Research European Office. He is on leave from the University of Texas at Austin, where he holds the Southwestern Bell Professorship in Engineering in the Department of Electrical and Computer Engineering.

Introduction

The emerging research field of responsive systems requires fault-tolerant and real-time performance in parallel and distributed computing environments. An increasing number of computer users are demanding these two important attributes, namely high reliability and timeliness. Responsive systems are indispensable in manufacturing, control engineering, life-support systems, transportation, and many other disciplines where the impact of unpredictable behavior by a computer system may range from a minor inconvenience to a major disaster. With the ever-increasing reliance on computers and the proliferation of computer services, the need is crucial for dependable machines that deliver services on time. Historically, the two communities of fault-tolerant computing and real-time systems research have worked separately with a very small overlap. The workshop's major goal was to facilitate integrating the two groups and encourage closer cooperation to make responsive systems a reality.

In October 1991, the First International Workshop on Responsive Computer Systems was held in Golfe-Juan on the French Riviera. The meeting brought together 30 active (many renown) researchers from Europe, Japan, and the U.S. The workshop created a unique forum for discussing specification, design, measurement, and implementation of responsive multicomputer systems. The Institute National de Recherche en Informatique et en Automatique (INRIA) and the Office of Naval Research (ONR) sponsored the workshop. Gerard Le Lann, INRIA, Rocquencourt near Paris, France, and I organized the workshop with administrative support from Claudie Thenault, INRIA, Rocquencourt, France.

Although it can be legitimately argued whether a new term "responsive" is needed as was pointed out by Radu Popescu-Zeletin of Gesellschaft für Mathematik und Datenverarbeitung (GMD) in Berlin, Federal Republic of Germany (FRG), there was general agreement that a new term will provide a focus on dealing with real time and fault tolerance in a much more mature manner and will accelerate the integration of both properties; i.e., reliability (or availability) and timeliness. The terminology issue stems from the fact that the fault-tolerant computing community may regard timing violations as faults. Hence, the real-time systems community is expected to consider hardware and software faults when guaranteeing timely behavior. (This seems to be wishful thinking at this time for a majority of the work in this field with some noteworthy exceptions such as a MAintainable Real-time System [MARS][1]).

While some researchers claim that dependability implies timeliness, most of the work in dependability proves otherwise. Typical dependability measures include reliability, availability, and mean-time-between-failures (MTBF) and are concerned with system attributes and not with the users needs (e.g., in meeting real-time requirements).

Consensus-Based Framework, Responsiveness, Assumptions, and Illusions

I opened the workshop with a presentation entitled "Issues in Responsive Systems Design" and focused on a fundamental tradeoff between space and time. Space is viewed as the cost or the amount of hardware, firmware, software, and liveware to operate a system. Time reflects a physical time to execute a given process in the presence or absence of faults. Any responsive system will require space/time redundancy. Yet, one of the main challenges in systems design remains--precisely evaluating this tradeoff in the design process while maximizing "responsiveness" and minimizing the system cost.

I also introduced a consensus-based framework for a responsive multicomputer systems design. The consensus problem is concerned with the agreement on a system's status (be it the system's clock or resource availability) by the fault-free segment of a population of processing units. The omnipresence of consensus demands that decisions on timing (effectively synchronization), communication, fault diagnosis, scheduling, and resource allocation are made in a consentaneous, timely, and reliable manner. So, for the design of any multicomputer system, these attributes must be built into the architecture and the operating systems to ensure high availability and timeliness. Even centrally controlled responsive systems would require replication of a controller, and consequently voting (which is a type of consensus).

[1] See Kopetz et al., 1989.

I proposed a definition of a task's responsiveness as a product of the availability and the probability of timely completion of the task in a fault-free system. A system's responsiveness may be obtained by calculating the average of the task responsivenesses. This separation of fault tolerance and real-time concerns may allow designers to optimize responsiveness by integrating design methodologies for both fault tolerance and real-time requirements. I concluded the talk with a list of critical issues. (See list on page 20 which has been combined with other issues raised by participants.)

The second speaker in the Plenary Session, Gerard Le Lann, gave an enlightening presentation entitled "Predictability and Responsiveness: Assumptions and Illusions." He proposed a fundamental criterion for a system's predictability as a product of assumption coverage and verification/proof/test coverage. This criterion indicates with what probability we can trust a system to behave in a predictable/expected manner. Frequently, a problem begins at the assumption level where inaccurate specification or an inadequate model will affect a system's predictability. Analogously, imperfect testing (or the inability of proving correctness) will diminish predictability. Although predictability is much more general than responsiveness as it addresses all aspects of a system's behavior, it may be narrowed to two critical features, namely dependability and timeliness. But even in this limited scope, claiming that both assumption coverage and verification/proof/test coverage are equal to one, even in relatively simple systems, would be näive. This is the first illusion. We cannot guarantee a system's behavior, even if we take a static approach to a system's design and enumerate most potential system states. Conversely, a dynamic approach may offer probabilistic guarantees that in reality may yield higher predictability as they are derived for the entire spectrum of parameter ranges, not just for "some points in space" as is the case with a static method.

According to Le Lann, the second illusion is the impossibility of verifying dynamic algorithms. In reality, dynamic algorithms can be verified and their performance can be guaranteed with a much higher confidence level than for the static methods even under an identical set of assumptions. Additionally, dynamic algorithms cope successfully with several unanticipated circumstances under which static methods may fail. Le Lann sketched a real-life example by comparing a dynamic protocol such as carrier-sense multiple access/collision detection (CSMA/CD) with a static one such as a token-passing ring protocol (G. Le Lann, 1991).

Computational Models and Design Approaches

At the first working session of the workshop, participants concentrated on deterministic (static) and probabilistic (dynamic) models. Although the question remains open and the community is divided, it seems that ultimately a hybrid approach might be deemed necessary. The deterministic approach at lower levels is both feasible and necessary. However, at the higher level, the probabilistic one might be the only one that can promise flexibility and higher responsiveness. The decision should be based on the level of the assumption coverage and both anticipated and unanticipated conditions coverage. In multicomputer systems, the prediction of all communication patterns, execution times, and faults is not feasible. Whether we like it or not, the sooner this fact is accepted, the faster progress can be made in responsive systems design and development of high-quality probabilistic guarantees.

The talk by Donald S. Fussell, University of Texas at Austin, focused on a probabilistic approach for designing responsive systems. He presented an example of a probabilistic consensus algorithm. This algorithm can produce, with high probability, results that are similar to those yielded by its deterministic counterparts, but with less time overhead. Fussell also described a highly promising technique for automatic verification of Boolean functions based on probabilistic methods.

Mathai Joseph, University of Warwick, United Kingdom (U.K.), introduced a method for specifying and verifying complex real-time systems based on a linear-time temporal logic. This logic has intervals whose end points are specified using state predicates or time values. He described models of time and tradeoffs between points and intervals.

Alan Burns, University of York, U.K., argued for the need of a framework in which alternative architecture approaches for distributed responsive systems can be articulated and compared. The key elements of this framework are:

- Time-bounded communication methods/protocols
- Scheduling
- Allocation
- Data communication models (between software components)
- Synchronization models
- Time models.

The talk focused on real-time systems and the methods by which temporal properties can be guaranteed.

A generic architecture was used as one example of the way different methods and approaches can be combined to meet application needs.

Herman Kopetz, Technical University of Vienna, Austria, discussed the benefits of using a sparse-time model to establish the consistent ordering, simultaneity, and temporal order properties, and to simplify testing of distributed computer architectures. He showed that a properly selected sparse time base can improve these properties and simplify the design process.

Al Mok, University of Texas at Austin, addressed issues related to the design of real-time databases. The main semantic differences between traditional databases and real-time databases were discussed. These included:

- Timeliness of data (the usefulness may decay with time)
- True parallelism (real-time applications may require truly concurrent operations, not just a series decomposition)
- Logical and physical schedules (sharing of the physical operations output)
- Continual operation (perpetuality of operation).

Lui Sha, Software Engineering Institute and Carnegie-Mellon University, cited the observation of Jim Gray, Digital Equipment Corporation, that software is becoming a bottleneck in achieving a high system dependability. In 1985, the ratio of hardware MTBF/software MTBF was about one; in 1989, it was approaching ten. This is because of the improvements in hardware availability and ever-growing software complexity. To remedy this problem, Sha presented a method for achieving software fault tolerance. The method was described by a control application example. The control function is executed normally by a complex algorithm that might not be highly reliable but is very accurate. In case a fault happens, the system switches to a simpler algorithm which is less accurate but highly reliable. Although this approach is similar to the recovery block method, the difference is that this method has an acceptance test which is based on the quality of performance and not on system invariants or self-tests.

Susan Davidson, University of Pennsylvania, described ongoing research in which formal methods are being developed that can be used to specify real-time fault-tolerant requirements, to model various fault-tolerant mechanisms and their overheads, and to analyze the timed behaviors of distributed applications built using fault-tolerant techniques. She introduced a real-time language called *communicating shared resources* which helps to bridge a gap between abstract computation models and implementation.

Edgar Nett, GMD, Schloss Birlinghoven, Bonn, FRG, proposed a software fault tolerance technique for distributed systems based on a paradigm called the *parallel dynamic action scheme*. In this approach, the various versions of a task in a fault-tolerant distributed system are designed as dynamic actions. This scheme may enhance the efficiency of the normal system operation by exploiting maximum concurrency and avoiding the consequences of increased error processing overhead by running these individual versions in parallel.

Responsive Communication

Yoshiaki Kakuda, Osaka University, Japan, presented the design methodology for responsive protocols in communication systems. The proposed method uses rollback recovery based on a broadcast mechanism which allows the system to return from an abnormal sequence of states to a normal state in bounded time. Its unique feature is that it can revert from any abnormal sequence to an intermediate normal state while retaining the consistency for the transmission and the reception of messages.

Kang G. Shin, University of Michigan, discussed fault-tolerant real-time communications in distributed systems with point-to-point interconnection networks. He described a provably correct method for establishing real-time channels by compromising between the utilization of communication resources and the ability of the system to provide delivery guarantees.

Scheduling

The ever-present problems of scheduling were vividly discussed in this special session. Five speakers were featured.

The presentation by Ken Chen, ENST, Paris, France, focused on the scheduling of real-time systems running on a single machine by time value functions. This research lead to a family of polynomial heuristic algorithms that provide sequences obeying the optimal decomposition of tasks, and frequently find an optimal sequence (in about 75 percent of simulated cases).

Ralf Agne, University of Kaiserslautern, FRG, presented off-line scheduling strategies for a global cyclic scheduling discipline. A software support system was built to implement the proposed ideas and includes a specification tool, a distributed off-line scheduler, and a central off-line scheduler. The method uses heuristics to compose the best possible schedule combining the results of the distributed and the global schedule.

Eric Nassor, Alcatel Alsthom Recherche, France, dealt with hard real-time, sporadic-task scheduling for fixed priority schedulers. He gave a necessary and sufficient condition for a sporadic task set to be feasible with a fixed priority scheduler. Also, he presented a pseudo-polynomial algorithm that can distinguish a feasible sporadic task set from an unfeasible one.

The talk by Zhen Liu, INRIA-Sophia, Antipolis, France, focused on the extremal scheduling of tasks in multiprocessors with and without real-time constraints. Dynamic nonpreemptive scheduling policies were proposed that do not use service time information. The job delays caused by the proposed scheduling policies were analyzed and compared.

Houssine Chetto, IUT of Nantes, France, concentrated on exploiting the system laxity to perform adaptable and predictable scheduling in hard real-time environments. The proposed method is adaptive by using precise knowledge of current processor workloads. An acceptance procedure was presented that can decide whether a critical sporadic task that unexpectedly occurs on a given node can be accepted by that node. This scheme allows the system to determine in advance whether a deadline is going to be missed.

Scheduling poses a lot of problems in environments that are becoming increasingly complex. With over 4,500 scheduling problems and potentially at least as many algorithms, solid probabilistic guarantees are needed on the quality and timeliness of schedulers.

Case Studies

Jack Stankovic, University of Massachusetts, Amherst, focused on the highlights of the Spring Project, which was originally designed to support time-critical applications. The next generation of this system will also focus on flexibility and dependability. In this project, rings of nodes are integrated into a node lattice via fiber optic communication channels. Each node consists of a group of processors with shared memory. Sophisticated scheduling algorithms have been developed and their performance was evaluated by simulation. These algorithms are decentralized, dynamic (deal with tasks upon their arrival), and adaptive (adapt to the system changes). External events are handled by special purpose processors so the regular computations are not delayed.

The talk by Reino Kurki-Suonio, Tampere University of Technology, Tampere, Finland, presented an overview of Project Distributed Cooperation (DisCo). The project is based on an action-oriented approach and aims at the specification and design of reactive systems (reactive systems are computer systems that "react" to environmental changes, as opposed to systems that are isolated). Kurki-Suonio introduced a joint action system where atomic actions can be executed by an arbitrary number of participants. Since no built-in notion of control is associated with this execution paradigm, there is no sequential nor process-oriented bias (this independence of architectures was, in fact, exploited in Chandy and Misra's Unity [Chandy and Misra, 1988]). The Kurki-Suonio's work resulted in developing an action-oriented design method and designing and implementing an executable specification language (also called DisCo) with an associated graphical environment. A prototype of the system and necessary software tools have also been implemented.

Paulo Verissimo, Instituto de Enghenaria de Sistemas e Computadores (INESC), Lisbon, Portugal, talked about the extra performance architecture (XPA) of the DELTA-4 Project (definition and design of an open dependable distributed systems architecture). The DELTA-4 is one of the major ESPRIT[2] projects for a highly dependable computing system distributed over local area networks. The DELTA-4 has two architectures--open systems architecture (OSA) is general and open while the XPA focuses on mechanisms to support the explicit requirements of responsive systems. The objective of XPA is to provide a solution to specialized application scenarios, which require fault tolerance and timeliness guarantees for real-time operation. A full report on DELTA-4 will soon be published by Springer-Verlag (D. Powell, 1991).

P.D.V. van der Stok, Eindhoven University of Technology, the Netherlands, presented the Dependable Distributed Operating System Project (DEDOS). The DEDOS Project is targeted at controlling distributed plants and embedded systems. Van der Stok focused on two aspects of such systems:

1. Control of a deterministic process with tight timing properties
2. Interaction of a process with a nondeterministic environment that can check the process's progress and modify the process's functional parameters.

The DEDOS Project uses the object-oriented paradigm to take advantage of reusability, refinement, and composition of objects. For real-time applications, execution times can be evaluated off-line under some typical restrictions (no recursion or dynamic binding, bounded number of operations). As a result, fault tolerance is achieved by replication or reconfiguration of programs over multiple processors.

Critical Issues and Future Directions

Gerard Le Lann and I moderated two open discussions focused on critical issues, directions, and goals. Participants tried to identify some core issues that are integral to parallel/distributed systems, fault tolerance, and real time. It seems that practical, responsive multicomputer systems should be time-bounded. Some alternatives exist and need to be further investigated (K. Birman et al, 1987 and T.D. Chandra et al, 1991). Responsive systems must have

[2]European Strategic Programme for Research and Development in Information Technologies.

timely and reliable concurrency control mechanisms (such as responsive consensus protocols, responsive communication, responsive scheduling, and resource allocation techniques), and must use efficient space replication and/or time replication (space/time redundancy) techniques.

Fault tolerance and real time are by no means orthogonal and must be dealt with concurrently (although separation of concerns as in the responsiveness criterion aids in optimization). For example, a missed deadline can be considered a fault, and a crash fault in a processor may cause deadlines to be missed.

The big three issues (timeliness, dependability, and distribution) must be integrated and then responsive distributed computing systems may become a reality. Current techniques are heuristic and exploratory and cannot provide meaningful guarantees. Models and languages are needed that deal with all three aspects of system design.

More accurate specification methods are required. More importantly, we must be aware of the assumption coverage. In addition, we must understand the accuracy of models as well as understand the effect of this coverage and accuracy on system design and performance. We must learn how to deal with uncertainty as well as how to manage and estimate its impact.

As in most domains of computer science, we have a problem with quantification and comparison of systems. Questions must be answered. What metrics and measurements should be used? What experiments should be carried out? What application domains should we concentrate on? What should be a responsive system benchmark?

Application-specific characteristics should be exploited whenever possible to achieve fault tolerance and timeliness with the lowest possible time overhead. As a result, this may create a longer development cycle. Obviously, it would be better if the efficiency of general methods could be improved.

The issue of task criticality must be resolved. Do we need to use such a subjective measure as task criticality, or should we simply deal with a binary set of critical and noncritical tasks? What should be done with tasks whose criticality may change from noncritical to critical (or vice versa) depending on the current mode of the application? Perhaps a simple order of the task criticalities would suffice. Least critical tasks could be abandoned or deferred in the presence of failing components. Partial orders create additional complications and should be avoided. Finally, we can outline several research and critical objectives.

Design Methodology. We need a comprehensive design methodology that integrates parallel/distributed computing, fault tolerance, and real time. When designing responsive systems, should one start with a fault-tolerant system and add real-time aspects? Should one start with a real-time system and add fault tolerance to avoid missing deadlines in the presence of faults? Should a designer try to find a general solution and apply it to specific cases? Should a designer solve specific problems and try to find the common paradigm behind them?

Specification, Verification, and Testing. A technology for verifying/testing responsive systems must be established.

Formal specification methods must be proposed so that clear requirements could be stated for:

- Which or how many external events can the system handle without missing deadlines
- What kinds of faults can the system tolerate
- How should one deal with assumptions
- Should the system have different sets of assumptions and related solutions?

Languages and Models. Languages and models for responsive systems must be developed that address timeliness, fault tolerance, and distribution/parallelism:

- What programming model is most appropriate for responsive systems
- Can object-oriented programming be used
- What model is more adequate for responsive systems--event driven (event triggered), time driven (time triggered), or both
- How should the time basis or granularity be chosen?

Scheduling and Concurrency Control. Timeliness predictability in the presence/absence of faults is a key point in responsive systems. The kernel should include scheduling procedures that can cope with deadlines even in adverse situations. Resilient concurrency control mechanisms are needed based on consensus.

Metrics, Testing and Experiments. Adequate metrics, measurement techniques, software tools, and instrumentation support need further research and development. Experiments in responsive systems must be carefully defined and focused.

Communication. Responsive communication systems must provide timely communication even in the presence of faults. Open issues include: multicast protocols, routing protocols, atomicity and granularity of messages, as well as multiple data types and sources.

Design Diversity. Finding efficient methods for dealing with software faults is most important, yet one of the most difficult problems to solve. Formal methods are still inadequate. Multiversion programming is not only excessively expensive but frequently may generate more problems than effective solutions. How shall we consider design diversity in which multiple copies may have different timeliness and availability characteristics? How shall we deal with replica determinism? Should both hardware and software replication be used to cover design faults?

The Second International Workshop on Responsive Computer Systems, will take place in Tokyo on October 1-2, 1992. I am convinced that participants will directly address and, hopefully, provide some innovative solutions to questions and problems described in this report. Guaranteeing timeliness and correctness even in the presence of faults is one of the major challenges in computer research for this decade.

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Thomson-Sintra Activités Sous Marines Arcueil Department: Wavelets and Neural Networks for Transient Classification

by Robert D. Ryan, a mathematician currently serving as a Liaison Scientist for Mathematics and Computer Science in Europe and the Middle East for the Office of Naval Research European Office. Mr. Ryan is on leave from the Office of Naval Research, Arlington, Virginia, where he is Director of the Special Programs Office.

Introduction

This report is about work at Thomson-Sintra's activity at Arcueil and focuses on the use of wavelets and neural networks for antisubmarine warfare (ASW) applications. Wavelet analysis is used for preprocessing (along with more conventional methods), with results being used as input to a neural network which does transient classification. For background, the report includes a discussion of the PYGMALION project on neural networks and the network toolkit, NeuroClass®, both of which have contributed to Thomson-Sintra's strong position in the field. By having these software tools, Thomson-Sintra has been able to quickly compare the various processing schemes for transient classification.

Thomson-Sintra Activités Sous Marines (TSASM) was founded in 1985 when the Activités Sous-Marines (ASM) division of the parent company, Thomson-CSF, merged with Sintra Alcatel. The TSASM employs about 2,600 people, most of whom work at four main sites: the headquarters in Valbonne in southern France, a smaller activity in Valbonne, the mine warfare activity in Brest, and the original Sintra Alcatel site at Arcueil (just south of the Parisian beltway).

Thomson-Sintra ASM is a large, "full service" ASW organization, with expertise in all aspects of combat and sonar systems for submarines, surface vessels, and aircraft and in torpedoes, mines, and countermeasures. They also lead in exporting sonar systems worldwide, and supply, install, and maintain equipment for every navy in the Western world.

The Visit

Recently, four scientists from Naval Underwater Systems Center (NUSC), Newport, Rhode Island, and I spent a day visiting TSASM at Arcueil. Our host was M. Jean-Luc Lambla, the Deputy Director of the Arcueil Department. The visit was prompted by our interest in the application of wavelets to signal and image processing, and by indications that TSASM Arcueil had incorporated wavelet analysis in some of their systems. Specifically, I had seen references to work in this area by Jean-Marie Nicolas and Alain Lemer, both of whom are at Arcueil.

The TSASM Arcueil employs 580 people, over half of whom are scientists and engineers. The unit's business amounts to 450 million French francs (F) ($74 million) a year, of which about F 135 million ($22 million) is accounted as research and development (R&D). The Arcueil department focuses on command and control, airborne acoustic systems--helicopter sonar, sonobuoy processors, sonobuoys (built by Thomson Bouées), weapons control for all platforms, submarine combat systems, and a relatively new effort in countermeasures (anti-torpedo) for submarines and surface ships. They also have expertise in towing systems (winches and cable) for fish and towed arrays.

Our visit to Arcueil focused on basic studies. These were introduced by M. Yves Blanchard, the manager of the Advanced Study Group. He described the emphasis of the group as

- ASW at Arcueil
- Coordinating four research topics: undersea environment, neural networks, artificial intelligence (AI), and experimental activities for all of TSASM
- External scientific exchange
- Transferring research results to new products.

The item on scientific exchange concerns staff publication and participation at scientific meetings. I have included a list of recent publications to indicate the scope of work that is being published.

Wavelets

Based upon the noted references, I had asked to hear about the work of Jean-Marie Nicolas and others concerning their use of wavelets in signal analysis. In response, Dr Nicolas presented what turned out to be a tutorial on wavelets. He noted that they had been working with wavelets since 1988, but he presented no new information. I got the impression that the group has good software tools for doing wavelet experiments, and that they had explored many different schemes for using wavelets for sonar detection and classification. However, they offered no details on their experience, except to note that the Daubechies wavelets of order 3 to 5 were perhaps appropriate for their applications.

Wavelets and Neural Networks

The talk by Alain Lemer on neural networks was also somewhat tutorial. However, it provided an overview of the TSASM's thinking about applications to ASW and the range of their work, either done or in progress. Because it provides the background and capability for all of TSASM's work being done with neural networks, it is appropriate to digress here and say something about the European Strategic Programme for Research and Development in Information Technologies (ESPRIT) project, PYGMALION, and other neural network research at Thomson-CSF.

The PYGMALION program was the main ESPRIT project in neural networks. The program operated for 2 years starting in February 1989. The coordinator was Thomson-CSF, Division Systèmes Electroniques, and consequently Thomson-CSF played a central role. The partners were Centro Studi e Laboratori Telecomunicazioni (Italy), École Normale Supérieure (France), École des Hautes Études en Informatique (France), Philips-LEP (France), Computer Technology Institute (Greece), Instituto de Engenharia de Sistemas e'Computadores (INESC) (Portugal), Standard Elektrik Lorenz (Denmark), University College London (U.K.), and Universidad Politecnica de Madrid (Spain).

The aim of PYGMALION was to promote the application of neural networks by European industry, and to develop standard European computational tools for programming and simulating neural networks. Specific objectives were to develop a portable European Neural Network Specification Language and tools to stand as an interface between applications and emulation architectures, and to demonstrate the potential of a neural approach through industrial applications, mainly for image and speech processing.

Here are some of the project's accomplishments:

- A high-level, object-oriented language (N) has been specified for defining neural network algorithms and applications. It is used with an algorithm library to specify the topology and dynamics of a neural network.
- An intermediate-level language (nC) has been developed as a lower-level, machine-independent network specification language. Both N and nC are closely related to the language C++.
- An algorithm library contains a collection of the common neural networks. These are written in the high-level language, N.
- The Graphics Monitor serves as a software environment for interactively controlling, executing, and monitoring a neural network application simulation.
- A small hardware studies activity has produced and tested a demonstration very large scale integration (VLSI) chip that offers full connectivity. This allows the programming of the most common neural networks.

Based on the experience with PYGMALION and other research at the central laboratories (Laboratoire Central de Recherche, Thomson-CSF), Thompson-CSF has explored applications to image processing, speech processing, and acoustic signal processing. Thomson has clearly developed an expertise in neural networks and has assessed their performance in several applications areas.

Antisubmarine Warfare

The work at TSASM concentrates on applications to ASW. From Lemer's talk it was clear that their group (ten scientists and five students) had explored and compared (with other methods as well as within the neural network context) a wide range of networks and signal preprocessing. Their library of preprocessing techniques includes Fourier analysis, autoregressive modeling, Pisarenko analysis, Prony analysis, Laplace analysis, bispectral analysis, Wigner-Ville analysis, cepstral analysis, and wavelet analysis. The applications discussed included passive sonar (ship identification using spectral lines, self noise identification, transient natural noise identification, and mechanical interferences identification), active sonar (aspect independent sub/no sub classification with helicopter dipping sonar), aerial acoustics, acoustic scene interpretation, image processing (LOFAR symbolic description, symbolic description of a mine acoustic shadow), control (inverted pendulum control), and several other applications.

A system was demonstrated for us that separated and classified transient natural noises from porpoises, sea lions, walrus, barnacles, dolphins, snapping shrimps, and ice cracking. The system uses mixed preprocessing. Wavelet analysis produced 14 parameters and an autoregressive analysis produced 17 parameters. These 31 parameters are input for the neural network. The system gave 98 percent recognition after being trained on one quarter of a database which contained over 1,100 individual transients.

Another system I found interesting was the acoustic scene interpreter. The system listens to the sounds from an office (door opening and closing, footsteps, voices, telephone) and gives an interpretation of the acoustic situation. The system also anticipates future events. The system involves the analysis of both transient and long term signals. The technology includes signal processing, neural networks, and artificial intelligence.

Alain Lemer briefly discussed NeuroClass®, the trade-marked name of a software environment developed by the Thomson-CSF Laboratoire Central de Researches. My understanding is that this toolkit contains a library of standard and neural discrimination algorithms, pre- and post-processing routines, and software for comparing different standard and neural methods. This system is designed to compare different methods and to provide statistical evaluations of the different techniques. From scanning business literature, I note that NeuroClass® is used by other French R&D organizations.

I have the impression that TSASM has built a strong toolset to systematically explore the applications of neural networks to ASW. This involves testing and comparing all of the established preprocessing methods as well as the newer wavelet techniques. The toolset also involves testing and comparing different neural networks in combination with different pre- and post-processing methods. In all of this work they place an emphasis on statistical evaluation, and indeed, statistical evaluation of the performance of different systems is a major research thrust.

Artificial Intelligence

Jean-Paul Pignon coordinates research on AI and languages for AI. (The Thomson-CSF AI language is called X-IA.) He indicated that their work was oriented towards the application of AI to "real" problems. In the context of ASW, these include mission planning, handling multisensor data, classification and identification, tactical situation assessment, critical situation reaction systems, mission programming for autonomous undersea vehicles, and command and control. Broken down differently, they envisage three kinds of research and applications: (1) onboard knowledge-based systems, (2) knowledge-based systems for scientists and engineers, and (3) "new" knowledge-based systems. Their research emphasizes the development of a fast prototyping toolkit. When I inquired about operational systems, Pignon indicated that there were no AI systems currently operational onboard ships.

In a paper presented at Ocean Space Advanced Technologies European Show, held at Brest, France, in September 1991, Jean-Paul Pignon and Jean-Marie Nicolas argue that recent advances in AI and mathematics (including discrete pursuit games, viability theory, and decision theory) offer the potential for elegant and robust solutions to the command and control problem for autonomous unmanned (underwater) vehicles. They make specific reference to work being done in this area at TSASM.

Summary

Based on my visit and reading the TSASM publications, I believe that Thomson-Sintra ASM, in collaboration with the Thomson-CSF central laboratories and other branches of Thomson, is undertaking systematic investigations of the application of newer technologies to ASW. These include wavelet analysis, neural networks, and AI. Two things impressed me:

1. The range of software tools they have put together for carrying out the work (NeuroClass and their discrete pursuit simulator being examples)
2. The systematic comparisons they are making among different systems.

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MATERIALS

NATO Advanced Research Workshop on Organometallic Polymers with Special Properties

by Kenneth J. Wynne, Program Manager, Organic and Polymeric Materials, Chemistry Division, Office of Naval Research, Arlington, Virginia.

Introduction

The NATO Advanced Research Workshop on Organometallic Polymers with Special Properties was held in Cap D'Agde (located between Bezier and Montpellier in southern France) in September 1990. The goal was to identify the scope and potential rewards of research on organometallic and inorganic polymers with novel electronic, optical, magnetic, or structural properties. To achieve this goal, the known properties of organic polymers were compared with those potentially achievable in organometallic polymers. Additional concerns were the identification of obstacles in chemical synthesis that must be surmounted to realize the potential available from organometallic polymers. Another concern was the determination of progress that must occur in parallel areas (processing science, structure-property analysis, and characterization methods). The meeting also focused on identifying commercial technologies that might drive the development of these new types of polymers. Also identified were spinoff technologies that might derive from research in inorganic and organometallic polymers.

Opening Lecture

I presented the opening lecture. The subjects covered included linear and nonlinear optical behavior of polymers and electronically conducting polymers. I discussed research from a Navy perspective, and included my research and that of scientists supported by the polymer program at the Office of Naval Research (ONR). In this paper, I described research that has shown that polymers with delocalized electronic states have unusual properties such as electronic conduction, liquid crystalline behavior, and accentuated linear and nonlinear optical behavior. I noted that restriction of chain mobility, which often accompanies delocalized polyaromatic structures, has presented considerable difficulties in the preparation of tractable systems that are required for the generation of fundamental knowledge. Highlights were provided about the interesting synthetic chemistry that has been developed to address this challenge.

Electronically Conducting Polymers and Macrocylic Systems

Discovering and developing polymers that conduct electronically is one of the most important innovations in polymer chemistry in the last 15 years. Many synthetic methods have been developed or adapted for preparing polymers with delocalized electronic states. When subjected to partial oxidation, reduction, or other methods of generating mobile charge, these new polymers can exhibit high electronic conductivities. Understanding the factors that control electronic conductivity, structure, and processability have been among the goals in this developing field. Selected progress in this area includes the discovery (1977) of electronically conducting polyacetylene derivatives (Chiang et al., 1977), the preparation of soluble precursors to the rather intractable polyacetylene (Edwards et al., 1980), and the discovery of soluble (i.e., processable) electronically conducting polymers (Jen et al., 1985; Inganas et al., 1988; Angelopoulos et al., 1988). Applications for electronically conducting polymers include antistatic materials, battery electrodes, reinforcing fibers for composites and, recently, as the active layer in a light-emitting diode (Friend et al., 1990).

New synthetic chemistry has brought into existence a wide range of new polymer structures that have played a key role in the development of the field. The highlights below focus on research in phthalocyanines and polyanilines, and the use of organometallic catalysts in the synthesis of polymers with delocalized electronic states.

Phthalocyanines. In considering various chemical systems with delocalized electronic states, interest in phthalocyanines (see Figure 1) stems from their robust thermo-oxidative stability and the ability to be "processed"; i.e., sublimed to form thin films. Representative of work in this area is the demonstration that fluoro(phthalocyanato)aluminum(III) and

gallium(III) can be partially oxidized with iodine or nitrosyl salts to conducting (to 3 S cm^{-1}) compositions (Kuznesof et al., 1981; Brant et al., 1985).

$(PcMF)_n + 1/2nI_2 \rightarrow (PcMFI_x)_n$
Equation 1.

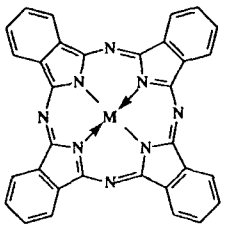


Figure 1. Phthalocyanines

Thermal stability in excess of 100°C was realized depending on the anion present in the solid. Vibrational spectroscopic data on $(PcMFI_x)_n$ and x-ray structural data on the neutral precursor PcGaF (Wynne, 1985) led to a structural model whereby conductivity occurs through a conduction band formed by the overlapping π-systems on the Pc rings. The anions form columns parallel to the stacking direction.

To obtain improved processability for a phthalocyanine-based conducting material, advantage was taken of the solubility of phthalocyanines and poly(p-phenylene terephthalamide) (Kevlar®) Wynne et al., 1985). Thus, extrusion and coagulation of concentrated solutions of poly(p-phenylene terephthalamide) and copper phthalocyanine in trifluoromethanesulphonic acid yields darkly colored fibers of Ni(Pc)I_y/(x)Kevlar, where y is the I:Ni mole ratio and x is the Kevlar-formula-unit:Ni mole ratio. Good conductivity and strength was observed for these materials (Inabe et al., 1984).

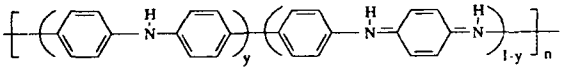
Professor John D. Wright, University of Kent, presented his work on the characterization of metallophthalocyanine polymers for application as semiconductor gas sensor materials. This application depends on the enhancement of semiconductivity by charge-transfer interactions with electron acceptor gases, which reduce the activation energy for charge carrier generation. Professor Wright's research has shown that the form and degree of purity of the metallophthalocyanine influences gas-sensing properties. This research focused on conductivity changes that occur on exposure of phthalocyanines to gases such as NO_2. Experimental conditions were described for achieving reproducible kinetics for the conductivity increases observed on exposure to NO_2 and for optimizing the operating temperature and minimizing interference effects in sensors based on these materials.

Professor Roeland Nolte, Department of Chemistry, University of Nijmegen, the Netherlands, discussed the conceptual design and preparation of materials wherein the molecular units are synthesized separately. In a subsequent step, they are organized to form a supramolecular system; i.e., an ordered system of the molecular units. He described his work using metallophthalocyanines (MPc) as the building blocks. These supramolecular assemblies are related to the materials described above wherein coordinate covalent bonds were used to organize "stacks" of Pc "poker chips" about a spine. In the case of Nolte's supramolecular assemblies, organization is effected through forming liquid crystalline phases or through metal ions bound to the periphery of the cyclic system.

To cause self-assembly to take place and the concomitant formation of a liquid crystalline phase, phthalocyanines are prepared that have eight long alkoxy tails attached to the periphery of the ring. Above about 80°C, these molecules form columnar mesophases that show enhanced electronic conductivity (0.1 S cm^{-1} by a microwave technique). Polymerization of the liquid-crystalline phthalocyanines in their mesophases leads to supramolecular structures in which the columnar organization is fixed. These structures have retained their electrical properties.

In the second procedure, stacking is realized with the help of crown ether rings that are attached to the phthalocyanine molecules. Addition of metal ions with diameters exceeding those of the crown ethers induces the formation of linear stacks of metallophthalocyanines. Charge transport within these stacks depends on the size of the added metal ion. Thus, from complex impedance measurements modeled by equivalent circuits, it was determined that with K^+, electronic conduction occurs without significant ionic conduction. In contrast, Cs^+ and Rb^+ show ionic conduction without electronic conduction.

Polyanilines. The polyaniline family of polymers has been known for many years (Green et al., 1910). Synthesis is straightforward compared to most electronically conducting polymers, and the monomers, aniline, or substituted anilines are readily obtained at low cost. The base form of polyaniline polymers is described by Figure 2.



reduced unit 2a **oxidized unit 2b**

Figure 2. Base form of polyaniline polymers

The oxidation state of the polymers is defined by the value of (1-y). The commonly used synthetic procedure utilizing aniline and persulfate in water yields the "emeraldine" state where y is approximately equal to 0.5 (MacDiarmid et al., 1985). The electronic conductivity of polyaniline may be controlled electrochemically by varying the oxidation state of the polymer or through localization of electron density on nitrogen through the formation of N-H (*protonic doping*) or N-C (alkylation) bonds.

An important recent discovery showed that emeraldine polymer is soluble (ca. 4 percent by weight) in N-methyl-pyrrolidinone (Angelopoulos et al., 1988). This finding allows solution characterization of the polymer and the preparation of films and fibers. Remarkably, it has been reported that the polymeric emeraldine base and emeraldine hydrochloride can be sublimed to give films with solid-state properties similar to the parent polymeric base (Angelopoulos et al., 1988).

The ready synthesis in water of high molecular weight (MacDiarmid et al., 1989) polyaniline through oxidative coupling is an interesting example of progress in polymers with electronically delocalized electronic states. Functionalized polyanilines can be prepared by several methods (Manohar et al., 1989; Yue et al., 1990) and the area promises to continue providing important new contributions to chemistry, physics, and technology.

Ring-Opening Metathesis Polymerization. As noted above, polymers with delocalized electronic states are often insoluble materials that decompose at temperatures below their melting point. This intractability may be dealt with through the synthesis of a soluble precursor polymer from which the desired polymer may be obtained thermally, photolytically, or in some other way.

The first precursor route to conducting polymers was the Edwards and Feast synthesis of polyacetylene (Edwards et al., 1980). This work demonstrated that organometallic catalysts are valuable in the synthesis of conjugated polymers via ring-opening metathesis polymerization (ROMP). Importantly, unlike most olefin polymerization reactions, double bonds are preserved in ROMP. While ROMP is not a new synthetic method, increased potential has been realized recently through the synthesis and use of new active non-Lewis acid catalysts (Grubbs et al., 1989). An example of the utility of ROMP is the synthesis of poly(benzoquinone) (PBQ) (see Figure 3). Although the quinone group is incompatible with the ROMP catalysts, a successful route was found via the bisketal monomer (Swager et al., 1990).

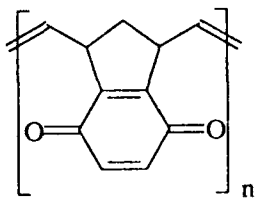


Figure 3. Synthesis of poly(benzoquinone)

These results show that organometallic catalysis can provide polymers with delocalized structures that could not be prepared by other methods. The polyquinones are presently under study to evaluate their potentially interesting charge storage properties.

Silicon Containing Polymers

There is a resurgence of research interest in polymers containing silicon in the backbone or as a pendant group. This stems partially from the lithographic applications of silicon-containing polymers and their use as reactive-ion etch-resistant resists. Such applications depend on the difference in reactivity with oxygen between silicon-containing polymers and organic polymers. Organic polymers are converted to CO_2 on exposure to an oxygen plasma, while silicon containing polymers convert in part to SiO_2, which protects an underlying material from attack. In addition to utilization as resists, polysilanes have interesting optical properties as a result of $\sum$ delocalization of electron density in the -Si-Si-polymer backbone. Another interest in research on silicon-containing polymers is their utility as preceramic polymers; i.e., polymers that undergo conversion to ceramic products such as SiC or Si_3N_4 on pyrolysis (Wynne et al., 1984).

Professor Claude Biran, University of Bordeaux, described her work on the electrochemical synthesis of SiC precursors including polysilanes (-Si-Si-backbone) and polycarbosilanes (-Si-C-backbone). Professor Biran used a sacrificial anode (Al) process in a metal tetrahaloaluminate electrolyte. In a model reaction, trimethylchlorosilane was converted to the disilane in 74 percent yield. Polysilanes were prepared through the electrolysis of diorganodichlorosilanes. In this way, poly(dimethylsilane) was prepared in 47 percent yield. Molecular carbosilanes could be prepared from the electrolysis of $ClCH_2Si(CH_3)_2Cl$. The products depended on current density. This work is important in giving a straightforward synthetic route to materials that are prepared conventionally with difficulty.

Professor Robert J.P. Corriu, University of Languedoc, Montpelier, presented his research which is aimed at the preparation of poly(alkylene silanes). He used intermolecular hydrosilation shown in equation 2 to obtain the poly(silylene-ethylene) shown.

$$Cl_2SiHCH{=}CH_2 \xrightarrow{Pt(cat)} [\text{-}SiCl_2CH_2CH_2\text{-}]_n \xrightarrow{LiAlH_4} [\text{-}SiH_2CH_2CH_2\text{-}]_n$$

Equation 2.

Most of the hydrosilation reaction gave the α addition polymer, but some β addition was observed. Both the solvent and the nature of the catalyst are important in controlling the α-to-β ratio. For example,

platinum on carbon gives 90 percent ∝ addition, while platinic acid yields 50-75 percent ∝. Solvent strongly affects the degree of polymerization with much higher molecular weights obtained in toluene than in chlorohydrocarbons.

This is an interesting polymerization route to carbosilanes structurally similar to the famous polymers prepared by Yajima (Yajima et al., 1981). The latter are believed to be used as precursors for Nippon Carbon Nicalon® silicon carbide fibers.

Professor J. Moreau, University of Languedoc, Montpelier, presented work aimed at incorporating silicon into polymers with delocalized electronic states. This research made extensive use of di-lithium reagents reacting with R_2SiCl_2. Several novel polymers were prepared in this way, though the molecular weights tended to be rather low. For example, the reaction of the lithiated diaryl silane, $(p\text{-}Li\text{-}C_6H_4)_2SiMe_2$ with dimethyl dichlorosilane gave the polymer $(\text{-}C_6H_4SiMe_2\text{-})_n$ with a molecular weight of about 4,000 amu. Clearly, better synthetic methods must be devised to synthesize these interesting macromolecules before their potentially interesting electronic and physical properties can be exploited.

Professor John Harrod, McGill University, Montreal, Canada, reported a similar problem with lack of polymerization to high polymers. Professor Harrod discovered an interesting catalyzed polymerization of trihydrido silanes.

$$RSiH_3 \xrightarrow{CpTiMe_2} (RSiH)_n + 1/2\ H_2$$

Equation 3.

Polymer is the kinetic product in this reaction, with other molecular species being produced at longer reaction times. Unfortunately, this most interesting and potentially important polymerization reaction is not very general, and leads to average chain lengths under the best of conditions of only about 10. There is very vigorous activity in the organometallic community underway to understand the mechanism of this reaction so better catalysts can be designed that will specifically effect Si-Si bond formation without parasitic reactions such as Si-C formation or scrambling.

Oxo-Polymers

As the interest in oxide ceramics and related materials increases because of optical, tribological, and structural applications, research is intensifying on the use of oxo-polymers and oligomers as precursors to metal- and metalloid-oxide ceramics.

In this vein, Dr. Clement Sanchez, Universite Pierre et Marie Curie, Paris, described the synthesizing, characterizing, and processing of some very interesting metal alkoxides. This work is related to the classic sol-gel approach to ceramics using silicon alkoxides. Sanchez' work is with titanium-group alkoxides, which react with alcohols much faster than silicon tetra-alkoxides. Among the problems addressed in this laboratory is the control of this reactivity through coordination chemistry. Thus, the presence of nonreactive coordinating ligands moderates the reactivity of titanium alkoxides and allows the controlled preparation of gels and ceramics. In particular, in the hydrolysis of the zirconium complex (see Figure 4) the coordinating group (O----O; e.g., acetylacetonate) finishes on the outside of the growing cluster. Thus the size of the polymeric cluster (sol) can be controlled by controlling the amount of coordinating ligand present. The greater the proportion of coordinating ligand, the smaller the particles that are prepared. The size of the polymer (sol) particle thus controls the size of the ceramic particle derived therefrom. This approach provides an important route to ceramic particles of controlled composition and ultrastructure.

Conference organizer, Professor Richard Laine's contribution was in this area. Professor Laine has been investigating using SiO_2 directly as a chemical reagent for the preparation of tractable inorganic polymers.

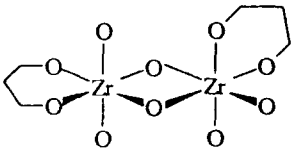


Figure 4. Zirconium complex

His research has shown that under basic conditions, SiO_2 reacts with ethylene glycol to form anions of defined composition. The nature of the anion depends on the alkoxide ligands present, but the salts are soluble in methanol.

Summary

This meeting covered several important areas in inorganic and organometallic chemistry. Important progress was reported in the synthesis of new polymers and solid-state materials. Results on the characterization of the new materials show that new capabilities may result from developments in this area.

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OCEANOGRAPHY

Scott Polar Research Institute at Cambridge University

by J.P. Dugan. Dr. Dugan is an oceanographer currently serving as a Liaison Scientist for Physical Oceanography in Europe and the Middle East for the Office of Naval Research European Office. Previously he formed and directed the Field Measurements Department for Arete Associates. Earlier, he was at the Naval Research Laboratory, Washington, D.C.

Introduction

The Scott Polar Research Institute (Institute) in Cambridge, United Kingdom (U.K.), was established in 1920 to record the many important findings of the previous century of British exploration in the polar regions and make them available to the public. Located in a single building near the center of Cambridge, it is a combination of a research laboratory, a library, and a museum. The museum dominates the entry to the building and it displays an impressive store of valuable items including photographs and relics from polar explorations. The library is the first and largest library in the world of polar affairs (more than 50,000 volumes). Also available is a very large collection of published and unpublished material including the papers, photographs, maps, logs, and notes of many major and minor polar explorers. The research topics that the Institute presently undertakes are a mix of historical matters associated with the polar regions, peoples, and current issues in the physical and social sciences.

Besides the research and the archival activities, the Institute is a major educational center for polar affairs. The Institute is a department of the University of Cambridge, and it offers graduate and undergraduate courses and seminars. The Master of Philosophy (M.P.) degree in polar studies focuses on polar policy and socioeconomic matters, and a Doctor of Philosophy (Ph.D.) degree is given in any of the specialties of the research groups. Typically, there are about 15 Ph.D. students and several degree candidates each year. The Institute welcomes visiting experts, researchers, and lecturers. A typically British institution, it organizes lectures of interest to the general public. A traditional Saturday night series of lectures is very popular with the Cambridge populace. In addition, the Institute frequently invites experts to lecture on special topics and runs many colloquia, workshops, and conferences on an impressively wide range of subjects.

The Institute also publishes several periodicals and books. *The Polar Record* is a quarterly publication of general interest featuring articles on current research and contemporary developments in several fields. In addition, the Institute publishes an abstracting service called Polar and Glaciological Abstracts with the World Data Center for Glaciology and it produces the bibliographical resource SPRILIST. This is a very good search service and will be available electronically in the future. Many books published by the Institute have fully documented the polar expeditions and their findings. More recent publications have addressed the ecology, history, and sociology of polar regions and peoples.

Research Groups

Dr. Peter Wadhams is the Director of the Institute. There are a half dozen research groups; the following are in the physical sciences:

- Sea Ice and Polar Oceanography Group - Headed by Dr. Robin Williams; concentrates on ice thickness observations and statistics, ice motion theory, and observations
- Glacier Geophysics Group - Headed by Dr. Julian Dowdeswell; concentrates on the behavior of large ice masses and their interactions with the marine environment
- Remote Sensing Group - Headed by Dr. W. Gareth Rees; focuses on measurement theory and technology of ice and snow by airborne and spaceborne sensors.

Other groups are Social Sciences and Soviet Northern Affairs, Polar Ecology and Management, and Polar History. The Librarian is Mr. William Mills. He has located important references for me on several occasions. The university supports six faculty members; funding for the remainder of the 70-odd staff members is external.

Standing costs are met through grants from the university, Her Majesty's Government, other Commonwealth governments, and industry. The major sources of research grants are the U.S. Office of Naval Research (ONR), the U.K. Natural Environment Research Council, and the Ministry of Defence (formerly the Admiralty Research Establishment). The total annual research budget is about $2 million. This annually supports about 60 publications in scientific journals and books annually.

Research Activities in the Sea Ice Group

The Institute is the leading Western institution in studies of the morphology of sea ice with its long history of active work in remote and *in situ* sensing of ice thickness. Researchers are very active in remote sensing of the bottomside by acoustic means and the topside by electromagnetic means. The bottomside-work has incorporated instruments mounted on nuclear submarines of the British fleet. A vertical acoustic range finder, or topsounder, has been used for many years to provide one-dimensional time series of the ice draft as the submarine transits beneath it. These data have been used for statistical distributions of ice thickness, leads, and distance between ice keels. More recently, a side scan sonar mounted upside down on a submarine has been used to provide two-dimensional images of the underside of the ice. This work has benefitted safe operations under the ice, and clearly leads U.S. efforts in this area. The airborne remote sensing of sea ice which began with measuring the freeboard with a laser altimeter, has progressed to using airborne and spaceborne synthetic aperture radars (SAR) for ice reconnaissance. A current research program utilizes the SAR that was recently launched on the European Space Agency's ERS-1 satellite.

There is a long-standing scientific issue concerning the sensitivity of the gross properties and distribution of ice in polar regions upon climatic changes. For example, are changes in the volume of Arctic sea ice an indicator of climatic change? This question is complex because sea ice is such a complicated material. The physical structure changes markedly over short distances because of differential motions forced by the atmosphere and ocean. Marine observations are a valuable source of data to resolve this issue and improve the understanding of ice properties. While the acoustic work has provided information on the bottom of the ice, the airborne and spaceborne work has provided information on the top. There are preliminary indications from analyses of this group that there is a strong correlation between the statistics of the two. If this withstands further scrutiny, airborne observations promise new methods of long-term monitoring of ice conditions both for navigational use and long-term changes related to the climate of the earth.

A second area of unequaled expertise concerns the propagation of oceanic swell into the ice pack and other sources of motions of the ice (see the accompanying article "The Music of Sea Ice"). The Sea Ice Group has made many observations of these motions from sensors on the ice and from ships in the ice. In recent years, measurements have been made during international expeditions such as the Coordinated Eastern Arctic Experiment (CEAREX) and the Weddell Ice Dynamics Experiment. Tiltmeters and strainmeters are used to measure the motions caused by the swell, internal waves in the thermocline below the ice, and ridging events as the floes interact. A unique data set was acquired during CEAREX in which a large amplitude internal wave was observed to pass beneath the instrumented floe. The water motions associated with this wave clearly tilted the surface a measurable amount and the observation confirms Soviet claims to have measured these waves many years ago. However, the strain of the ice surface that must accompany this motion was not readily observed because of other sources of noise in the strain data. Determining which physical mechanisms are responsible for this additional noise remain a puzzle to be sorted out in future research.

An important recent contribution of the ice dynamics work is a Ph.D. thesis by P. Rottier on wave/ice interactions in the marginal ice zone and the generation of ambient noise. This work provides a physical model for the generation of acoustic noise in the marginal ice zone, explaining in part the increased noise level that is sometimes observed near the ice edge. Research associated with the mechanics of sea ice is expected to continue in an ONR Accelerated Research Initiative on Ice Mechanics.

Research Activities in the Glacier Geophysics Group

The Glacier Geophysics Group works on the behavior of large ice masses and their interactions with the marine environment and climate. Major activities focus on field studies, and these studies are often in collaboration with other organizations. As in many areas of science, this work has benefitted from recent innovations in methodology and several glaciological dynamical

processes are being successfully researched. For example, airborne radio sounding has become a powerful tool for surveying glacier masses. The results of these surveys are used for morphological studies as well as for research on dynamic processes. The dependence of bed slope and the subglacial substrate on the flow and of periodic multiyear surging are specifically related to understanding glaciological processes.

Of particular marine interest is research on the processes and rates of production of icebergs by glacier calving. These are being studied by sequential airborne and satellite imagery of glaciers on Svalbard and Greenland. Consequently, this work is providing some of the first quantitative data on the rates of production which is important for heat and fresh water fluxes in the sub Arctic Seas.

Research Activities in the Remote Sensing Group

Remote sensing of polar regions by airborne and spaceborne instruments has advanced markedly in the last two decades. New techniques avoid the difficult logistical problems of exploration on the surface. However, they also provide the benefit of a larger perspective that immensely improves the approach to understanding some problems. Measurements of various atmospheric and surface conditions can be made during the dark months as well as in light. Also, some measurements can be made through clouds.

The research programs in the Remote Sensing Group use known techniques to support other research groups. Additionally, they develop new techniques in electromagnetic sensing and image processing. Field data are available from many types of sources, and satellite systems now provide common data sets to many users. As an example, a joint project with the Glacier Geophysics Group uses data from the ERS-1 satellite to study the form, condition, and mass balance of the Greenland and Nordaustlandet ice sheets. The radar altimeter provides altitude of the surface; the SAR provides surface texture; the scanning radiometer provides temperature.

The Remote Sensing Group also is collaborating with the Sea Ice Group in using the ERS-1 SAR images to provide observations on the distribution and dynamic behavior of sea ice in both polar regions. There is much interest in techniques of using consecutive images to study the motion of pack ice, both in gross speed and direction and in smaller scale strains within the pack. The internal strain causes pressure ridging if the motion is compressive and causes the opening of leads if it is dilatory. These processes are of particular interest for navigation and predictions of noise generation. There have long been predictions that a SAR will be operationally useful for these problems, but there is little solid evidence nor any operational experience. For example, precise mapping of open or recently refrozen leads and subsequent optimal ship routing is expected to benefit shipping in ice-covered regions. Also, charting of regions of active pressure ridging is of naval interest because they are expected to be acoustically noisy. The potential benefits are important enough that these applications of the SAR data are also being studied by other organizations. Several in the U.S. include the Naval Oceanographic and Atmospheric Research Laboratory, Bay St. Louis, Mississippi, the Environmental Research Institute of Michigan, Ann Arbor, and the Jet Propulsion Laboratory, Pasadena, California. Although there is apparently some duplication of effort in this area, there are many research ideas and specific algorithms to be tested, and there are many locations to be studied.

The Remote Sensing Group is also pursuing an interesting application of inverse methods for image generation. The problem is the refraction of electromagnetic energy by gradients in the index of refraction. This occurs in visible wavelength remote sensing, radio echo sounding of ice sheets, navigation and imaging radars, as well as marine acoustics. The most dramatic occurrence is when the energy travels nearly horizontally in a vertically stratified medium like the atmosphere or ocean. The forward problem of calculating the image is straightforward, given the index of refraction profile. However, in many of these applications, the profile is not known in advance. The challenging problem is to estimate the profile from the data in such a way as to improve the quality of the image. Encouraging results have been obtained for an iterative technique that has been applied to cases of terrestrial images where the imaging system encounters a relatively simple index of refraction profile.

New Research Programs in the Sea Ice Group

New programs of the Institute have two dominant themes. These are (1) the impact of increased international interest in world climate, and (2) the opening of Soviet boundaries. For example, an agreement has been reached with the Soviet Hydrometeorological Office and the Arctic and Antarctic Research Institute (AARI) in Saint Petersburg to collaborate on sea ice and glaciological processes in the Arctic. In addition, the Institute is one of three western institutions (the others are Woods Hole Oceanographic Institute, Falmouth, Massachusetts, and the Fridtjof Nansen Institute, Oslo, Norway) to participate in a project to study the northern sea route under the auspices of the Soviet Ministry of Merchant Marine. The challenging goal is to open the northern sea route to year-round and western usage. The project

incorporates studies of sea ice and climatic conditions, economic and technical feasibility of usage, and political and legal factors. Hopefully, the project will give the institutions access to once closely held Soviet research and operational information.

The Scoresby Programme is another upcoming Institute project. This British research effort includes several universities to study the physical, chemical, acoustical, and biological properties of the ocean in the marginal ice zone in the Greenland Sea in spring 1993. Observations are scheduled to take advantage of other international participants in the Greenland Sea Project having its last intensive measurement period in the same general location and time frame.

Special Seminar

Because of the interactions with the Arctic and Antarctic Research Institute (AARI), the well-known Soviet ice mechanics expert Dr. V.N. Smirnov of AARI recently visited Scott Polar Research Institute (see accompanying article, "The Music of Sea Ice"). (I was fortunate to participate in discussions of collaborative research on ice dynamics between the two institutes.) Smirnov is a leading Soviet scientist on the physics and mechanics of sea ice and is the Head of the Laboratory of Ice Physics at AARI. While at the Institute, he presented an invited lecture on his group's observations of several different mechanisms causing vibrational motions of sea ice. This work is expected to continue soon in coordination with Dr. Wadhams. During the AnZone Program in spring 1992, the groups will measure motion and strain during the Weddell Sea drift camp along the Antarctic Peninsula.

Connections with British Antarctic Survey in Cambridge

The Institute has several unofficial connections with the British Antarctic Survey (BAS) in Cambridge. Because of the Antarctic Treaty, the Falklands War, and (former) Prime Minister Margaret Thatcher's interest in the Antarctic, BAS has a much larger government funding base than does the Institute. The BAS is nearly one order of magnitude larger than the Institute. However, because of its emphasis on the Antarctic (specifically on climatic issues; e.g., the ozone hole) and on necessary station support activities, focused research on sea ice is less active than at the Institute. An example of collaborative research between the two institutions is work by Dr. Swithinbank of the Institute on a digital cartographic data base of Antarctica which is supported by BAS. For further information, contact

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The Music of Sea Ice--Ice Vibrations Seminar at Cambridge University

by J.P. Dugan

Introduction

Dr. Peter Wadhams, Director, Scott Polar Research Institute (the Institute), invited me to participate in an ice vibration seminar at the University of Cambridge. The meeting honored the visit of the distinguished Soviet ice physicist, Dr. Victor N. Smirnov, head of the Laboratory of Ice Physics of the Arctic and Antarctic Research Institute (AARI) in Leningrad. The purpose of the 1-day meeting was to exchange views on current research on ice motions and to plan future research activities. As a special attraction for the students at the Institute, both Drs. Smirnov and I lectured on results of our recent research on ice vibrations.

In this context, the term "vibrations" is used synonymously with, or often substituted for, the word "motions." This terminology is used here because the subject under scrutiny is the vertical movement of the ice, not the horizontal drift of the ice pack as the term "ice motion" often connotes to most Navy personnel and ice researchers.

Drs. Wadhams, Smirnov, and I have made extensive observations of the vibrations of pack ice in the Arctic. Dr. Smirnov and his group have reported measurements of ice vibrations caused by internal waves in the ocean and to floe interactions. Dr. Wadhams and his group have reported measurements and developed models of swell propagating into pack ice in the marginal ice zone and of wind generated motions in pack ice. My group and I have observed vibrations caused by swell, wind, floe interactions, and fracturing events.

Unique Opportunity

The original purpose of this article was to summarize what occurred at the meeting with emphasis on the scientific contributions by Dr. Smirnov and his group. However, the meeting of these noted Eastern and Western scientists was an unusual occurrence that provided a particularly good opportunity to review the state of knowledge concerning all known mechanisms causing vibrations of sea ice. Since research activity has been diverse and there is no available review of this topic, I have expanded the scope to provide a short, comprehensive review of these processes emphasizing observations in the Arctic. Unavoidably, it exhibits a slight bias toward the contributions of those attending the meeting. While references are provided for further reading, no claim is made that this list is all-inclusive.

The Motion Spectrum

A useful focal point for discussion of vibrations of pack ice is the spectrum of motions (see Figure 1). The vertical axis is variance density of vertical velocity of the ice surface and the horizontal axis is the frequency of the motion. The several curves in the figure are representative of the energy levels caused by the specifically identified processes which cause the motions. They are:

- Very low-frequency waves
- Internal waves
- Swell
- Wind
- Flexural waves caused by floe interactions
- Acoustic waves or "sound" in the water and ice.

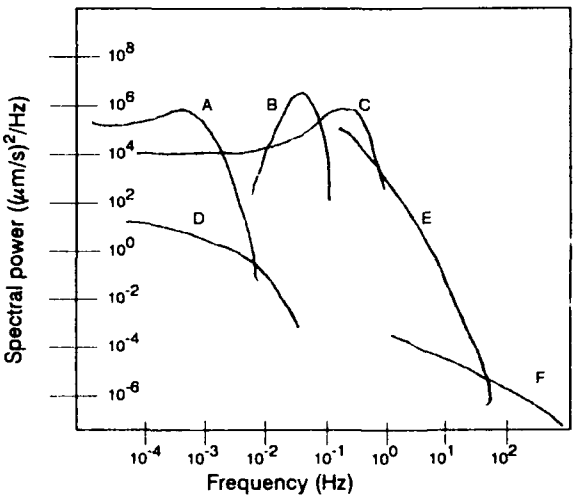

Figure 1. Model spectrum of vertical velocity of ice surface. Curves from various theories and observations: (a) internal waves, (b) swell, (c) wind turbulence, (d) water turbulence, (e) flexural waves from ridging, (f) acoustic waves in the water from farfield fracturing and thermal fracturing.

The last category includes several identified sources, specifically floe interactions, thermal cracking, and wind blown ice crystals. In the following sections these identified vibration mechanisms are discussed in turn.

Very Low-Frequency Waves

Very low-frequency vertical motions of the water surface are caused by tides and mesoscale water motions; i.e., ocean eddies. Well-quantified, low-frequency measurements in the Arctic are scarce because of the limited timespan of most periods of observation. The motions exhibit spectral lines at the M2 lunar frequency of about 1/12 cycle/hr and other natural periods associated with polar tides. The amplitude of the tides are dependent upon specific location and in the open Arctic Ocean are typically tens of centimeters. In addition, there is a low-frequency rise in the spectrum caused by eddies that also cause 10-cm vertical surface deflections as they move past the instrumented floe. The ice simply moves up and down with the water surface at these low frequencies.

Internal Gravity Waves

Dr. Smirnov first identified a low-frequency source of waves in the ice as being internal gravity waves (IW) propagating in the density stratified ocean below the ice. A seminal paper in 1972 discussed the mechanism and provided samples of the ocean thermocline and ice motion data. He terms these waves "slow waves" because they propagate so slowly compared with ocean swell or elastic waves. This mechanism has been a recurring subject in Soviet papers since the early 1970s.

These waves have been measured by using seismographs frozen into the surface of the ice. These are pendulum-type accelerometers. The sensors essentially measure the slope of the surface at these low frequencies since the tilt in the gravity field of the earth usually dominates other accelerations. According to Dr. Smirnov, the waves

- Are long (probably 1 km or longer)
- Travel long distances (though how long has not been established from the observations) at 1-2 m/s
- Cause vertical motions of the ice of 1-10 mm in amplitude.

The IWs would have to be longer than several hundred meters to affect the surface appreciably because of exponential dependence of the evanescent decay of the wave motion in the typical mixed layer of about 50-m depth. Also, the wave amplitudes in the pycnocline would be expected to be 1 m to move the surface 1-10 mm. These observations are consistent with what is known about IWs in the stratified ocean below the ice in the Arctic (Levine et al., 1987), so these observations provide no surprises. The length of these waves is so large that the flexural rigidity of the ice is not important. Therefore, the presence of the ice is immaterial. The waves simply move the surface up and down hydrostatically as they would move the free surface in the open ocean. Observations regarding the directional properties of the waves are scant.

The Arctic Sciences Program in the Office of Naval Research (ONR) supported the Arctic Internal Wave Experiment (AIWEX) in spring 1985 in the Beaufort Sea north of Alaska. The experiment's objective was to quantify the level of IW activity in the pycnocline and the associated ice motion. Waves were observed in the ice tilt data which probably were caused by IWs, but the association is more circumstantial than direct. In a more recent ONR experiment, the Coordinated Eastern Arctic Experiment (CEAREX) north of the island of Svalbard, there was a very clear example of a large amplitude IW group in the ocean temperature measurements which also is apparent in the ice motions (Williams et al., 1990). This wave group was traveling northward away from the nearest underwater topographic feature. This is a very clear IW signal that locally dominates other signals, but it remains uncertain just how much of the ice motion energy under average conditions is associated with IWs.

Note in the figure that the IW signal has a peak near $3x10^{-3}$ Hz, which is a typical maximum value of the Vaisala frequency profile in the upper pycnocline. The spectrum is flat toward lower frequencies because previously observed spectra of vertical water motions in the ocean thermocline indicate this. Thus, presuming the ice motion is caused by these waves, it must have the same general form, with perhaps minor changes caused by the details of the vertical wave number structure of the IWs.

Measurements to date have not made a convincing case that they are associated with IWs. It is not certain that the average level of the spectrum is caused by IWs, but rather, exhibits significant contributions from other processes. Moreover, measured spectra of ice strains in this frequency range by personnel from the Institute and the U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, are not obviously related to IWs.

Surface Gravity Waves

All low-frequency motion observations in the Arctic exhibit a sharp spectral line in the frequency band of 0.03-0.05 Hz which is caused by swell from the open ocean. Surface gravity waves that are generated by the wind outside the ice-covered ocean propagate into the ice and all motions having frequency above about 0.1 Hz are heavily dissipated. This bounding frequency occurs because higher-frequency waves must flex the ice, causing various dissipation mechanisms to occur. This

suppresses the waves (Wadhams 1973; Wadhams et al., 1988). On the other hand, lower-frequency components (25-30-sec wave period) do not flex the ice appreciably and the waves propagate practically unattenuated throughout the Arctic (Hunkins, 1962; Dugan et al., 1991). These waves have been observed, for example, in the Beaufort Sea, which was a long distance from the open ocean at the time of the observations. The longest waves apparently propagate into the pack from the East Greenland Sea. They spread throughout the Arctic just as low-frequency swell from great storms in the Antarctic has been observed in the northern hemisphere.

Wind Waves

The wind can generate waves locally, but only on thinner ice. Even then, the waves cannot travel far into the surrounding pack which is made up of thicker floes. This effect was first noted by Hunkins (1962) and studied more recently by Crocker and Wadhams (1988). This motion is caused by pressure fluctuations associated with eddies in the turbulent atmospheric boundary layer which are carried downwind at the mean windspeed (DiMarco et al., 1991). If the windspeed is less than the minimum phase speed of flexural gravity waves, the longer wavelength pressure fluctuations associated with the turbulent eddies simply move the ice up and down quasistatically as the eddies are advected downwind. This mechanism is termed subcritical, and small motions are generated by the wind on all sea ice.

However, if the windspeed is greater than the minimum phase speed of flexural gravity waves, wave motions are generated resonantly near this speed in a situation that is termed super critical. The critical speed is proportional to ice thickness, so the resonance always first occurs on thinner ice. The peak in the spectrum in Figure 1 near 0.2 Hz is an example for first year refrozen lead ice of 0.5-m thickness and a mean windspeed of 10 m/s. These waves are generated efficiently, so they can get quite large on the thinner ice of refrozen leads. The waves are able to propagate a small distance into the surrounding multiyear floes before they are dissipated by the bending of the ice discussed previously.

In theory, a similar mechanism must occur for turbulence in the water boundary layer below the ice. Just as for the atmosphere, the water pressure fluctuations move the ice quasistatically as eddies are swept past the ice by the mean current. In this case, mean waterspeeds are very slow, so the mechanism is always subcritical. The ice velocity variance varies as the third power of the waterspeed past the ice (see DiMarco et al., 1991). A modeled value of the spectrum is provided by curve D in Figure 1. The ice velocity is not significantly below the level of measured ice motions if the waterspeed is greater than 0.3 m/s. In fact, this turbulence mechanism is conjectured to set the spectral level in the "spectral gap" between the swell and IW peaks when little wind is present.

Floe Interactions

The ice cover in the interior of the Arctic Ocean does not move around as a solid surface, but experiences periods of dilation and compression caused by stresses from wind and currents. Under dilation, the ice opens up leads of water which refreeze very rapidly in the winter providing areas of thinner ice. Upon compression, the thinner (and sometimes thicker) ice is broken up and rafted or piled into ridges. This process is very noisy and presumably accounts for much of the noise in the Arctic Ocean (Pritchard, 1984). This process is event-like or intermittent, as it typically only occurs for short durations from minutes to hours. Accompanying changes in the motional energy level on instrumented floes can be very high. The level shown in the figure is for a reasonably active period of time, but the level often can be reduced by many orders of magnitude during quiet periods.

If ridging activity occurs on the margins or interior of the instrumented floe, vertical motions are high in the frequency band of 0.2-10 Hz as shown in the figure. The motions propagate across the floe as flexural waves (Dugan et al., 1991). Presumably, the waves are so highly energetic because the buckling process that occurs during the ridging is flexural and causes large vertical excursions of the ice when it fractures. These waves are coupled to the ice-water-air interface just as surface gravity waves are coupled to the surface of the ocean. Therefore, they do not directly propagate into the water column below the ice. On the other hand, much energy in the form of pressure waves is propagated into the water as "sound" by the fracturing mechanism. If ridging is occurring only on floes some distance from the instrumented floe, the motions in the frequency band below 10 Hz are much reduced. However, all frequencies within an octave or two of 10 Hz are energized by the sound propagating through the water to the instrumented floe.

Another source of these flexural-gravity waves has been iceberg calving events as observed in the Antarctic (Smirnov and Lin'kov, 1967). In retrospect, this is not surprising because of the large vertical motions that commonly occur during such events.

Dr. Smirnov has published interesting observations of events of "high Q" motions having center frequency near 0.5-1 Hz (Bogorodskii and Smirnov, 1980). Typically, the duration of the events is several minutes or longer. The term "high Q" is mine--the spectral peak is more than ten times the bandwidth. There also is a harmonic in the published data, but it is apparently caused by some nonlinearity in either the sensor or recording system.

These wave groups have been observed in both the Arctic and the Antarctic. Dr. Smirnov calls these motions "relaxation self-excited oscillations." The waves must be elastic since they travel faster than 1 km/sec, a speed that was established by using a three-element triangular array of sensors 1-km apart. The particle motions and phase are such that they appear to be shear, horizontal polarization (SH) waves. These have major axis of motions in the horizontal plane and perpendicular to the direction of propagation. Dr. Smirnov postulates that the generation mechanism is slippage of one floe past another while in compression. The term "stick-slip" (a popular term in fracture mechanics) was used during the presentation. This hypothesis is plausible since some horizontal and lateral shear would be necessary to generate the motion in an SH wave.

Details concerning the generation mechanism of these waves are not particularly clear, but the measurements are interesting enough to suggest they be repeated. This particular type of wave has not been identified by other observers, although I once observed recurring "high Q" oscillations near 1 Hz in an accelerometer measurement system after being installed on the ice and while being tuned up. At the time, the oscillations were attributed to unstable high-gain amplifiers. In retrospect, they might have been an example of this type of wave. Some confusion necessarily occurs in this frequency range because accelerometers respond to both tilts and lateral accelerations.

Sound

In the frequency band higher than about 10 Hz, the ice exhibits several types of motion associated with the propagation of elastic waves. The motions may or may not be purely compressive as in sound propagation in the water.

As noted above, interaction events on the margin of the instrumented floe probably generate energetic, high-speed (order several km/sec) elastic waves in the ice. However, their presence often is dominated by the very large amplitude flexural waves that also are generated in the same frequency band. The acoustic waves are launched both directly into the water in the vicinity of fractures (Buck and Wilson, 1986) and into the ice along the surface. The waves that are launched into the ice plate leak out into the water because of the slower phase speed there. Consequently, the combination of these source mechanisms introduces considerable sound into the water column. Sound in the water is detected by vibration instruments on the ice in cases where the fracturing occurs on floes removed from the instrumented one.

In addition, there are two processes that commonly occur on Arctic ice which efficiently generate acoustic waves but not flexural waves, so the acoustic modes are evident. When the ice surface cools, either caused by the passage of a meteorological front or the loss of insulation, the ice surface contracts and fractures sporadically in a sound reminiscent of popping corn. The sound waves that are generated propagate in the ice and into the water, and the spectrum averaged over many events exhibits a peak near 100 Hz (Ganton and Milne, 1965). In addition, when the wind gets higher than about 4 m/s, it picks up ice crystals from the surface, and they make a hissing noise as they blow across the surface of the ice. This has a weak spectral peak closer to 1 kHz, and the energy level is a strong function of the windspeed.

Plans For The Future

Progress in establishing the mechanisms for ice vibrations has advanced only slowly over several years, as the mechanisms responsible for these vibrations have not been a focus of any one research program. Most of the observations have been made while attempting to understand other processes. Hunkins (1962) found waves in measurements of the gravity field. Czipott (unpublished) made surface tilt measurements to account for a source of noise in magnetic measurements. Dugan et al. (1991) were trying to understand the low-frequency sound field. Even these latter observations were unusual since most previous sound field measurements have used hydrophones alone instead of in combination with motion sensors.

The Arctic Sciences Program of ONR has had several field programs which have supported these measurements--specifically, the Marginal Ice Zone Experiments (MIZEX) as well as AIWEX and CEAREX. However, the ice motion measurements have been obtained only as part of these larger and more ambitious measurement programs which have had many diverse goals. The near-term future does not appear any different, as current ONR research initiatives such as Arctic Leads and Ice Mechanics are expected to require these type of measurements. Again, they will not be the principal focus of the observations.

Drs. Wadhams and Smirnov are planning joint measurements during the upcoming AnZone Program in the Antarctic. An ice camp will be manned for many months while it drifts in the Weddell Sea. Motion and strain sensors will be deployed near the camp by both organizations. One interesting goal is to make comparisons of the different technologies. The surrounding region will be instrumented by radio buoys so the larger-scale context also will be known. Some of the above-mentioned outstanding issues are expected to be addressed.

Personal Notes

The success of this meeting exceeded all expectations with significant exchange of points of view. Dr. Smirnov speaks some English, but interactions between scientists without translation were halting. The interaction was smoothed tremendously by very able translation performed by a Cambridge University student. At dinner, after a full day of talks, Dr. Smirnov was very gracious to the host, Dr. Wadhams, and to me. He kindly but firmly told me that I talk too fast for him to easily follow. I assume that he was being nice to me, as he didn't mention the speed at which I wave my arms!

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Institute for Baltic Sea Research at Warnemunde

by J.P. Dugan

Introduction

The Institute of Marine Research (Institute) was the leading oceanographic research institution in the German Democratic Republic (GDR) before the reunification of the GDR with the Federal Republic of Germany (FRG). The Institute is located on the Baltic Sea in Warnemunde, a coastal suburb of the seaport and shipbuilding city of Rostock. As a result of the current plans for realignment of all German research institutions after reunification, this institute's name will become the Institut für Ostseeforschung (Institute for Baltic Sea Research) an der Universität Rostock. The addition of the "an" in the title is significant...it now is "at" the university instead of "of" the university. Accordingly, the focus will change to researching and monitoring the Baltic instead of the previous charter which enabled considerable open ocean work along with work in the Baltic. The purpose of this change is to reduce duplication with other FRG oceanographic research institutions. In particular, the Institute für Meereskunde in Kiel will reduce the importance of the Baltic in its priorities. The 1-day visit was made by CAPT F .ul Gaffney, Commanding Officer of the Naval Research Laboratory (NRL) and me.

Facilities

The Institute is housed in a single building of undistinguished architecture built in 1966 to include offices and laboratories. A beautiful beach is nearby, and the very active harbor is several blocks away. The Institute was established from several smaller groups in 1958 to be the lead oceanographic research institution of the Academy of Sciences of the former GDR. Funded on a sustaining basis by the government, research was toward both military and nonmilitary applications. In that form, it grew to a size of about 150 people performing general oceanographic research, instrumentation development, and oceanographic surveys.

The major facilities of the Institute, in addition to the building, are two research vessels. The *A.V. Humboldt* was built in 1967 (rebuilt in 1978), displaces 1,275 tons, and can accommodate 13 scientists. The *Professor Albrecht Penck* was built in 1951, displaces 310 tons, and can accommodate 10 scientists. The larger ship has undertaken cruises throughout the world's oceans, including the tropical Atlantic and Indian Oceans, while the smaller one has been restricted to the Baltic. Both have the expected facilities, including hydrographic and deep-sea winches, navigation aids (SatNav, and Global Positioning System [GPS]), echo sounders, and laboratories. Unfortunately, during our visit the ships were at sea and therefore were unavailable for our inspection. One surprising aspect is that the ships are operated solely by the Institute for use by their own personnel. The crews currently are Institute employees, although this is expected to change to a contractual basis (more like research vessel operations in the West).

Publications

The Institute supports a journal entitled *Contributions to Marine Scientific Research* with papers accepted in German, English, or Russian. Although open to all researchers in marine sciences, most papers are contributed, not surprisingly, by staff members. The journal appears periodically and is now in its 70th issue. Professionally printed, most (but not all) papers are in German. The authors are fully apprised of references in the field in Western scientific journals, although many journals were not previously available at the Institute.

The Institute also has a publication called *Marine Scientific Reports*. These are much more detailed reports of analyses; most of those we examined include many plots of data. They are comparable in quality to NRL formal reports, which is to say scholarly, but provide much more detail than is appropriate for most academic journals.

Organization

The Institute is organized into several departments as shown in Figure 1. There are the usual disciplines; e.g., physics, biology, and chemistry. These are separate from the technology and observational departments which are responsible for instrumentation and computers and data analysis, respectively. Professor Dr. Dieter Lange is Institute Director. His background is in geology and he has worked on the Western Baltic. Professor Dr. Hans Brosin heads the Physical Oceanography Group; work has been in various aspects of remote sensing

of the ocean. Additional groups working in the physical sciences include Theoretical and Regional Oceanography. The latter includes a small microstructure group.

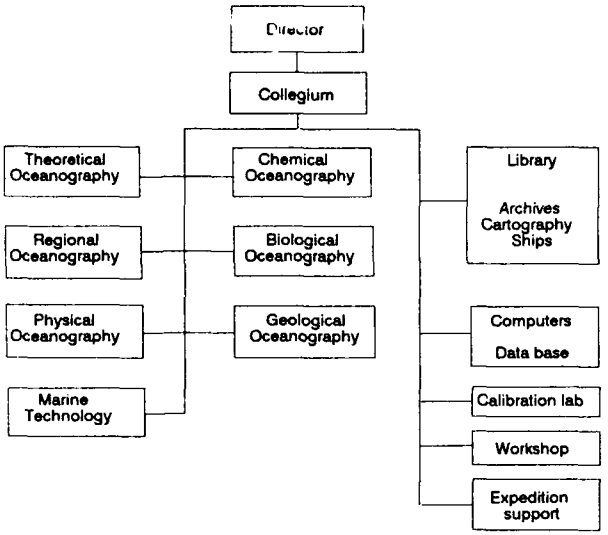

Figure 1. Organizational chart for the Institute of Marine Research

Theoretical Physical Oceanography

Dr. Wolfgang Fennel heads the theoretical group. He wrote a book in collaboration with Dr. Hans Ulrich Lass entitled *Analytical Theory of Forced Oceanic Waves*, Akademie-Verlag, Berlin, publisher. Published in 1989, this book is primarily concerned with the linear response of simplified oceans to wind stress. The mathematical approach is by Green's functions which permits the solution of more complicated problems by superposition of these analytical functions. They argue that analytical theory is important to complement the more typical numerical modeling because it more clearly establishes the underlying physical principles. Also, theory may be used to provide exact solutions with which to check numerical results. Even in applications in which nonlinear terms are important in the governing equations, linear features often persist into the nonlinear range. The theory can provide some physical insight. This book is more recent than the much larger book *Waves in the Ocean* by LeBlond and Mysak. In addition, it specializes on particular solutions forced by wind stress as opposed to LeBlond and Mysak's emphasis on freely propagating waves. Although clearly written in English, it has not had wide advertisement nor wide distribution because of the publisher's limitations. Also, it purportedly took more than 3 years to produce. Finally, the references are almost entirely to Western literature and they are reasonably complete up to 1985 (about the time the book was completed).

The emphasis of this group on theoretical work, surely, must be based upon the fact that, until the very recent past, computers were not widely available in the GDR. With the advent of access to computers, this group has more recently implemented numerical models. An example they are proud to discuss is a response model of the Western Baltic, which has very detailed bathymetry. The model is an adaptation of the well-known (but now over 10 years old) Bryan-Cox model. Implementation is on an Intel 486-based computer, which was the fastest machine that we saw. The model, including the code, was obtained from Dr. Kirk Bryan (at the National Oceanic and Atmospheric Administration [NOAA] Geophysical Fluid Dynamics Laboratory in Princeton) and adapted locally to the Baltic. Much of the auxiliary software for plotting and the like is commercially available in the West.

Observational Physical Oceanography and Instrumentation

With two full-time ships, observational work has dominated the physical sciences in the Institute. Physical properties of the water column are usually measured with a conductivity-temperature-depth (CTD) profiler which is lowered through the water column by cable from the research vessel. The Institute has three CTDs which have been used to obtain a very complete hydrographic series of temperature, salinity, density, and sound velocity measurements in the western Baltic.

Remarkably, the instruments have been designed, built, and maintained entirely by the Institute's engineering staff. This has occurred because of the previous unavailability of individual components as well as entire units from suppliers. All sensors are similar to Western ones, although the conductivity sensor uses the principle of induction rather than the more usual direct contact resistance principle as in the Neil Brown or Sea-Bird sensors. The workmanship is excellent and, apparently, unusual care has been applied to maintenance of calibration standards.

The concern with calibrations has led this group to include a sing-around sound velocity sensor to their instrument. This provides a redundant measurement which is used in all data processing to maintain a check on the calibrations of the sensors. This check is accomplished by computing the sound velocity from temperature, salinity, and depth measurements (as done almost entirely in the West), and comparing the result with the directly measured sound velocity. Any sudden and unexpected change in this comparison indicates a problem with one or more of the sensors in the instrument. It is unclear whether this is an exhibit of extra care on their part, or only a requirement because of sensor problems in the past.

There is a small physical oceanography group, led by Dr. Hartmut Prandke, that observes turbulence in the thermocline and in the bottom boundary layer. The group has developed its own free-fall profiler completely from scratch. The profiler is similar to early U.S. technology on the order of 10 years ago, providing vertical profiles of very small-scale fluctuations. The first instrument was constructed in 1980 with only one channel each of temperature and microconductivity. This was later modified to provide some simultaneous horizontal structure (dropped horizontal coherence in physical oceanography terminology) by having several sensors separated horizontally by distances from several mm to 2 m. A newer generation instrument was developed in 1986 called the MSS 86, having eight channels of data digitized and transmitted up the cable at 1-kHz rate. This sensor incorporates two microscale airfoil velocity sensors visually similar to those typically used in profilers in the West. They do not yet have the present capability of measuring larger-scale velocity gradients, as in the University of Washington multiscale profiler of Gregg and Sanford. Although they can estimate the kinetic energy dissipation rate, they cannot yet measure the velocity profile to estimate the local Richardson number.

The currently used MSS 86 includes microtemperature, conductivity, velocity, and turbidity sensors. An interesting computer-controlled winch manages payout of the cable. This permits the instrument to free-fall while loosely tethered. When it reaches the bottom of the cast, it is winched up in preparation for the next profile. The overall instrument technology is almost 10 years behind the best in the West. Considering the effort required to design, build, and maintain such instrumentation without modern facilities and availability of components, it must be expected to catch up very quickly.

The research is directed toward an understanding of turbulence processes with two applications. There is interest in the bottom boundary layer, including the entrainment and transport of sediments. This is an interesting application of the instrumentation, but there is no concurrent work from bottom-mounted instrumentation frames like that in the West. The second application is sound scattering layers caused by the thermal microstructure. Drs. Prandke and Stips have written several papers on this. They conclude that the bulk of the scattering is from microbubbles generated by decaying organic matter suspended in the strong gradients in the thermocline.

Geology and Geophysics

In addition to the grid of physical oceanography data obtained in the western Baltic, the Institute has a survey grid of bottom measurements. These data include echosounder recordings and many bottom core samples. As a result, several very nicely produced charts of the bottom properties are available.

Final Note

The Institute of Marine Research is undergoing a massive and disruptive change. The recent Federal Science review was positive. As a result, they will reorganize, continue as a viable institute, and receive funds from the Federal and the local state government. However, Drs. Lange and Brosin could not be specific about what work will continue and what will not. They have recently reduced staff and expect some further reduction soon. Environmental monitoring work in the Baltic will grow over the next few years and will involve about 30 staff members. Probably, this will require increased emphasis in marine chemistry and biology and perhaps some reduced emphasis on physical oceanography. However, this necessarily must involve mostly survey work. The impact on the number and type of personnel was unclear.

The technical personnel whom we interviewed were very sharp and reasonably abreast of Western technology. Clearly, they were good scientists whose work, unfortunately, was hindered by the need to build too many fundamental components of their instruments, and by the lack of computer technology in particular. The technical personnel are not versed in how to sell their research in a competitive research environment. Adaptation to the Western way of scientific investigation will be interesting to watch.

Both CAPT Gaffney and I spoke to an assembled staff of about 35 scientists. We discussed the organization of the Office of Naval Research (ONR) and NRL, detailed U.S. Navy research ship and aircraft facilities, and discussed funding and managing research in U.S. institutions. They were very interested and responsive, though clearly uninformed. Both Drs. Lange and Brosin were interested in collaborations with U.S. institutions and especially interested in how to expose their younger researchers to U.S. research institutions. If any readers are interested in receiving or providing visiting scientists, please contact me or the Institute.

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NEWS, NOTES, AND ABSTRACTS

TeraFLOPS Computers and Parallel Computing for the Masses

by Miroslaw Malek, the Liaison Scientist for Computer Science and Computer Engineering in the Office of Naval Research European Office. He is on leave from the University of Texas at Austin, where he holds the Southwestern Bell Professorship in Engineering in the Department of Electrical and Computer Engineering.

TeraFLOPS Computers by 1993?

The fierce competition in building the world's fastest computer continues and performance predictions change literally every six months.

Parsytec, a start-up company manufacturing supernodes (transputer-based parallel systems with up to 1,024 processors) in the Federal Republic of Germany (FRG), has announced plans to build a system of 65,536 (64K) T9000 transputers. This system could potentially deliver aggregated performance exceeding one trillion floating-point operations per second! Parsytec plans to have the system operational by 1993. Parsytec's delivery date seems too optimistic. With delays in T9000 availability, high initial cost, and several technical problems that need to be solved, this ambitious project may simply not be ready by 1993.

Thinking Machines, Cambridge, Massachusetts, struck back by announcing Connection Machine-5, which may potentially deliver two TeraFLOPS. Of course, these are all speculations. Even a one-TeraFLOPS machine has not been built at this time.

Parallel Computing for the Masses?

Ease of parallel programming and use, portability, and reliability have so far eluded parallel systems developers. A consortium supported by ESPRIT has been set up to address these issues.

The General Purpose Multiple-Instruction Multiple-Data (GP-MIMD) parallel computer project is a concerted effort of four major companies in partnership and several associated contractors from research laboratories, companies, and universities to create a scalable parallel computer with portable software. The main partners are Inmos (T9000 processor manufacturer from Bristol, the United Kingdom [U.K.]) and three manufacturers of transputer-based systems-- Meiko (U.K.), Parsys (U.K.), and Telmat (France). Associated contractors include Grupo APD (Spain), the European High-Energy Research Center (CERN, Geneva), Chorus Systems (France), Instituto de Enghenaria de Sistemas e Computadores (INESC, Lisbon), Siemens (FRG), Swedish Institute of Computer Science, Southampton University (U.K.), and Institut de Recherche en Informatique et Systems Aleatoires (IRISA, France).

Besides scalability and portability the major design objectives include:

1.Software
- Application support interface
- Ease of parallel programming
- Architectural independence.

2.Hardware
- Standard I/O interfaces
- Cost-effectiveness
- Fault tolerance
- Simplicity
- Ease of manufacturing.

This impressive list of goals boils down to one issue: bring parallel computing to the mass market where a personal computer user can comfortably work on parallel machines. If standards are established and parallel programming becomes easy, software houses can invest in a new generation of software and build upon a common software layer. The partner companies have established a common, transputer-based platform for supernodes. They should be praised for the joint work towards the standardization, which may have a lasting impact on parallel computing. Likely, GP-MIMD will be remembered as a pioneer of viable standards for parallel computing, but not for breakthrough performance. The key to success will be a consensus on standards and their international acceptance. This is a truly unique endeavor and I do not know of anyone in the U.S. or Japan undertaking a similar concerted effort. If standards are accepted (it may take a miracle for this to happen), then the portability issue would be resolved once and for all.

The initial GP-MIMD architecture will consist of 1,024 T9000 transputers connected by a multistage network. A prototype should be ready in the second half of 1992 and commercial availability is expected by the end of 1992. This is a truly aggressive schedule, and it remains to be seen whether it can be met. If the goal of scalability in both hardware and software prototypes is attained, then the systems of one or two orders of magnitude larger could be built.

Conclusion

While impressive advances in "raw speed" are continuing, the critical issues that would make parallel computing widely acceptable are still ease of parallel programming and use, portability, and reliability.

Functional Languages: Optimization for Parallelism

by Rishiyur S. Nikhil, Research Scientist, Digital Equipment Corporation, Cambridge Research Laboratory, Cambridge, Massachusetts

Introduction

The Dagstuhl Seminar on Functional Languages: Optimization for Paralellism, was held in Schloss Dagstuhl, Federal Republic of Germany (FRG), 3-7 September 1990. The Schloss Dagstuhl International Conference and Research Center for Computer Science is a chateau that is being established as a conference center exclusively for computer science. The establishment is under the auspices of the German states Saarland and Rheinland-Pfalz, and the Saarbrücken, Kaiserslautern, and Karlsruhe Universities. The seminars here are intentionally informal with no fixed agenda and no proceedings. Proposals for subsequent seminars and workshops can be sent to

Scientific Directorate
Internationales Begegnungs und
Forschungszentrum Informatik
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Seminar Purpose

For several reasons, functional programming has long been regarded as a promising approach for programming parallel computers.

- A high level of programming: the programmer does not have to think in terms of details of processes and synchronization. These concepts are implicit in the parallel execution model. Unlike other parallel programming languages which are often complicated extensions of sequential languages, functional programming can actually simplify programming.
- Abundant implicit parallelism: functional programs do not need sophisticated *parallelizing compilers*; they have abundant parallelism in their normal execution semantics.
- Debugging programs written in other parallel languages can be a nightmare because different scheduling choices can produce nondeterministic behavior. Functional programs have the Church-Rosser property, which guarantees deterministic results, no matter what the scheduling choices.

On the other hand, functional programs have other serious resource management problems--voracious heap store use in particular.

Impressions

A mixture of theorists and practitioners participated in this seminar. Countries represented were the U.S., Denmark, Scotland, England, the FRG, Sweden, the Netherlands, and France. Only three participants are involved in constructing or using specialized parallel hardware for functional languages. The others are concentrating on the theory and practice of program analysis, compilation, and optimization. I think that both the geographical and topical distribution of researchers accurately reflects the research community in functional programming. Many of the researchers present seem to be involved in cooperative projects that span university and national boundaries. This may be partially because of the requirements of ESPRIT[1] funding.

Functional programming has had very little impact outside the research community because of a lack of good implementations and integration with conventional operating systems; it has had a limited impact even within the research community. Thus, while functional programming has been a great source of theoretical problems to investigate, it has had very little practical impact. There are far more European than American researchers in functional languages. That seems to reflect a dominance of theory over practice.

In the early to mid 1980s, there were many proposals and projects to build parallel architectures for executing functional languages. Enthusiasm for such projects is now more subdued. This is partly because of lack of money. Also, I suspect that it is partly because of a realization that good compiling on high-performance stock hardware can outperform lower-technology, special-purpose hardware. At this seminar, most attendees were more interested in compilers and optimizations for commercially available parallel machines.

INMOS transputer networks seem to be a popular choice in the functional programming community, because they are available (and heavily promoted) to researchers in Europe. I do not think that the transputer is a good building block for parallelism, functional programming, or otherwise. The unsuitability is because messages between two processors must pass through all intervening processors, and because occam is not a good implementation language. The next version of the T9000, which does routing separately from the processor, will alleviate many of these problems. However, current transputer networks may be useful in gaining some initial experience in parallel functional programming.

[1]European Strategic Programme for Research and Development in Information Technologies

The only two unusual parallel architectures discussed were GRIP (Glasgow University) and P-PISC (Massachusetts Institute of Technology [MIT]). Built by Prof. Simon Peyton Jones, GRIP uses *parallel graph reduction* (Peyton Jones et al.). Basically a shared-memory multiprocessor, GRIP has additional intelligence to transfer entire objects to processors' local memories and to participate in load balancing and garbage collecting. Since GRIP's processors are now several years old, its main use will be to study performance-neutral issues such as scalability. The P-RISC architecture combines the best of von Neumann and dataflow architectures (Nikhil and Arvind). Computer scientists at MIT are now using P-RISC as an intermediate language to compile functional languages for nondataflow machines. Also, MIT is planning to build a machine along P-RISC lines.

Many people have built compilers for parallel machines (typically transputer networks). However, not many significant performance results are available because the compilers are still new or almost done and need much work on optimization. Also, some preliminary work on resource management was reported (partitioning arrays, load balancing). This topic is still in its infancy in the functional programming community.

I was disappointed that so many people use the NFIB program as a benchmark. The program is embarrassingly parallel and strict, and does not use any data structures. The NFIB program does not address any serious implementation issues (a functional programmer's MIPS rating). Unfortunately, there are no good standard benchmarks for functional language implementations, so they are difficult to compare.

As expected, abstract interpretation is a hot topic for everything--strictness, sharing, garbage collection, binding time analysis. There is excellent theoretical work being done in this field at several European locations. However, no one has implemented them in a serious compiler and evaluated their effectiveness on real programs.

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International Conference on Quantitative Surface Analysis

by Noel H. Turner, Chemistry Division, Naval Research Laboratory, Washington, D.C.

Introduction

Approximately 175 surface analysts met in London for the Sixth International Conference on Quantitative Surface Analysis. These biennial meetings are organized by the National Physical Laboratory, Teddington, United Kingdom (U.K.), with the sponsorship from over 10 scientific organizations. Twenty-three countries were represented--15 attendees from North America. Most of the 40 oral presentations and 64 posters dealt with either the electron spectroscopies (x-ray photoelectron spectroscopy [XPS] and Auger electron spectroscopy [AES]) or secondary ion mass spectrometry (SIMS). In this brief overview, I am omitting other outstanding work. Also, I do not mention many of the practical applications of quantitative surface analysis; e.g., electronics, corrosion, catalysis, and polymers. These applications will continue to provide much impetus for further work in this area.

The electron spectroscopies use electrons with a kinetic energy in the range of about 100- to 2,000-eV which have an unattenuated escape depth of about 2 nm or less. Each element has a set of unique energies for the ejected electrons. In XPS, the governing process is given by the Einstein photoelectric effect. With AES, the energy distribution of the ejected electrons is assigned by the relationship that defines the Auger process. It should be noted that Auger electrons can be observed in XPS, but the more common excitation source in AES is a 2- to 20-keV electron beam. With both techniques, all the elements (except hydrogen and helium) can be detected to about the 1 percent level in the surface region.

The SIMS is a mass spectrometric technique in which energetic ions in the 1- to 25-keV energy region strike a surface and the ejected, ionized atoms or clusters are mass analyzed. Over the years, several different analyzer designs have been used in SIMS, with the time-of-flight design being utilized currently in many applications because of its relatively high sensitivity and the large mass range that can be accessed. Other designs are used also, often for specialized applications. There are two different modes of operation in SIMS--static and dynamic. In static SIMS, the ion beam dose is such that only the first layer on the surface is removed over a period of a few hours. Dynamic SIMS, on the other hand, has current densities that remove many atomic layers each second. This latter mode of analysis yields a depth profile of the analyzed material for depths in the range of micrometers. The SIMS can detect all of the elements.

The detection limit of SIMS can be below the ppm range for some elements. However, the element being detected and the matrix can have a large effect on the detection limit in a specific system.

Presentations

The presentation that caused the most discussion was by J.E. Castle and M.A. Baker, University of Surrey, U.K. Castle described initial efforts towards a computerized expert system for XPS and AES. He envisioned a series of computer algorithms that would allow a novice user to obtain results and conclusions that now only an expert can make. This corresponds to a low-level artificial intelligence system for these analytical methods. Such a system would have judgement capabilities in addition to the usual data treatment programs found in most systems. Also, it would contain databases that presently are available only in stand-alone programs. Interactions during the data collection process could improve the quality of the spectra and decrease the time required to obtain them. The expert system should give a report that details the decisions that were made, along with their corresponding confidence level. This would ensure accountability of the process. Currently, some of the required "shell" programs have been obtained. Possibly, work in this area can be started soon. Many U.K. users are being asked for rules governing the system.

Instrument performance is an important aspect in any proposed expert system that includes quantification procedures. Under the direction of M.P. Seah at the National Physical Laboratory, several studies have been directed towards gaining a better knowledge of such factors as instrument design, long-term electron detector stability, traceable methods with reference materials, data handling procedures, and conducting round-robin comparisons of instruments. Preliminary evaluation of a recent XPS round-robin series for spectrometers showed that comparisons with standard spectra were within 5 percent of data gathered under highly controlled conditions. Interlaboratory comparisons could be improved to within 2 percent.

In electron beam excited AES spectra, the effect of backscattered electrons must be included if quantification is being considered. These electrons are produced from the incident beam in the bulk that is directed back towards the surface. They also must have enough energy to start a detectable Auger transition. With thin films technologically very important, better knowledge of this factor under a wide variety of experimental conditions is needed. M.M. El Gomati and coworkers, University of York, U.K., and J. Cazaux and O. Jbara, University of Reims, France, have used the ingenious technique of placing ultra-thin films of one element on columns of the same or a different element. Differences in backscattering between the unsupported film region and the supported portion could be determined under a wide variety of conditions. For example, the York group reported that more backscattering was obtained with a low Z film on a high Z support. They also noted that backscattering became more important as the beam voltage was increased. The Reims researchers noted that measurement of the emitted x rays (the alternative decay mode to Auger electron emission) could be used under conditions when surface contamination is severe. Both groups found that the backscattering coefficient became larger with increasing film thickness. J.P. Langeron and coworkers, Centre National de la Recherche Scientifique in Vitry-sur-Yvette, France, computed backscattering coefficients from a slab model and made comparisons with a Monte Carlo approach. Usually small differences were noted between the methods; however, they found that the angle of incidence of the electron beam was important. This group will investigate the effect of specimen crystallinity.

For quantitative analyses in electron spectroscopy, the area under a peak usually is determined. However, in AES many workers still use the peak-to-peak height of the first derivative of the spectrum for quantitative purposes. Often, many of the analysis methods will use very crude models to remove background effects (some are nearly 20 years old). These background problems occur when an electron loses energy caused by another electron being promoted into the conduction band or into the continuum. The energy loss that the electron suffers ranges from a few eV to about 50 eV. Recently, at Odense University, Denmark, S. Tougaard and coworkers have developed models that consider these phenomena in XPS. In inhomogeneous samples, the Tougaard approach has reduced the error in area determinations by a factor of 10 compared to the earlier procedures. With alloys and pure materials, similar improvements were obtained also. H. Bender, the Interuniversitair Micro-Electronica Centrum, Leuven, Belgium, has tested Tougaard's approach with AES spectra and

compared the results with optical data models. The optical method resulted in distortions in the nonspectral regions; also the needed data often are not available. However, the Tougaard technique distorted the line shapes somewhat. Both approaches gave comparable area estimates, which is the useful value for quantitative purposes.

A. Benninghoven, University of Münster, Federal Republic of Germany (FRG), reviewed the question of quantification in SIMS. Factors such as the sputter and secondary ion yields, transformation probability, damage cross-section, and detection efficiency all contribute to the observed signal. The effect of the substrate and the ion being detected also play a role in quantification with SIMS. For example, the use of chemically similar molecules, internal standards, solvent evaporation, or isotopically labelled species may be profitable directions to explore for future improvements. In some systems, comparisons with other techniques (such as XPS) may prove useful for checking the SIMS determinations. Several other workers also have investigated the combination of techniques for quantification of SIMS. For example, W. Berneike, Atomika Analysetechnik, Oberschleissheim, FRG, showed that total reflection x-ray fluorescence (TXRF) has a detection limit of 10^{10} atoms/cm^2 for some smooth samples. (TXRF requires the angle of incidence of an x-ray source to be below the critical angle of the specimen and uses standard x-ray detectors.) With care, this method can be combined successfully with SIMS. M. Grasserbauer, Technical University of Vienna, Austria, has used inert gas fusion analysis (measures the amount of CO_2 released) combined with SIMS and has achieved a ppm detection limit for precipitates in SiO_2. This also has allowed the distribution to be determined in three dimensions of the participates.

E. Niehuis, University of Münster, discussed an offshoot of SIMS, secondary neutral mass spectrometry (SNMS). In SNMS, the neutral species ejected with an energetic ion beam are ionized and then detected. This approach has advantages over standard SIMS; i.e., elemental sensitivity is more nearly linear and matrix effects are much less severe or absent. Earlier instruments have used either electron beam or plasma discharge for ionization to monitor the ejected species. More recent work from this laboratory has focused on using laser excitation for the ionization step. Several factors have to be taken into account with laser ionization; e.g., the background vacuum levels, nonlinear ionization probability of clusters and the dynamic range of the detectors and electronics. However, even with these problems, this group has achieved detection limits in the ppm range with alloys and Pt_xSi_{1-x}.

Presentations were made on analytical techniques other than XPS, AES, and SIMS. D.G. Armour, University of Salford, U.K., discussed work with medium energy ion scattering (MEIS). In this technique, both incoming H_2+ ions with 100 keV of energy and the scattered particles have a small angular deviation. Atoms can be detected qualitatively down to about seven layers. By varying the experimental detection system, high depth resolution can be achieved to distinguish various species as a function of depth. Examples of this type of analysis were given with various SiO_x moieties in the surface region of Si (001) that had undergone various annealing and etching procedures. H. Niehus, Institute for Interface Research and Vacuum Physics, Jülich, FRG, presented work with ion scattering at lower energies; i.e., 0.5- to 5-keV. The technique is known as ion scattering spectroscopy (ISS). Here the scattered particles from the surface are detected as a function of angle from the surface. In many cases, this approach (while being very surface sensitive) has been hampered by neutralization and reionization during the interaction of the ions with the surface. Often it has been possible to detect adsorbates on the surface and to obtain "finger print" spectra for many systems. More recent studies have focused on detecting backscattered particles and changes in the azimuthal angle for different crystals faces with single crystals. Calculations have been used for simulation purposes, and it was shown that neutralization occurs in the first layer while scattering ensues from several layers below the surface.

The Second International Conference on Ice Technology

by Yapa D. S. Rajapakse, Scientific Officer for Solid Mechanics, Mechanics Division, Office of Naval Research, Washington, D.C.

Introduction

The Second International Conference on Ice Technology was held at Downing College, Cambridge University, Cambridge, U.K., in September 1990. The conference provided an international forum for the exchange of information on ice technology, mainly for problems of Arctic and Antarctic operations. Gathered were researchers in geophysics, oceanography, solid mechanics, acoustics, marine engineering, civil engineering, naval architecture and glaciology. Recent advances were reported on various aspects of ice research and engineering.

Significant Data and Information

At the conference, approximately 35 papers were presented in

- Ice environment
- Vessels and structures in ice
- Ice operations and ice management
- Remote sensing of sea ice, ice forecasting, and ice acoustics.

Dr. Andrew Palmer, Andrew Palmer and Associates, London, U.K., presented the keynote address. He commented on global economic implications of significant fluctuations of the price of oil caused by instabilities in regions that currently provide a large share of the world's energy needs. He discussed the need to have access to reliable sources of oil, such as in the Arctic, and consequently on the need to understand the behavior of ice for Arctic oil exploration and utilization.

Dr. Peter Wadhams, Director of the Scott Polar Institute, Cambridge, U.K., discussed ice thickness distribution in the Arctic Ocean. He reviewed methods for estimating ice thickness distribution, and provided the geographical distribution of mean thickness. These methods include ocean acoustic tomography, airborne laser profilometry, synthetic aperture radar sensors, satellite radar altimeter, and airborne electromagnetic techniques.

Professor J.P. Dempsey, Clarkson University, Potsdam, New York, presented a paper entitled *Size and Brittleness Effects on the Fracture of Ice*, in which he highlighted the importance of notch sensitivity and notch acuity (crack tip sharpness) in fracture studies of ice. He demonstrated that the proper use of these concepts in the selection of specimen size and crack length leads to a valid fracture test. Consequently, more reliable fracture toughness data is obtained with much less scatter compared to available data in the literature.

Professor E.M. Schulsen, Dartmouth College, Hanover, New Hampshire, discussed an interesting study on the ductile to brittle transition in ice under compression. He utilized micromechanics models of brittle compression behavior of ice, based on the analysis of wing cracking. These models incorporate frictional sliding and crack tip deformation zones in a new formulation.

Professor H. Vaughn of the University of British Columbia, Canada, discussed the dynamics, flexural response, and damage of ships in ice. He provided a finite-element model of a ship impacting an icefloe, receiving damage, and being deflected from its path or becoming stranded on the floe. His analysis showed that a ship heading into a yielding but compacting layer can experience large flexural stresses even though the impulse applied to the ship is fairly soft.

In a paper on a mathematical model for predicting icebreaker performance, Dr. T. Pierce, Transportation Development Center, Montreal, Canada, described an analytical method for the prediction of the total icebreaking resistance of ships moving continuously in level ice, accounting for both ship and ice characteristics. The model has been substantiated by relevant results of laboratory and field tests.

Professor W.M. Sackinger, University of Alaska, Fairbanks, Alaska, presented a paper entitled *Analysis of Ice Island Dynamics*, in which he discussed two movement episodes of Hobson's Choice ice island in terms of forces acting on the island. These forces included windshear, waterdrag, Coriolis force, and residual force (combination of pack ice force, sea surface tilt, and tidal forces). Sackinger provided a quadratic relationship for the residual force as a function of ice island velocity.

Professor M.O. Jeffries, University of Alaska, Fairbanks, presented a paper entitled *Near Real-Time, Synthetic Aperture Radar Detection of a Calving Event at the Milne Ice Shelf, Northwest Territories (N.W.T.), and the Contribution of Offshore Winds*. Here *calving* is used in the sense of *birth*, or formation of an island. Airborne synthetic aperture radar images of a section of the north coast of Ellesmere Island, N.W.T., taken on February 22, 1988, were shown to reveal the calving of a large multiyear landfast sea ice floe from the ice shelf. This separation event was attributed to forces caused by relatively high offshore winds preceding the calving event.

Unusual Observations and Happenings

When the Middle East erupted in August 1990, the rapid increase in the price of oil, and the uncertainties associated with these effects, underlined the timeliness of the conference on ice technology. The event also emphasized the need for accelerating the exploration and exploitation of energy resources in the Arctic region.

Technical Conclusions Reached and Recommendations Made

Research in ice involves activities at many different scales, from microscale behavior to large-scale or geophysical behavior. Researchers working at one scale should be aware of activities at other scales, and attempt to couple different scales.

Ice research involves scientists from many disciplines, including geophysics, oceanography, materials science, solid mechanics, and structural mechanics. A better cross fertilization between these disciplines is necessary. Conferences of this type help to foster such couplings. There is a need for ice researchers, especially those involved in large-scale behavior, to emphasize the more quantitative aspects of ice behavior. A greater involvement by the mechanics community in ice research is essential to establish the scientific foundations and quantitative aspects of deformation and fracture of ice.

Interpretations, Conclusions, and Recommendations

This is the only conference totally devoted to ice research and development. Thus, it brings together researchers and engineers working on all aspects of ice from academia, industry, and government. Because of this diversity, the quality of the presentations varied.

Although good research was presented on laboratory-scale behavior of ice and on large-scale behavior of ice, it was apparent there is at present no systematic, scientifically based framework to couple behavior at different scales.

Starting in fiscal year 1992, a new research program at the Office of Naval Research on sea ice mechanics will address fundamental issues of deformation and failure of sea ice, and establish methods for coupling ice behavior at different scales. This program is most timely and will contribute significantly to future needs in ice technology.

National Science Foundation Contributions

Belgian Ministry of Budget and Scientific Policy

by Tom Owens, National Science Foundation, European representative

Science and the Law of Federal Reform

Science policy has been decentralized a great deal through the 1988 Law of Federal Reform. This law mandated that certain governmental functions be turned over by the Federal Government to the regions (Flanders, Walonia, and Brussels) and the communities (Flemish, Walloon, and German). The communities were made responsible for all person-related governmental functions; e.g., culture, education and language. The regions were made responsible for locale-related governmental functions; e.g., public works, industry, and commerce. The Federal Government retains responsibility for defense, foreign affairs (with the communities), justice, public debt, agriculture (even though it is locale-related), and social security (even though person-related). These last two functions may be turned over to the regions and the communities within a few years.

Research is within the competence of the entity (federal, communities, regions) with the greatest competence. The Federal Government acts on all matters subject to an international agreement or anything requiring a scope of action or resources beyond the framework of one community. Furthermore, competence is achieved temporarily by taking initiative. This pertains especially to the research calls for proposals. The Ministry of Economic and Scientific Policy informs the regions and communities of its intention to issue a call for proposals, invites cooperation and proposes an agreement. The regions or communities may or may not wish to participate, and the Federal Government has always been able to proceed.

Belgian National Science Foundation and the Universities

The Belgian National Science Foundation (BNSF) is a private foundation funded 100 percent by government. In the past, that meant the national government, support of education, and the BNSF's research support work has been transferred to the communities in Belgium. Therefore, it is hard to talk of one BNSF since its work and staff is divided along the lines of the two communities. There is even a strong demand to divide the BNSF into two separate foundations (Flemish and French) and such a split has been discussed for 2 years.

The BNSF is headed by a director (currently from the French-speaking community) who is advised by a board composed of the rectors of the country's universities. There are 26 committees who help to select the proposals to be funded as recommended by the peer review panels and reviewers. The panel meetings last 2-3 hours, during which panel members select, on the basis of merit, those proposals in the panel's disciplinary competence that should be supported. Recommendations are sent to the board committees, which make final selections taking into account the distribution across the Flemish and French-speaking communities, the prestige of the universities and other factors. The BNSF budget is BF1.5 billion (about $50 million), excluding salaries and including perhaps 200 doctoral fellowships. These BNSF fellowships support fully the 6-10 years that it takes to get a Ph.D. in social sciences and humanities and the 4 years that it takes to get a Ph.D. in the natural sciences. These are the most prestigious graduate fellowships. An additional 60 or so fellowships are available each year from the Institute for Applied Research in Industry and Agriculture and from the Ministry of Education. The latter require 50 percent time to be devoted to teaching and 50 percent to research.

The salaries of university professors, including all those engaged in research, are paid by the education authorities in the communities. Somewhere between one third and one half of all research positions are not tenured, but depend on the availability of research contracts/grants. Large increases in tenured positions during the 1970s are now clogging the university promotion system.

While there are no large research organizations outside the universities, National Scientific Institutions (NSI) have research programs. These are directed to support the NSI missions, which is to manage collections of cultural and scientific importance. Cooperation in research between universities and private firms is, by and large, more talk than action. The regional industry or commerce authorities provide funds for industrial support centers, and these have some limited research capability.

Priority Making for Research

In theory, the National Research Council (Council) is the source of ideas for new directions in national research programs. The Council, composed of university rectors plus representatives from industry and labor, makes recommendations to the Minister of Science Policy. The Minister and the ministry staff then develop programs to implement the suggestions of the Council. However, the process is more complicated than that. The cabinet system in Belgium means that each minister brings into the ministries several assistants and their colleagues in the ministry who are professional bureaucrats. The politicians actually dominate the priority-setting process but must listen to the Council and they must depend on the bureaucrats for implementation.

The present Minister comes from a small party, and he has chosen to bring in mostly apolitical people from universities to be his assistants. These new ways have been well received in the research community. Public calls for proposals are used extensively, and they encompass a wide variety of basic and applied research topics. The more basic research topics are selected to help develop capabilities in a strategic field such as electronics. Each proposal is reviewed for scientific merit by two reviewers from outside Belgium. The reviews are used to rank the proposals, and grants are distributed to the best proposals until the money runs out. For more applied projects, a committee composed of representatives of potential user groups and researchers establishes a set of policy priorities. Proposals that have a very high potential for addressing the policy priorities will be more highly rated than proposals with equal marks for scientific quality. The Council of Ministers makes sure that the results of each call for proposals are reasonable from the Flemish/French and university hierarchy perspectives. Ministry of Science Policy specialists prepare packages of projects to be supported that satisfy standards of scientific excellence but take into account political realities as well. Annual budget for these priority competitions is BF2.5 billion to BF3.0 billion ($83 million to $100 million), and can include some private as well as government funds. The Ministry also supports Belgian participation in the European Space Agency (ESA) (1991-BF4 billion, 1992-BF5 billion). Belgian firms receive contracts to provide inputs for ESA projects. These contracts are primarily in the vehicle rather than the technical end of the available work. Consequently, the scientific return to Belgium is modest. Belgium recently used cooperation with the U.S.S.R. on a space-based telescope as an experiment with other possible avenues for space research.

International Cooperation

Belgium monitors the development and progress of Commission of the European Communities (Commission) programs. The Ministry tries to be sure that Belgian researchers are current in the skills that they will need to successfully obtain Commission support. As of now, Belgium gets more money back from the Commission than it puts in. More Commission support goes to French-speaking Belgium than to the Flemish side. To a certain extent, this is because the Flemish industrial community has a dynamic research sector made up of small firms. These firms (in contrast to their French-speaking Belgian counterparts) are not interested in the grant-seeking culture which requires lots of paperwork and much discussion with Commission bureaucrats.

Cooperation with France just happens. There is no government-to-government concerted effort for cooperation beyond an occasional meeting. French Belgium is attuned to the French intellectual scene. The Flemish are generally empiricist/rationalist in their approach, while the French community prefers a participant/observer approach; e.g. in sociology. The Flemish researcher will seek funds for a personal computer while the French counterpart will request a video camera. There are no special plans to establish joint research institutes with participation from France and French-speaking Belgian research organizations.

The U.S. is still the land of endless opportunity for Belgian researchers. The Belgian-American Education Foundation (BAF) and the Hoover Foundation have been the prime movers in helping link the American and Belgian research communities. Perhaps 30 Belgians per year go the U.S. via these programs. The European Community (EC) ERASMUS and SCIENCE programs are beginning to replace the BAF as the dominant influence on the postdoctoral plans of Belgian researchers. Cooperation with the U.S. could be increased if it were more possible for Belgian researchers to participate in research projects without leaving Belgium. There is a slight stigma attached to being away from Belgium for long periods.

Author Comments

The complexities of supporting science in Belgium are obvious, and include, to a greater extent, issues unrelated to scientific merit than in most other countries. Despite the complicating factors of community and region (which are not completely unknown in U.S. decisions), it is obvious that great effort goes into making scientific merit

a priority question. That is, in order to get to the question of regional and community distribution at all, the project should be rated highly on merit. One comes away with the feeling that this is the objective, even if it is not achieved every time.

The problems inherent in obtaining objective reviews in a small community of researchers is resolved by the exclusive use of foreign reviewers for the government research programs. The small size of the Belgian scientific community provides a builtin orientation toward international cooperation, even without the language-related affinities. The EC programs for cooperation are the dominant and growing influence in Belgium. They are likely to remain so, absent some important U.S. initiative for cooperation.

National Center for Scientific Research: Limited Reform

by Tom Owens

Introduction

In June 1989, Centre National de la Recherche Scientifique (CNRS) Director-General, Dr. Francois Kourilsky, announced his modernization plans. With 26,000 employees, including over 11,000 researchers, CNRS is France's largest research and development (R&D) organization and is responsible for the support of most of France's non-mission oriented research. At over $2 billion, the annual budget is about 23 percent of the civil R&D budget; it is in its 50th year. The modernization is to prepare CNRS for the new Europe which will arrive with economic integration in 1993; it will adjust the organization to the demands of modern society. Important elements to be included in the modernization effort are reducing bureaucracy and centralization, increasing interaction between the various disciplines, and improving the mobility and motivation of scientific personnel.

Reducing bureaucracy and centralization has been attacked in several ways. The most notable is the program for regionalizing and creating a formal evaluation program for the non-science functions.

Regionalizing Component

While CNRS has had regional offices for decades, in January 1991 it put into place a formal system. The system combines responsibility for administrative/ management matters and scientific cooperation and coordination in the hands of 17 regional delegates. France is divided into 12 regional delegations (the Ile-de-France area around Paris has five subdivisions; the Rhone-Alps region has two) whose work involves an extraordinary array of functions. These include

- Providing overhead-type services for all CNRS-affiliated laboratories and research groups in the region
- Keeping all research budgets and accounting for expenditures
- Handling the paperwork on all CNRS personnel actions in the region
- Contracting for all services to the laboratories and setting up training for employees.

In addition, the regional delegate is responsible for relations with private industry and with other research organizations, plus municipal, departmental, and regional governments. The delegate encourages beneficial cooperation, coordinates with research-related activities of other organizations, and finds support for CNRS laboratories from other financial sources in the region. The hand of the regional delegate is considerably stronger than in the past.

The regional delegations will be at the center of activities in their regions. They will be instrumental in executing policy decisions for research program emphasis, international cooperation, and innovations in personnel and administrative practices. The northeastern, eastern, and southern regions are the magnets that CNRS' management hopes will be able to draw down the proportion of personnel and financial resources now concentrated (53 percent) around Paris. Most of the new positions and new laboratories will be consigned to these regions. Regional delegations will be responsible for all of the preparatory work necessary to manage the growth (or, in Ile-de-France, the decline).

Evaluation Component

With a staff of four, audits and studies delegation Director, M. Jean-Marie Schwartz, carries out about eight audits per year with a budget of about FF3.5 million ($615,000).

The 9-month audit process is complex, involving accounting firms, government auditors, and academic experts in evaluation-related fields. The consultative committee ensures that the terms of reference and the methods used are sound and appropriate. In the organization being audited, a correspondent is appointed to facilitate communication and access for the audit team.

The Director-General is involved at every stage of the audit process, including appointing various participants and signing the final report. Each report contains a section on what CNRS plans to do about any problems discovered in the audit. Post-audit reviews of corrective actions taken are scheduled 2 or 3 years after the audit is completed. The first recheck will take place in 1992.

The audit reports have some common elements, including an auditor's summary report, a committee of expert's report, a consultative committee report, and the audited organization's report. All audits are announced in advance, and the report is published (available to senior CNRS personnel at a minimum).

One printing services audit resulted in a reduction of 50-60 percent in the activity's staff and equipment at CNRS headquarters. About 14 audits have included procedures for:

- Recruiting administrative and technical employees
- Internal communications
- Editorial policy and publication of the *Journal du CNRS*
- Interdisciplinary materials research program PIRMAT.

Human Resources Component

M. Christian Pralon, personnel practices expert, has been brought in to put into place a new human resources policy. M. Pralon seeks to establish methods and a culture for attending to individuals as they pursue their careers at CNRS, and to introduce modern methods of personnel management to its laboratories. Some of the methods being employed in the new policy include establishing

- Annual interviews between supervisors and their employees (*entretien annuel d'activite*)
- Management training for laboratory directors
- Study of management dynamics in the laboratory to identify problem areas.

Some problem areas identified include:

- Involving the administrative and technical staff (ITA) in laboratory life
- Communicating with ITA staff
- Recognizing laboratory directors, who are trained as researchers rather than managers
- Recruiting people to the laboratories
- Improving internal communication (fostering debate that will underlie excellence).

Pralon observes that CNRS' strength has been its ability to produce quality research. To continue that strength may require laboratory directors who are managers well-versed in research instead of researchers who must manage. There has been little opposition to the measures so far taken under the new policy, including from the unions. However, not everyone at CNRS will agree that the most important quality of the laboratory director should be managerial talent.

Interdiscipline Component

Interdiscipline has been addressed by setting up some additional programs dedicated to encouraging new research groups and favoring interdisciplinarity. Created in 1979, the original interdiscipline program, PIREN, focused on environmental problems. PIREN was succeeded by, and expanded in, the "*environnement*" program and joined in the 1980s by PIRSEM (energy and raw materials), PIRMAT (materials), and PIRTTEM (technology, employment, and lifestyles-related research). The programs added as part of the modernization program include IMABIO (engineering of biological macromolecules), COGNISCIENCES (cognitive sciences) and ULTIMATECH, to encourage innovative research techniques and their diffusion to neighboring disciplines.

The other interdiscipline-related enterprise has been the most controversial of Dr. Kourilsky's reforms: restructuring the Comite National (CN). The most important advisory body at CNRS, it combines some of the policy debate function of a board of directors with other activities (e.g., research evaluation functions of disciplinary review panels, personnel selection, and evaluation functions of management officials). Kourilsky suggested reducing the CN's disciplinary sections from 49 to less than 40. Also, he suggested grouping related disciplines and reducing the membership of each section. The ensuing debate took more than a year. The CNRS had to address complaints that fewer sections would not be able to adequately judge some research specialties, some sections would have to respond to more than one CNRS scientific department, and reduced sections would not be able to function with fewer members. The education ministry objected to the theme orientation of the new sections (complex molecular systems, physical phenomena, and theories and models) rather than disciplinary orientation.

After the dust settled, 42 sections were approved for the CN whose members will be selected in late 1991. Two-thirds will be elected by CNRS personnel and researchers from other organizations in France, and one-third to be appointed by the Minister of Research (advised by CNRS Director-General). Each section will have 21 members.

In parallel with the restructuring of the CN was a further appraisal of its functions, including communication. In 1990, Dr. Kourilsky appointed a fact-finding committee (Comite d'Organization) to elucidate the issues and possible solutions. This committee identified and delved into several issues. Among the more salient of these were:

- Maintaining credibility in CN's procedures for the selecting research projects to support or for recruiting and promoting researchers
- Setting appropriate boundaries between the CN and the CNRS management, private industry, and other research organizations in France and abroad.

In early 1991, the committee presented its findings and final proposals. Recommendations for changes in operations were formulated for the new CN.

International Component

In organizational terms, the international component is expressed as a desire for each of the scientific departments to have an international component. The Director of the CNRS International Relations Office, M. Jean-Francois Stuyck-Taillandier, coordinates with the person in each scientific department who handles international activities. He meets periodically with scientific department staff to discuss policy matters and administrative concerns. He conducts quarterly coordination meetings with the regional delega es. Those northeastern, eastern, and southern delegations will have an important part in the international cooperative activities of CNRS. Geographical priorities of CNRS for international collaboration are Western Europe, Eastern Europe, Japan, Eastern and Southeastern Asia.

The CNRS would like to maintain the already-high relationship with the United States (U.S.). The Western Europe strategy calls for the development of European Associated Laboratories (*Laboratoires Europeens Associes*). These would be analogous to the associated laboratories that involve CNRS researchers in a jointly managed facility with researchers from other French government agencies. Such laboratories planned in 1991 are:

- Spain - 2
- Federal Republic of Germany (FRG) - 2
- United Kingdom (U.K.) - 1
- the Netherlands - 1
- Belgium - 1.

One of the laboratories to be set up with Spain will be in Barcelona, and one of the cooperative ventures with the FRG could also involve Switzerland. The CNRS devised the office in Brussels (known as CLORA), which is staffed by representatives of all the French research agencies to better obtain funds from the activities of the Commission of the European Communities (Commission). Likely, some of the transborder cooperation will be funded partially with money from the European Community's regional development fund. The Eastern European strategy focuses on giving Eastern European researchers opportunities to upgrade their research opportunities without leaving their countries permanently.

The international priorities fit nicely with the strategy for development of the regions, and for the ultimate aim of integrating French research more completely with the rest of Europe. The associated laboratories planned with Spain are very timely, coming as Spanish resources for R&D have reached the end of a period of rapid growth.

Author Comment

After almost 2 years, the modernization of CNRS is really just getting underway in most areas. Some things, like the restructuring of the CN and of the regional delegations, took longer than expected. Some, like the planned dispersion of research resources throughout France, will take a long time in any case. The audit program and the human resources policy, with relatively small budgets, are not rocking any important boats despite their high potential to do so. The modernization plan is coherent and comprehensive, as can be seen in the published version (*Schema Strategique du CNRS 1990-1992*). Yet the same plan makes it clear that it is a small margin in which the reforms may be contemplated and implemented. Almost 80 percent of the CNRS budget of about $2 billion goes to salaries. The remainder leaves little room for innovation or for large changes in emphasis when spread across 11,200 researchers in 1,338 research groups and laboratories.

However, the modernization plan does strike at the fundamental elements necessary to effect the desired changes. If the considerable pressure is maintained from the Director-General, the incremental changes put in place so far will have a salutary effect. The question is whether the changes will be big enough, to be noticed when the "New Europe" of which Dr. Kourilsky speaks actually arrives. Probably, the changes will not be in place by 1993, but perhaps in 10 years.

The subject of CNRS modernization is treated in more detail in NSF/Europe Report No. 24, copies of which may be obtained from Alice Leeds of the Division of International Programs at NSF, Tel. (202) 357-7393.

The Observatoire des Sciences et des Techniques: A New French Organization for Science and Technology Indicators

by Tom Owens

Background

The Science and Technology Observatory (OST) is a new organization dedicated to the development of science and technology indicators for France. According to Hubert Curien, Minister of Research and Technology, the OST will "contribute to a better understanding of the place of French research in the international context, and to improving our capacity to prepare our long-range planning and the changes required." The OST membership includes the science and technology-related ministries, government organizations that support research, and industry through an industry association (see Table 1). Founded on March 28, 1990, for an initial term of 6 years, it has the status of a Groupement d'Interet Public (a nongovernmental organization working in the public interest). The OST is housed on three floors of a small modern building at the back of an interior passageway/courtyard near Montparnasse: 93, Rue de Vaugirard, 75006 Paris.

Table 1. Founding Members of the Observatoire des Sciences et des Techniques

- Ministry of Research and Technology
- Ministry of Defense
- Ministry of the Economy and Finance and the National Institute for Statistics and Economic Studies (INSEE)
- Ministry of Industry and National and Regional Development
- Ministry of Posts, Telecommunications and Space (now the Ministry of Posts and Telecommunications), and the National Center for Telecommunications Studies (CNET)
- National Center for Scientific Research (CNRS)
- National Center for Space Studies (CNES)
- Atomic Energy Commission
- National Institute of Health and Medical Research (INSERM)
- National Institute of Agronomic Research (INRA).

Functioning like a board of directors, the OST Council of Administration is chaired by M. Pierre Papon, President Director General of the French Institute for the Exploitation of the Sea (IFREMER). Senior planning officials of the member organizations make up the membership.

Science and Technology Observatory Director's Objectives and Resources

The Director of OST is M. Rémi Barré, educated at one of the Grandes Écoles (Mines and Engineering, a Ph.D. in Economics) and at the University of North Carolina, Chapel Hill (M.A. in Regional Planning). M. Barré has held posts in the Ministry of Research and Technology (or its predecessors) working for M. Curien and Robert Chaball, and as a professor at the Conservatoire des Arts et Metiers (economic analysis and strategic analysis). He emphasizes that OST is a small and new organization, having opened its doors in November 1990.

The OST's first major report, due in September 1991, will present indicators for France in international comparisons. Focused on trends and strengths and weaknesses (down to the disciplinary level), the report will help assess the dynamics of the French research and development (R&D) system. While this major OST product will be inspired by the U.S. National Science Board's *Science Indicators*, it will also be different.

The work of the OST will be trying to bridge some classic gaps in France between civilian and military R&D and between basic and applied research. The OST will not generate new survey data but will concentrate on new and original treatment of the data being obtained. The broad commission is to analyze and develop indicators even down to the level of department or region in France. The OST will not do individual consulting firm-like studies for individual members. The OST must strengthen the knowledge base for discussion and debate of science policy issues.

The OST staff has six to eight full-time equivalents but some are part-time with the organization. The budget is about FF7 million (about $1.22 million) for the fiscal year 1990-91. However, all of that money is not in the OST budget since it includes the salary and other costs associated with personnel donated by member organizations. About one-half that sum goes for personnel and the other half is equally divided between overhead costs and research costs, including contracts.

International Involvement

M. Barré is interested in making connections with other organizations in the fields of science indicators and evaluation of R&D, including abroad. Indeed, he chairs the Output Network Group of the Commission of the European Communities (EC). In this group, European workers in these fields come together under EC sponsorship to report on and to discuss methodological and analytical innovations. M. Barré hopes that after the first report appears, he might visit the U.S., including the National Science Foundation, to present its results.

Fraunhofer Institute for Laser Technology

by Tom Owens

The Fraunhofer Society

The Fraunhofer Society is a government-funded private organization with an aim to assist industry with research and development (R&D)-related activities. The Fraunhofer Society has about 6,000 people (about 40 percent of whom are scientists) and a budget of some DM650 million ($384.6 million). About 35 percent of the funds are base financing from the Federal Ministry for Science and Technology (BMFT), and another 10 percent comes from the German states, or *Laender*. The rest comes from industry and government contracts. The institutes are run like profit-making organizations, with a light management hand from the presidency. The laboratories specialize in fields as diverse as production engineering, solar energy, atmospheric pollution, and military-related research. The institutes compete with the universities and other research institutes for their work. The base funds of some institutes (such as one that performs pollution testing) is larger than others. Losses and cost overruns come out of the base funds and can sometimes be shifted from year to year.

Institute for Laser Technology

The Fraunhofer-Institute for Laser Technology (ILT) is located near Aachen, Federal Republic of Germany (FRG) Dr. Falk Ruhl is deputy director. One of 32 independent institutes of the Fraunhofer Society, the ILT is making many proposals. However, two or three must be made for every successful one. Most of the money comes from government-funded projects. Most contracts of the BMFT are not fully funded and require industry participation. From 50 to 75 percent of the total cost might be expected from the government (Federal and *Laender*). By the same token, contracts with industry usually depend on some additional funds from government. Overall, the ILT now has 25 percent of its money coming directly from industry, with another 20 percent from mixed government/industry. Included in the latter is industry money that originates in European Community (EC) contracts. Another 45 percent comes from contracts with all forms of government (including EC). The last 10 percent comes from the government-provided base funds. Lasers in general are not a growth area. Furthermore, the demands on the economy from the *Neue Laender* (formerly the German Democratic Republic [GDR]) may mean that industry and government support will likely decline.

Like many Fraunhofer institutes, a university professor (Dr.-Ing. G. Herziger) is president. The ILT has been set up near the Fraunhofer Institute for Production Technology and it must offer research opportunities to students. Students work about 15 hours/week at DM12/hour. Basic research was relatively neglected at ILT earlier, but it is now moving to catch up (about 15 percent of its work). Dr. Herziger supervises about eight PhD students on the program of Technical University, Aachen, plus 50 students and seven more PhD students from other universities. While working at ILT, the PhD takes about 3-5 years.

The European Community Programs

The EC does not allow industry in member countries to receive more than 40 percent of its support from government. That is true even if the industrial concern is doing precompetitive research, or it only operates in the FRG, or only with *Laender* support. The EC programs require much paperwork and red tape. Many forms must be filled out, and one can only ask for about half of the necessary money. Typically, this is not enough for the Fraunhofer institutes, so it is difficult to try to participate in EC R&D programs. The other 50 percent should be found in industry or taken from the base funds. If a German aspires to EC program money, he should enlist a French or Italian partner who can do the necessary preparatory work. More and more national R&D funding goes to Brussels, and research organizations must do so as well. EC R&D program funding is for political as well as technical reasons. Some companies are having trouble finding uncommitted (to EC) companies to collaborate with.

Science in the *Neue Laender*

Research in the *Neue Laender* can be characterized by good science, poor equipment, and over-staffed organizations. There is a high level of intellectual quality, especially in theoretics, but all the infrastructure and equipment must be developed from the beginning. The Fraunhofer Society was among the first to try to address the problems of reconstruction in the *Neue Laender*, moving before the Deutsche Forschungemeinschaft (DFG) and the Max Planck Society, for instance. Fraunhofer has set up 16 new research groups in the *Neue Laender*. These might have functioned as well in existing institutes but they will be attempting to build upon some special skills built up in the GDR. In lasers, the ILT will be a big brother to a Fraunhofer group set up in Dresden. Dresden has people experienced in surface treatment techniques with strength in materials science. The united ILT/Dresden group will work on laser, electron beam, and plasma technologies. The association with Dresden

has required some adjustments at ILT, including ability to exchange personnel. In the short run, it is possible that German research standards will go down in the West while going up in the East. Also, there may be an impact on German competitiveness.

Cooperation with the U.S.

American researchers would be welcome at ILT on cooperative research projects. They would need to bring salary support but could use ILT's considerable laser facilities. The fields of research in which the ILT has the most capability that would offer the greatest opportunity for visiting researchers are

- Use of lasers for industry
- Materials processing
- Behavior of materials in high average intensities
- Phase behavior of materials
- Diagnostic spectroscopy
- Gas dynamics
- Data management
- Process diagraming/modeling of laser techniques
- Experimental design
- Solid state lasers/diode pumps
- Equipment and systems for laser research.

Author Comment

The impact of the requirements of the *Neue Laender* in every resource category and a realization that everyone in the FRG will feel the impact reaches even to this specialized research institute.

Policy for Science and Technology in the New German States

By Tom Owens

Introduction

Dr. Josef Rembser is the Assistant Secretary/Basic Research-Research Coordination-International Cooperation at the German Federal Ministry for Research and Technology (BMFT). I attended his presentation on the German government's efforts to bring the *Neue Laender* (the new German states formed from the territory of the former German Democratic Republic [GDR]) up to international standards in science and technology (S&T). Except where otherwise indicated, the opinions expressed here are Dr. Rembser's, as I understood them.

The unification of the GDR with the Federal Republic of Germany (FRG) has increased the gross national product by 10 percent, the population by 25 percent, the number of Research and Development (R&D) personnel by 40 percent, and the national debt by 100 percent. The unification is the defining event in the lives of this generation of Germans.

The Universities

In the East, the universities were responsible for educating politically reliable people to do something preassigned in science and engineering. Very little research was done in the universities, and where it was done it was oriented toward production and services rather than basic research. The social sciences and the humanities have undergone a catastrophe; history, economics, and management are in a shambles.

The first task for the universities is to reintegrate research and education, to provide new leadership, and to change the system of education. The percentage of people in western FRG coming out of the *gymnasium* (high school equivalent level) to the university is about 24 percent; in the East it was 13 percent. At the same time, there are more professors in the East than in the West. The system must be all on the same footing. The research institutes of the Academy of Sciences are disbanded, and many of their researchers will find positions in the universities. Indeed, some of the academy researchers started in the universities but were reassigned because of lack of political reliability. The requirement that professors have the highest ideological reliability is the reason behind a questionnaire that will be filled out by all professors. This questionnaire requests information concerning previous involvements with the communist party of the GDR and with the secret police. Those who were members of the *Reiscadre* had many privileges, including relatively easy travel. They were virtually all party members and some were also agents of the secret police. In any event, anyone who traveled abroad had to report to the secret police upon their return. Faculties of humanities have been dissolved, and those professors who meet the requirements (result of their questionnaire responses) will be reappointed. The *Laender* are responsible for the universities in the western portion of FRG, but the new *Laender* in the eastern portion have very few financial resources. The West is providing them with DM65 billion (about $41 billion). The new professors who come from the disbanded academy will have their salary paid by these western funds.

Industry

There were about 100,000 enterprises in the East; 20-25,000 either did research or got research expertise from the universities. There were about 300 industrial enterprises in the GDR, including the largest *kombinata* (industrial combines). Industrial research institutes did

some research as well but had great difficulty transferring results to production processes. The overall R&D system had to be quite self sufficient because of inability to purchase necessary instruments and equipment. In R&D, 60 percent of the people carried on the research, while 40 percent were in support roles.

Some "research companies, limited" have been formed now, combining the research personnel of several companies to perform in the private sector. For the most part, however, R&D now is an unaffordable luxury for enterprises in the East. Since industrial researches are a private sector responsibility, these people are in the worst position of all researchers in the East. The BMFT has a fund of DM1 billion which has been set up to help form and promote small high-technology companies. However, any amount taken from this fund must be matched by the *Laender* in the East; that is very difficult.

The Academy of Sciences System

The GDR Academy of Sciences was organized on the Soviet model, with 28,000 people running research institutes. In addition, there were 15,000 Academy of Agricultural Sciences members and 2-3,000 Academy of Engineering members. Such large government research institutes have no place in the German system today, where the goal is that two-thirds of all R&D will be done in the private sector. The academies still exist as associations of scholars (except the East Berlin Academy, which was hopelessly ideological). The institutes have become the responsibility of the *Laender* governments.

The German Science Council[1] will perform a peer review of 100 institutes and make recommendations based on various measures of performance and quality and on results of site visits. The recommendations will go progressively to an evaluation committee, science and administration committees, and finally to a plenary discussion and recommendations. Since over half of the academy institutes were in Berlin, some will surely be recommended to move to other *Laender*. Perhaps 15,000 of the Academy of Sciences' 28,000 personnel will be advised to leave the public R&D sector. Some of the academy institutes will become institutes of the Federal or *Laender* governments, or of the Fraunhofer-Gesellschaft (a government-funded, private society for the support of industry-related research). The Max Planck Gesellschaft (also a publicly funded private society) has established 20 institutes at universities in the East. In 5 years, these will become either university institutes or permanent Max Planck institutes. Some of the laboratories may be combined with existing federal laboratories, especially those specializing in the environment, geosciences, and space.

All of the public servants in the former GDR will have to be recertified before they can continue in government service. Programs are being set up to create new jobs and to retrain people for up to 2 years. However, the cost of the shift to merit-based and market-driven R&D will still be very high. For instance, much of GDR chemistry was based on the chemistry of brown coal (basically a dead-end line of research in the West).

International

The GDR was integrated into the COMECON (previous community of economic cooperation) but all bases for legal performance within it of GDR contracts were dissolved upon unification. However, the FRG will review and assist with cooperation where possible dislocations occur, especially in former COMECON countries. Equally, if the U.S. finds it valuable to continue contacts with German researchers in the East, the BMFT will help.

Eastern Europe

Seeds, instruments, and other inputs were made from the GDR to the R&D systems of Eastern European countries. Bilateral agreements have been made and mixed commissions are trying to address problems. The Eastern Europeans are not interested in the research capacity of the former GDR. They are looking for cooperation elsewhere in Western Europe, the U.S., and Japan. Poland joined the European high-energy research center (CERN), Geneva, Switzerland, and is drifting away from its cooperation with the U.S.S.R. The Eastern European focus on the U.S.S.R. was artificial, and despite a few special cases to the contrary, former COMECON countries are looking west.

The European Community

The Structural Fund of the European Community (EC) will help in a general way with the economic development of the East. However, the overwhelming majority of support needs will fall directly on the FRG. European S&T is not the same as the S&T of the Commission of the EC; it is the scientific systems of the individual states that matter. The researchers, laboratories, and institutes are almost exclusively of the individual states.

[1]A group of 400 people, approximately 50 percent scientists and 50 percent bureaucrats and consultants, reporting to the Federal Government.

The United States

Researchers and official from the U.S. should inform themselves on what is happening in the eastern portion of FRG. They are invited to travel there, and to talk to the people who are living through the changes. They can help to find out what to do or what might work on specific R&D-related matters. American researchers are welcome to collaborate with researchers from the eastern part of the FRG. American social scientists are invited to be involved in the study of the transition from a command economy to a market economy.

Author Comment

The tone and the intensity of this presentation indicated the magnitude of the problem that FRG science policy officials have discovered. There is very little in the East German R&D system that, despite its precollapse reputation, can measure up to world-class standards. There will be many researchers cut adrift at the margin, some of whom might find places in the U.S. or in Western Europe. For the time being, the problems described by Dr. Rembser in R&D in the eastern part of the FRG would likely heavily outweigh the technical and scientific returns.

The Plan Nacional de Investigacion Cientifica y Desarrollo Technologico[1]

by Tom Owens

Introduction

Luis A. Oro Giral is the Secretary General of the Plan Nacional de Investigacion Cientifica y Desarrollo Technologico (Plan Nacional) and is responsible for its implementation. Part of his duties include coordinating international cooperation involving participation of the Spanish government. Dr. Oro noted there has been a historical orientation of the Spanish research community toward cooperation with the U.S.. However, since the end of the funds provided by the Bases Agreement for Cooperation, working with American researchers has been mostly a one-way street.

Lacking any formal cooperation mechanism, the cooperation that has taken place has been financed largely by the Spanish. This has included both sending Spanish researchers to America and receiving American researchers in Spain. The situation has resulted in diminished cooperation. The researchers are losing connections, and the U.S. is losing influence in Spanish science and technology (S&T). Both the U.S. and Spain have invested in educating students and in training researchers in the U.S. It should be possible to reinforce that investment with some formal mechanism for cooperation in which both sides contribute and both sides benefit. The Plan Nacional could make available a considerable sum as the Spanish contribution to such a cooperative activity. One possible mechanism for the cooperation would be the Acciones Integradas[2].

The plan for the Interministerial Commission on Science and Technology (CICYT) administers the National Research Fund. About 217 million European Currency Units (ECU) will be available for problem-oriented research and 83 million ECU for basic research. These funds are dispensed on the basis of proposals submitted by research institutes, universities, and private companies. The evaluation of the proposals is done against two main criteria--quality and opportunity. While both criteria play a role in evaluating both basic and applied research, quality is uppermost for basic research and opportunity is uppermost for applied research.

Spain and the Programs of the Commission of the European Community

The programs of the Commission (Commission) of the European Community (EC) for the support of S&T must specialize in activities that promote mobility and the formation of human capital. They must provide a value-added function, rather than try to address every country's priorities.

The EC programs are necessary for European diversification. Programs like STIMULATION and its successor SCIENCE require university participation from several countries (usually benefitting the universities). E[illegible] European countries who want to cooperate with the EC and the West in general will result in an increase of well-qualified people to work in the West. Since salaries in Spain are competitive, Spain is not likely to suffer its own brain drain after economic integration is complete in the EC. However, this may not be true in Portugal and Greece. If EC programs disappeared, the rate Spanish growth in research and development (R&D) would be about the same. In 1982,

[1]The National Plan of Scientific Research and Technological Development consists of a group of national programs of research in strategic fields with socio-economic importance in Spain. The focus is on applied themes, and involves Spanish industry in cooperation with universities and public research institutes.

[2]They look like the NSF Cooperative Research awards in many international programs (the marginal costs of internationalizing an existing research project, provided over 1 or more years).

S&T were established as important elements for the nation. In 1983, university reform was initiated. In 1986, the Law of Research established the National Plan. This all happened before Spain entered the EC in 1986.

The longer that Spain and the U.S. go without some formal mechanism for cooperation in S&T, the more tenuous the links will become between the two countries' research communities. The National Plan is prepared will try to resolve the problems and to participate in new cooperative efforts.

Centro Superior de Investigaciones Cientificas

Dr. Jesus Avila is the Scientific and Technical Coordinator in biology and biomedicine at the Higher Centre for Scientific Research (CSIC). His job includes relations between the research community and the funding agencies (especially CICYT) to help obtain resources. In addition, he helps to set up policy for areas to be emphasized in the discipline(s) concerned.

Biotechnology is not being emphasized. In March 1991, a new biotechnology center opened and is located on the campus of the Universidad Autonoma de Madrid. This center specializes in protein engineering, and primarily performs applied research. One of its objectives is to liaise with industry. This will be one of a series of elite research organizations to be set up over the next few years in Spain. Historically, Spain has been outstanding in biology research. The Centro de Biologia Molecular (Center for Molecular Biology) has been operating for many years; it is a CSIC laboratory located at and comanaged with the Autonomous University of Madrid.

The CSIC has about 40 billion Pesetas (about $422 million) to cover the salaries, buildings, and other institutional costs associated with biological science research. The research costs, including equipment and infrastructure, are obtained primarily from CICYT, but also from autonomous regions of Andalucia, Basque, and Madrid. The EC is a flexible source of funds. Applicants for research support from Spanish agencies must specify how much time will be spent on the project. The CICYT keeps a central record so that no one may bid more than 100 percent of their time. This restriction does not apply to EC awards. Someone 100-percent committed on Spanish-source projects may still apply for and receive funds from the EC. The EC project money goes to proposals that will use advanced techniques and will have some potential technological impact.

Proposals to CICYT are handled by a program manager who gets the opinion of two reviewers. Most reviewers are located outside of Spain, but are required to speak Spanish. Biannually, a committee examines the reviews and makes funding recommendations. Though they are not required to follow the committee's written recommendations, they almost always do. The success rate for proposals is about 30 to 40 percent.

One of the great challenges to Spanish science policy is making decisions on closing unproductive institutes. Ways must be found to reorient unproductive researchers into new work.

Centro de Investigaciones Bilogicas

The Centro de Investigaciones Bilogicas (Biological Research Center [Center]), located in downtown Madrid is the motherhouse of Spanish biological research. Dr. Jose Luis Canovas Palacio-Valdes is acting Director. The Center has a 400-person staff (90 Ph.D.s and 10 doctoral students). Research advisors for the students are located in universities throughout Spain. Likewise, the students working at the Center can earn degrees from any of those universities. The Center is known as one of the best biological research institutions in Spain.

The Research Program. Research units of the Center specialize in:

- Bacterial genetics
- Endocrine physiology
- Genetic engineering
- Virology
- Cytogenetics
- Immunology
- Cellular structures
- Biomembranes
- Cell reproduction
- Phytopathology
- Applied microbiology.

The Center has a library with over 60,000 publications, and a computerized reference service that includes holdings at other CSIC institutes. There is an animal unit with seven rooms to breed and monitor animals used in the Center's research. Four electron microscopes, gas and liquid chromatography, a cellular micromanipulation service, and other advanced analytical and cell/culture handling and management services are available at the Center. The Center's 1989 budget was about 332 million Pesetas (about $3.5 million).

Dr. Juan Ramirez heads a unit that specializes in biomembrane research. There are several small groups within the unit (typical research organization). Two people are working on light-harvesting pigments. They are studying the orientation of pigments (chlorophylls and carotenoids) and the quenching by carotenoids of the triple-state chlorophyll which is a byproduct of photosynthesis. Spectrographic data show not single molecules, but rather a dymeric organization. The group is interested in the effect of this phenomenon on the energy transfer function in photosynthesis. Samples are sent elsewhere for analyses on large equipment not available at the Center. The group's strengths have been in developing purification and concentration processes,

and in preparing biological materials for analysis without disturbing their original structure. The unit has a cold room, spectrometry, and a culture room, as well as a 10'x 10' laboratory. Also, the Ramirez group has centrifuges, a 30°C room, chromatographic columns, and another cold room.

Author Comment

Since its inauguration in 1958, the building has accommodated a growing number of research units, accommodating pre-existing research institutes as well as new units responding to evolutions in the biological sciences. Despite the down-at-the-heels appearance of the building, the people are energetic, which keeps many of the Center's groups at the international level. The latest available annual report (1988) shows 300 publications for the year, most of which are in international journals.

The Instituto Cajal

The Instituto Cajal (Cajal Institute) bears the name of the Spanish Nobel Prize winner, Santiago Ramon y Cajal. The Cajal Institute is Spain's oldest biological research institute, and has been under the CSIC since the Spanish Civil War. Historically, it specialized in neurohistological research; however, it has expanded its scope over the past few years to include 16 groups working on many aspects of neurobiology. Dr. Jose Borrel Andres is the current director of the Cajal Institute, but will soon return to the laboratory. Dr. Luis Miguel Garcia Segura will replace him.

One the important current objectives is to attract young researchers to neurobiology and molecular biology. The staff numbers 140, including 30 permanent research staff, 60 students and post-doctorates, and 40 technicians. Students take their degrees from universities throughout Spain, presenting the results of their research done here. Funds come primarily from the CICYT, but private foundations and contract work for industry provide additional funds, as do contracts from the EC. The Cajal Institute now has four contracts that provide funds under the EC's SCIENCE program. The European Science Foundation (ESF) also provides funds for participation in its neuroscience network. The total budget is about 650 million Pesetas (about $6.8 million). About 350 million Pesetas are for salaries and wages. The research budget of about 300 million Pesetas is higher than normal because of the large equipment purchases made in conjunction with moving to their new quarters. A more normal figure would be 200 million Pesetas ($2.1 million).

The Research Program. All neurobiological fields are included in the work of the Cajal Institute. All equipment needed for neurobiological research is available here, and it is relatively easy to move among the various disciplines. The research has a distinct biomedical potential but is basic research; the general lines of research are:

- Organization of the cerebral cortex
- Involvement of hormonal factors in the development of the central nervous system
- Mechanism of generation and flux of nerve cells
- Characterization of neurotransmitters and neuromodulators
- Neuroplasticity
- Molecular ion channels
- Entropy functions.

In 1989, the Cajal Institute moved into its present modern building. Each research floor (designed specifically for biological research) has laboratories on one side of the corridor and common facilities on the other. Equipment available includes two JEOL electron microscopes, two florescence microscopes, liquid scintillation, DNA synthesizers, densitometer, and various centrifuges. There is an animal colony; behavior, photo, and cryopreparation laboratories; and an assortment of cold rooms.

Support from the European Community

Spanish-source funds are generally for 3 years. Grants from the EC can supplement the availability of Spanish funds because there is no restriction based on other time commitments. Having an EC award provides a sort of cachet that helps to get Spanish funds as well. Also, Spanish planners are looking to EC programs to supply a percentage of support for Spanish research work. There has been enough money for Spanish researchers from Spanish sources. However, that is changing as the Spanish R&D budget flattens. Pressures to compete for EC money will be growing, though the volume of Spanish applications is still relatively low. In biomedicine, most projects supported by the EC with Spanish participation have been initiated by researchers in other countries. Despite all this, there is a readiness to cooperate with the U.S. Eighty percent of the postdoctorates at the Cajal Institute would like to do some of their postdoctoral training in the U.S. In fact, most people have been trained in the U.S., but the pressures to work within the EC are growing.

Meeting with Vice-Rectors of Spanish Universities

Dr. Robert Morris (U.S. Embassy Science Counsellor, Madrid) and . met with the Vice-Rectors of universities in the Madrid area. Jose Antonio Munoz-Delgado Ortiz and Francisco Ferrandiz, of the Secretariat of the National Plan for Research and Development organized the meeting. The following people attended:

- Dr. Guillermo Calleja Pardo, Vice-Rector for International Relations, Universidad Complutense
- Dr. Jose Vicente Lopez Alvarez, Director, Office of Technology Transfer, Universidad Politecnica de Madrid
- Dr. Carlos Sanchez, Vice-Rector for Infrastructure Research, Universidad Autonoma de Madrid
- Dr. Manuel Najera-Aleson, Director, Office for Transfer of Research Results, Faculty of Medicine, Universidad de Alcala.

This meeting was primarily an opportunity for the Vice-Rectors to reiterate the readiness of Spanish researchers (in this case, at the universities) to cooperate with American researchers. Cooperative visits are hard to arrange, and their is less cooperation since the end of the Bases Agreement. They stressed importance to the universities of having a formal structure fo S&T cooperation. The meeting also provided an opportunity to highlight the necessity of coming to grips with the questior of intellectual property rights.

Centro de Biologia Molecular

The Centro de Biologia Molecular (Center for Molecular Biology [CMB]) belongs to both the CSIC and the Autonomous University of Madrid on whose campus it is located. The director is Dr. Gines Morata Perez. Historically, the director and the deputy director are alternately from the CSIC contingent of the institute and the university contingent. The staff of 434 is the largest in Spain. This staff is divided between the CSIC and the Autonomous University of Spain, 60-40 percent, respectively. There are 80 permanent researchers among the 340-person research staff, which is, in turn, divided into 34 research groups. There are about 50 postdoctorates and about 150 graduate students. The rest of the staff performs various technical and support activities. The CMB budget is about 900 million Pesetas (about $9.5 million), excluding salaries. Table 1 lists CMB fundamental biological research.

The CMB is staffed by a relatively young group of researchers, most of whom have studied and/or trained abroad for at least 2 years. The atmosphere is busy and serious. The researchers are supported by a computer center, a photography laboratory, and advanced analytical equipment. Their animal center is being converted to adapt to EC standards for keeping laboratory animals and to provide the appropriate isolation of sterile animals. The strong research areas are in virology, immunology, cell biology, developmental microgenetics, and *drosophila*.

Table 1. CMB Fundamental Biological Research

- Biology of animal virus infection
- African swine fever virus
- Variability of foot-and-mouth disease virus
- Genetic variability of influenza viruses
- Molecular biology of plum fox virus
- Structural analysis of biological material by electron microscopy and digital analysis
- Immunobiology of transmissible gastroenteritis coronavirus
- Immunobiology
- Activation of the immune system
- Control of gene expression in prokaryotic organisms
- Cellular organization: biogenesis of organelles
- Regulation of cell envelop biosynthesis in bacteria
- Structure and function of the ribosome
- Molecular biology of extremophiles
- Protein synthesis and its regulation in eukaryotes
- Gene expression in *streptomyces* and yeasts
- Hormonal regulation of gene expression
- Molecular mechanisms of hormonal action
- Biochemistry of aging
- Molecular pathology of amino acid metabolism
- Postnatal development of mitochondrial functions
- Microtubules
- Protein-nucleic acid interactions in chromatin
- Analysis of gene expression
- Genetic analysis of morphogenetic mechanisms in *drosophila*
- Molecular biology of development in *drosophila*
- Genetics of morphogenesis of *drosophila*
- Genetic analysis of cell division in *drosophila*
- Developmental neurobiology in *drosophila*
- Developmental neurobiology
- Amino acids mediated neurotransmitters
- Mechanisms of action of neuropeptides
- Structure, function and regulation of plasma membrane receptors.

Each research group must seek research funds, while the CMB provides the necessary infrastructure and equipment. About 90 percent of the funds come from Spanish sources, primarily the Agencia Nacional de Evaluacion in the Ministry of Education and Science. Because Spanish research funds are declining, the future may be affected. Applications to the EC are encouraged by the Spanish government via mailings and presentations to explain applications procedures. The CMB is involved in an EC contract to clone (but not to sequence) the *drosophila* genome. Researchers from Greece and the Federal Republic of Germany are also involved in the effort, which is led by a Greek-American researcher on Crete.

THE EMBASSIES: TECHNOLOGY ROUNDUP

Federal Republic of Germany

For further information on FRG items, contact Mr. Francis M. Kinnelly, Science Counselor, American Embassy, Bonn, APO New York 09080-7400.

1990 Annual Report of Federal Republic of Germany Patent Office

According to the 1990 annual report of the Federal Republic of Germany (FRG) patent office, 41,338 patent applications were submitted in 1990 compared with 42,472 in 1989. In presenting this report, patent office president Erich Haeusser said the number of patent applications had increased only in medical technology. In biotechnology, lasers, aerospace and space technology, and automobile technology, the former level of applications had been maintained. In contrast to Japan and the U.S., the value of trademark protection and patent protection for an international marketing strategy has not been fully recognized in the FRG. In the future, Haeusser expects some 50,000 applications per year considering the high innovation potential in the five new Laender (states).

In 1990, the most important event for the patent office was the takeover of East Berlin's Amt Fuer Erfindungen und Patentwesen (Office for Inventions and Patent Affairs) as a result of unification. At the moment, this office administers 137,782 patents. This figure includes

- Pending applications - 27,593
- Registered trademarks - 10,526
- Internationally registered trade marks - 3,403
- Industrial samples (protected design) and a complete documentation of Soviet patents.

Of the East Berlin office's 527 employees, 404 will continue to be employed; 127 are engineers who have attended two semesters at the East Berlin Humboldt University specializing in patent matters. Haeusser advocates maintaining this special training in the reorganization of the GDR universities.

EUREKA[1]: First Marketable Results of Research and Development on Flexible Manufacturing Systems

The economic newspaper *Handelsblatt* reported on the first marketable results of research and development (R&D) on flexible manufacturing systems (FAMOS) done by European firms and research institutions in the framework of the EUREKA Program. The R&D project's goal is to catch up with Japan's leading position in flexible manufacturing. A FAMOS spokesman said about 40 percent of the production costs in European industry were assembly costs, and that there have been made no endeavors so far to lower these costs.

In 1986, only six European countries had embarked on joint research in flexible manufacturing systems. Since then, 170 enterprises and 50 research institutes from 17 countries have participated in 40 research projects. Twenty new research projects are currently under preparation. Sixty research participants have generated these results. So far, DM 1.2 billion has been spent on this initiative. Depending on the country in which the research participant is located, the government contributes between 32 to 50 percent of the costs.

Research topics cover various industries but focus at the moment on production of electro-mechanical components, electrical household appliances, and components for the automobile industry.

Fraunhofer Institutes in the New States

The Fraunhofer Society in Munich has decided to found 19 new Fraunhofer research institutes in the former GDR. The new institutes are planned as follows:

- Berlin - Institute for software techniques and systems technology (75 employees)
- Brandenburg - Institute for applied polymer research (80 employees)
- Saxony: Five institutes - Microelectronics, electron beams and plasma physics (the former Manfred Von Ardenne Institut), materials physics and lamination technology, ceramics and sintered materials, molding technology, and machine tools (432 employees)
- Saxony-Anhalt - Manufacturing operations and automation (30 employees).

Besides these larger institutes, the Fraunhofer Society plans 10 smaller branch units of institutes (employing 250 people) and operating in western FRG. They will be located in Berlin (3), Saxony (3), Brandenburg (2), Mecklenburg-Vorpommern (1), and Saxony-Anhalt (1).

The Federal government and the states plan to spend about DM 500 million to put these plans into effect. For the coming 3 years, the Federal government will provide 90 percent of this amount.

[1]European Research Coordination Agency

Rebuilding Science and Technology in the New States

The research budget plan allocates DM 1.6 billion to support research and build scientific institutes in the new states. Of this amount, DM 585 million will be allocated to establishing or rebuilding research institutes, primarily those under the former German Democratic Republic Academy of Science that have received positive evaluations from the federal science council. Several new research institutes will be created. They will include a major environmental research institute with departments in Leipzig and Halle, a branch of the German Air and Space Research Agency (DLR), several *blue list* institutes that receive their funding partly from the Federal government and partly from the state governments, 19 new Fraunhofer institutes, and new branches of Max Planck Institutes.

Environmental Climate Research

DM 624.1 million will be allocated to environmental technology development and climate research (an increase of 3.2 percent over 1991). Programs demonstrating modern environmental technologies will be developed in the new states, especially in water quality, waste remediation, and air pollution. Climate research will focus on analyzing trends in the climate and atmosphere with new research activities in climate diagnosis and extreme value statistics. Climate effect analysis will focus on agriculture, the coasts, and alpine regions.

Energy Research

Support for fossil energy research will drop by 11.4 percent to DM 129.4 million. Further reductions are planned in the future. Support for renewable technologies and conservation will also drop, falling by 8.1 percent to DM 323.4 million. Nuclear energy research will increase by 2.4 percent to DM 586.3 million. Almost half of the nuclear programs will be in nuclear waste, with most of the remaining programs focused on reactor safety.

Critical Technologies

Funding for research will increasingly focus on key technologies, including information processing, physics technology, biotechnology, lasers, and materials research. One of the goals is to develop the FRG's scientific and technological base by encouraging research in new fields such as biosensors, neurobiology, brain research, and nanotechnologies. A second goal is to support the transfer of these technologies to the private sector. Research capacity in these new fields will be built up in eastern Germany (for example, the institute for applied semiconductor research in Frankfurt and Berlin and the institute for molecular biology, cell, and microbiology in Jena).

Space Budget

The cabinet agreed to increase the space budget by 12.4 percent to DM 1.7 billion. This increase is more than the 1.6 billion that had previously been embarked for space, but fell short of the 1.9 billion needed to meet all requirements for national space programs and for the German contribution to European Space Agency (ESA) projects. According to the German Ministry of Research and Technology (BMFT), the limited financing possibilities in the next few years is expected to make German participation in the major ESA projects (Hermes and Columbus) possible only if there are definite reductions in the German share. This will require difficult consultations with the European partners in the coming months. Binding decisions on the medium-term space program and the 1992 budget will not be taken until consultations with industry and the research community are completed on a framework for working out a space program that is financially sustainable. The share of the research budget allocated to space, including the atmospheric and ultrasonic programs, will be limited to less than 20 percent of the BMFT budget.

Social Sciences and Science Policy

The budget will be increased by 8.5 percent to DM 121.5 million. Science planning and evaluating of technology risks will be emphasized. Technology assessment projects are now being undertaken in the major research areas. The dialogue on basic ethical issues, such as gene research, will be intensified on both the European and international levels.

Institutional Support

The 13 major Federal institutes will receive DM 2.3 billion--approximately the same support as that received in 1991. Whereas funding for these institutes had been increasing rapidly with annual increases reaching as high as 29.3 percent in 1990, it is expected to remain level over the next 2 years. Incremental funds will instead be allocated to institutions in the new states of eastern Germany. Support for the Fraunhofer Institutes will increase 81.9 percent to DM 328 million, with the additional funds designated to support establishing the new Fraunhofer institutes. Funding for the existing Max Planck Institutes will increase 8.5 percent to DM 555 million with the additional funds also designed to support new Max Planck Institute branches in eastern Germany.

The BMFT funds for private sector research have been dropping substantially--from DM 3.245 billion in 1982 to DM 1.656 billion in 1990. Most of this impact fell on larger enterprises that have been increasing their own research budgets. The 1991 and 1992 budgets show little change for private research activities since 1990. Future emphasis will be placed on space, environmental, and health research, and for the development of environment-friendly traffic and transport systems, energy research, and support for critical technologies.

The Cosmos Research Institute

The supervisory board of the DLR approved the establishment of a DLR center in Berlin. The center will concentrate on activities of the former GDR Institute for Kosmosforschung (IKF). Two institutes will comprise the center--in Berlin and a ground station in Neustrelitz. Although exact tasks are undefined, the center will probably concentrate on IKF's intercosmos programs, including imaging instrumentation and planetary science. Management tasks will be undertaken for the BMFT in terrestrial communications research. Operation is scheduled to begin in early 1992.

In an evaluation of IKF prepared by the German Science Council, the IKF is described as an institute with considerable experience in remote planetary exploration. This experience was gained through participation in Soviet space missions and its expertise developed in the design and manufacture of related equipment and measurement techniques. These activities were cited as justification for continuing selected aspects of IKF's programs. General scientific interest as well as obligations to ongoing Soviet space projects argue convincingly for IKF's continued existence. These two factors suggest a future for IKF in planetary remote sensing--an area where the former West Germany was weak.

The Science Council also recommended that a planetary remote sensing institute of DLR be established in Berlin-Adlershof. During the transition phase from IKF's present status until full integration into the German space infr ıstructure, IKF's activities that duplicate those of DLR are recommended to be eliminated. The council recommended that research projects planned by IKF in extraterrestrial astronomy and cosmic plasma physics should be continued under the umbrella of Max Planck work groups in a neighboring university and in close coordination with DLR. The DLR should assume responsibility for the Neustrelitz Satellite Groundstation, which may evolve into a regional remote sensing facility and eventually into a user data center.

Founded in 1967, the IKF was an institute of the GDR Academy of Sciences. The number of employees will decrease under the reorganization. Previously, work centered on support for several aspects of the Soviet space program. Under the direction of Prof. Dr. H. John, it has developed a variety of remote sensing and other electronics packages for the Salyut and MIR stations and for various satellites. The IKF has research programs in remote sensing spectrometry, optoelectronic systems, extraterrestrial physics, and technical support. Since the late 1960s, IKF

- Developed research instruments and programs in remote sensing, materials science, and space medicine in connection with the USSR/GDR joint manned space flight in 1978
- Developed and constructed infrared Fourier spectrometers for three Soviet meteor satellites for continuous measurements of the temperature profile in the Earth's atmosphere.
- Designed and produced multispectral instrumentation complex MKS-M with high spectral resolution and radiometric accuracy for long-time use aboard Salyut and MIR
- Constructed ground receiving station for orbiting and geostationary meteorological satellites
- Developed precise optoelectronic complex for the automatic astro-orientation of the images of Halley's Comet.

France

For further information on France items, contact Dr. Michael Michaud, Science Counselor, American Embassy, Paris, APO New York 09777.

Grenoble - a Major Science and Technology Center in France

Since World War II, Grenoble (located at the foot of the Alps in southeastern France) has become an increasingly important center for scientific research and technology development. The Centre National de Recherche Scientifique (CNRS) established an important research center there in 1946; in 1956, France's Atomic Energy Commission (CEA) created a large nuclear research center. In 1966, the Institut Laue-Langevin (ILL) was created. The ILL is a European institution housing a powerful neutron source and its associated laboratories. In 1976, France Telecom established the largest research laboratory of its Centre National d'Études des Telecommunications (CNET). In 1986, Grenoble won the contest for the location of the

European Synchotron Radiation Facility (ESRF) now under construction. The Grenoble area also features four university-level institutions

1. Universite Joseph Fourier - science, technology, and medicine
2. Universite des Science Sociales de Grenoble - social sciences
3. Universite Stendahl - arts
4. Institut National Polytechnique de Grenoble - engineering.

Along with Strasbourg, Toulouse, and the Orsay region near Paris, Grenoble has been designated by the French government as a university "pole of attraction." Grenoble also has active promotional organizations in the science and technology fields, including the Association for the Development of Research and the Association Grenoble Research.

Grenoble boasts an unusual concentration of scientific and technological brainpower. Over 8,000 people work in research there--5,500 in the public sector and 2,500 in the private sector. Of these researchers, an estimated 62.5 percent are in basic research and 37.5 percent in applied research. In addition, there are about 40,000 students in the area. Grenoble's scientific leaders have emphasized interactions among research institutions and have attempted to encourage multidisciplinary approaches.

European Synchotron Radiation Facility

Interactions are encouraged by the fact that the European Synchotron Radiation Facility (ESRF), ILL, Grenoble Nuclear Research Center, and the Grenoble branch of the CNRS are all colocated on a point of land between two rivers, known as the Polygon Scientifique Louis Neel.

The most visually impressive scientific installation in Grenoble is the ESRF, intended to produce x rays of high quality for scientific research. The synchotron that feeds the storage ring will operate at an energy level of six gigaelectron volts. The ESRF's radiation source is an above-ground storage ring for electrons or positrons, with an 850-m circumference (2,805 feet). The beams of particles will be guided by hundreds of magnets (64 dipoles, 320 quadripoles, and 224 sextupoles) that will keep the diameter of the beam to 1/10th of a millimeter. The storage ring consists of 64 straight sections and the same number of curves, with synchotron radiation emerging from the curved parts. Wigglers and undulators in straight sections will increase the flux of synchotron radiation. The x rays coming out of the storage ring at 30 points (beam lines) will be focused by optical systems into experimental bays, whose detectors will be provided by national research groups.

Begun in January 1988, construction is 6 months ahead of schedule. This will make high-quality beams available to researchers from the beginning of 1993. Technical challenges to be faced include the stability and steerability of the beam, and the high density of radiation at the detectors. When in operation, the ESRF will employ about 430 people, and expects to receive 2,000 visiting scientists annually. The Director-General of ESRF is Professor Ruprect Haensel, University of Kiel, FRG. The address of ESRF is: B.P. 220, 38043 Grenoble Cedex; Tel: (33) 76-88-20-00, FAX: (33) 76-88-20-20.

Institut Laue-Langevin

Adjoining the ESRF is the Institute Laue-Langevin (ILL), which stems from a Franco-German agreement signed in 1967; the U.K. joined as an equal partner in 1973. The aim was to provide the scientists of those countries with a unique neutron beam facility applicable to the physics of condensed matter, chemistry, biology, nuclear physics, and materials science. The high-flux reactor went critical in 1971, and reached its full power of 57 MW later that year. The reactor provides cold and hot sources and neutron guides. There are 35 permanent instruments and 15 temporary instruments in the extensive experiment halls around the reactor. At the moment, 30 experiments are under way. While regular upgrades of facilities take place, there are no plans for a major expansion. The ILL and ESRF cooperate in planning facilities and research, including a joint building. In addition, the Heidelberg-based European Molecular Biology Laboratory has an outstation adjoining the ILL, and uses the neutron source in its research. Spain and Switzerland have become associated scientific members of the ILL. The ILL has a budget of about FF300 million (about $53 million) a year. The Director of the ILL is Peter Day of the U.K. The address is: B.P. 156X, Avenue des Martyrs, 38042 Grenoble Cedex. Tel: (33) 76-48-71-11, FAX: (33) 76-48-39-06.

Polycone Scientifique Louis Néel

The CNRS has several buildings on the Polycone Scientifique Louis Neel, including the Very Low Temperatures Research Center, the Louis Néel Magnetism Laboratory, the National Intense Magnetic Fields Service (which includes researchers from the FRG's Max Planck Institute), the Electrostatic and Dielectric Materials Laboratory, the Glaciology and Environmental Physics Laboratory, a crystallography laboratory, the Center for Research on Plant Macromolecules, and the Energy Policy and Economy Institute. There also is a millimetric radio astronomy institute (in cooperation with Max Planck) and a helium liquefaction service. This center employs 1,200, including 600 researchers, and has an annual budget of about FF500 million (about $88 million). The regional delegate for CNRS is Bernard Fandre. The address is: B.P. 166X, 25, Avenue des Martyrs, 38042 Grenoble Cedex. Tel: (33) 76-88-10-00, FAX: (33) 76-88-11-61.

Centre d'Études Nuclaeires de Grenoble

Centre d'Études Nuclaeires de Grenoble (CENG) is one of CEA's largest research centers in Grenoble with a staff of 3,000. One half of its work is applied non-nuclear research, basic research and applied nuclear research get one-quarter, respectively. The CEA's equipment includes two reactors (35 MW and 100 kW), a very high-resolution electron microscope, and very high-field nuclear magnetic resonance equipment. The primary departments and laboratories are fundamental research, chemistry, molecular and structural biology, protein engineering, thermohydraulics, and materials, and metallurgy. There also are nuclear energy-specific groups that address safety, health, and operations. Particularly significant is the Laboratoire d'Electronique, de Technologies, et d'Instrumentation (LETI). The CENG's Director is Francis de Cool. The address is: B.P. 854, 17, Avenue des Martyrs, 38041 Grenoble Cedex. Tel: (33) 76-88-44-00, FAX: (33) 76-88-34-32.

Laboratoire d'Electronique, de Technologies, et d'Instrumentation

The Laboratoire d'Electronique, de Technologies, et d'Instrumentation (LETI) is one of CENG's most important divisions. This division does applied research in electronics and microelectronics technology, with the intent of licensing technologies and processes to industry (there is also a LETI laboratory at the Nuclear Research Center at Saclay near Paris). The LETI has a staff of 900, including 315 engineers, as well as large laboratories. The program includes photo detectors, flat panel displays, sensors, silicon-integrated circuits, silicon on insulator, lasers, mass memories, robotics, architecture and engineering, artificial intelligence and software engineering, instrumentation for nuclear, biological and medical physics, and environmental applications. The LETI's infrared laboratory has attracted much attention. The Director of LETI Grenoble is Denis Randet. The address is CENG, 85X, F-38041 Grenoble Cedex. Tel: (33) 76-88-30-78, FAX: (33) 76-88-51-05.

Norbert Segard Center

In a research park near Grenoble, France Telecom maintains the largest research center of CNET. Opened in 1981, the Norbert Segard Center specializes in microelectronics and collaborates with 50 companies with a staff of 400, including 220 engineers. Among its most active areas of research are integrated circuits, complementary metal oxide semiconductor (CMOS), computer-aided design (CAD) for integrated circuits, and process and device simulation. The director of the Norbert Segard Center is Jean-Pierre Noblanc. The address is: B.P. 98, 28, Chemin du Vieux Chene, 38243 Maylan Cedex. Tel: (33) 76-76-40-00, FAX: (33) 76-90-34-43.

Open Software Research Foundation

Grenoble also is the location of the European branch of the Open Software Research Foundation. Advanced development work is currently focused on a multithreaded server emulating the OSF/1 operating system. The Director is Jacques Febvre. The address is: 2, Avenue de Vignate, 38610 Gieres Cedex. Tel: (33) 76-42-82-39, FAX: (33) 76-54-03-99.

Université Joseph Fourier

Of Grenoble's four university-level institutions, the Université Joseph Fourier is the most oriented toward scientific research. This university has 14,000 students with 1,000 permanent professor-researchers and 500 external teachers. About 30 percent of its researchers work in physics and 14 percent in medicine. Major facilities include the Grenoble Center for Nuclear Magnetic Resonance. The university is a partner in several research institutions (some on its campus), including the Mechanics Institute of Grenoble. The Vice President for Research is Andre Rossi. The address is: B.P. 53X, 38041 Grenoble Cedex. Tel: (33) 76-51-46-00, FAX: (33) 76-51-48-48.

Institut National Polytechnique de Grenoble

The Institut National Polytechnique de Grenoble (INPG), an engineering school, also conducts research. The INPG has 3,600 students, 1,000 researchers, 275 professors and lecturers, and an annual research budget of over FF300 million ($53 million). The President is G. Lespard. The address is: 46, Avenue Felix-Viallet, 38041 Grenoble Cedex. Tel: (33) 76-57-45-00, FAX: (33) 76-57-45-01.

Several companies have decided to locate plants or research and development centers in the area. Perhaps the most important is Hewlett-Packard, which is transferring its world-wide personal computer operation to Grenoble. Reportedly, Sun Microsystems will locate its European research center in the same research park that houses CNET's Norbert Segard Center.

Hungary

For further information on Hungary items, contact Scientific Attaché, American Embassy, V. Szabadsag Ter 12, Budapest, APO New York 09213-5270.

Hungary - Current Environmental Issues

Hungary has condemned the Czechoslovakian decision to complete the Gabcikovo hydroelectric project. The Hungarian government has offered to build a gas turbine powerstation as a replacement. The compromise proposal is unacceptable to the Czechoslovakian government.

Significant environmental damage at many of the abandoned Soviet military bases in Hungary occurred just before final withdrawal of Soviet troops. Rather than hand over the fuel to the Hungarians, the Soviets maliciously dumped thousands of liters of leftover petroleum products onto the sandy soil. The contamination is swiftly entering Hungary's most important aquifers. Without immediate remedial action, restoration will be almost impossible and prohibitively expensive. The Ministry of the Environment has identified 19 Soviet base sites in Hungary as hazardous waste sites that require immediate treatment. Talks with the Soviets about compensation are slated for well after the sites become combustible.

Italy

For further information on Italy items, contact Mr. Reno Harnish, III, Office of the Science Counselor, American Embassy, Rome, APO New York 09794-9500.

Italian Press Reacts to Space Station Freedom Cuts

The U.S. Congress Appropriations Committee voted to virtually stop all financing for the space station that had started in 1984. Now the National Aeronautics and Space Administration, supported by the White House, will have to face another strenuous battle to avoid the disappearance of a project that thus far has kept 30,000 persons in the United States (U.S.) employed and that has seen considerable involvement of Europeans, Canada, and Japan.

After signs of difficulty for Japan, now it is the turn of Europeans led by the Federal Republic of Germany (FRG), the largest investor in the Columbus Module Program. The FRG is requesting that the European Space Agency (ESA) decrease its commitment in the space station program by 750 billion Lire (about $600 million) from the total estimated of 3,500 billion Lire. The financial problems are causing a general slowdown of the whole project. Since the FRG is building the moveable part of the Columbus module, they are forced to postpone all stages of their work share. In the meantime, the FRG proposes to obtain some of the work connected with the attached pressurized module (APM) which will be completed relatively early in the process, but which is committed exclusively to Italy.

The FRG is also trying to cut down the length of the module to contain only five (or at best six) that are the containers housing the experiments. The FRG proposal is not supported by Professor Luciano Guerriero, President of the Italian Space Agency (ASI). He said that Italy, with a 25 percent participation in the program, is second only to the FRG which has a 38 percent share. However, Italy intends to carry out its commitments without drastic cuts. Guerrero says that the project supported firmly by Italy has now reached the contracting stage and it cannot be reshaped according to the FRG proposals. Guerriero says, however, that Italy might consider a decrease in the number of racks (no fewer than eight). This way, the length of the module is also affected. With these new smaller proportions, the module might be suitable to be assembled before being launched. Before cutting of size, the larger dimensions demanded that the finishing be accomplished by the astronauts in orbit with an operation that would have been much more costly.

Guerrero concluded that this was the maximum reduction that Italy could accept in the program. The same opinion was also manifested by Ernesto Vallerani, President of Alenia Spazio--the firm responsible for the Italian portion of the module. Vallerani said that it is out of the question to discuss further measures to reduce the program. He said that the lobbying of the FRG within ESA is unilateral; Italy does not support it.

Italy Will Create More Science Parks

Italian political and science authorities have recently been taken by the idea adding to its four or five science parks. A new fervor is pervasive in the scientific, political, and industrial worlds to see that Italy gains a more advanced position proportional to its scientific and industrial level. Only Greece, Ireland, and Portugal have fewer functioning science parks. There are areas in Italy that contain a concentration of research laboratories and institutes belonging to the National Research Council in Rome, Milan, and Naples. Compared with science parks in the United Kingdom, France, the FRG, and Spain, the Italian status seems to be negligible. Therefore, the Ministries of University and Scientific Research of the budget and of development of the south have jointly approved the expenditure of 1,100 billion Lire (about $880 million) to create science parks in the south.

The EC is responding favorably to the Italian effort. The EC is financing with the Italian Government three

science parks plus a project for data transmission in the south of the country (total expenditure - 261 billion Lire, about $209 million). These parks are:

- Technological park of "Val Basento" - will be created by a consortium of industries already active in the Southern Region of Basilicata, will be managed by an industrial consortium, and will specialize in polymers and fibers
- Brindisi Research City - advanced materials and related technology and post-graduation specialized training, will be managed by a special consortium, and total cost estimate is 110 billion Lire with the EC providing 45 percent
- Technological Park of Calabria for Informatics - will be created by a consortium, managed by a mixed public/private consortium, and total cost estimate is 59.7 billion Lire with the EC providing 45 percent
- High-speed network of scientific data transmission for the southern universities linked to the national and international networks, and total cost estimate is 5 billion Lire with the EC providing 47 percent.

In addition to these science parks, others are being planned such as a center at Cagliari, Sardinia; cost estimate is over 700 billion Lire.

European Community Tough Measures for Urban Wastewater

The EC has directed that by the end of the century all towns with a population over 15,000 should be equipped with a system for treatment of wastewater. Also, by 2005 the towns with a population between 2,000 and 15,000 should have wastewater purifiers. The cost estimate is about 20,000 billion Lire by 2000 (about $16.5 billion). Carlo Ripa Di Meana, who is responsible for environmental affairs at the EC, said that it is indecent that at least 200 million inhabitants of the EC lack any water treatment apparatus. The EC directives provide some exceptions for those towns and regions that are discharging their water directly into the Atlantic Ocean.

An International Court for Environment

At the 1992 Rio de Janeiro United Nations (U.N.) conference on environment, Italy will present a proposal for an International Court for Environment. The court would operate under the aegis of the U.N. and EC. In addition to the court, an agency would be created that would act like a super ministry of environment responsible for the control and monitoring of environmental status of the Earth. The court would be modeled after the International Court of The Hague.

Bacteria to Clean up Oil Slick

The biologist Paolo Broglio, manager of the company Ecologia Applicata of Milan, is trying to relaunch using bacteria to metabolize oil slicks polluting the sea. These bacteria were singled out by a study conducted at the University of Texas by Carl Oppenheimer and the Italian biologist Roberto Blundo, now a teacher of Microbiology at the University of Rome. The discovery was patented by the two researchers and now these bacteria are cultivated by two companies--Alpha Biosea of Austin, Texas, and the ECOBIOS of Rome, with branches in Capri. During a test conducted in the Capri facility, it was demonstrated that a kg of Arabian oil treated with 20 g of bacteria/sqm has dissolved after 3 hours. The bacteria attack the oil and transform it into soluble mono, bi, and triglyceride fats which become a feeding substance for fish and plankton. Afterwards, the bacteria die for lack of food and do not leave any trace of their presence after their cleaning action. It was calculated that 100/200 kg of bacteria, together with rapid growth yeast powder, may eliminate 10,000 sqm of oil slicks at a cost between 5 and 10 million Lire/hg. However, this apparently successful technique was prohibited by the Italian Ministries of Environment and Civil Protection which vetoed the treatment of oil slicks both with chemical solvents and bacteria.

Industry-Environment Award

The Italian National Agency for Nuclear and Renewable Energies (ENEA) with the Ministries of Environment and Industry have sponsored a national competition for new processes and ideas for safeguarding the environment. The competition is called Industry-Environment 1991. The response was enthusiastic, especially from small and medium industry, and several ideas emerged. Among the most significant of these ideas was one by the company Cogeim of Bergamo to purify highly polluted water by introducing it in a reactor where it is submitted to oxygen at pressures of 150 to 250 atmospheres. The reaction generates heat up to 300C and favors the formation of salts that are sold to manufacturing industry while the water is 95 percent purified and can be completely purified by normal biological processes. The initial investment for this type of reactor is about 1 billion Lire for a capacity of a cm of wastewater to be treated in 1 hour. The process costs 15 Lire/kg of waste treated (against the 300-400 Lire by traditional methods). The Ginatta Company proposed the recovery of lead from spent batteries by using an electrolysis method. This method allows the recuperation of pure lead from spent batteries by using an electrolysis method. This method allows the recuperation of pure lead at the annual rate of 4,000 tons against the 25,000 tons recuperated with thermic plants. However, the advantage of electrolysis lies in the fact that the method produce little waste, and the initial investment for the plant is minimal. The company Worgas of Modena has developed a low-flame burner that decreases the nitrogen oxides produced in the combustion from 100-200 to 40 ppm on a traditional burner. Another burner to produce only 25 ppm of nitrogen oxides is under

study. The company Idronaut has developed a buoy for monitoring sea and lake waters. The buoy is equipped with a gadget that takes data on the conditions of the water at several depths and transmits the data to a checkpoint. Several other devices and ideas were also developed in the same competition.

Italy Stops Monitoring Glaciers

Since 1895, the Italian Glacier Committee has been monitoring the approximately 1,000 Italian glaciers. Approximately 4,000 exist in the Alps and cover a 3,000-sq km area; 600 are in the Italian territory. These glaciers provide water for hydroelectric plants and urban aqueducts. Their size reflects variations of temperature and changes of climate over the years. The committee ascertained that a modest expansion of the Italian glaciers started in 1972 and ended abruptly in 1985 when repeated drought years and increase of summer and fall temperatures started a decrease of the glacier-occupied area. The Italian committee is part of the Italian National Research Council, but lately its financing dwindled down almost to nothing with no financing from the interested Ministries of Public Works, Environment, and Civil Protection. Glaciers monitoring is now entrusted to volunteers.

Italian Chemical Industry

The Italian chemical industry may be world competitive in some sectors, while in others it lags behind. The investment for research in basic chemistry in Italy is estimated to be 2-3 percent of the business turnover, while it is 5-7 percent for fine chemicals and new materials. The pharmaceutical chemistry investment is 10 percent with companies that have a peak of 18 percent. The Italian chemical industry is a world leader in polymers which allows Italian industry to supply 60 percent of the world demand for polypropylene. Italian technology is excellent in the organic chemistry of fluorine. Italian industry is weak in macrotechnologies such as new materials and biotechnologies where projects started in the early 1980s are losing out to foreign competitors. The government through the Ministry of University and Scientific Research has tried to help chemistry by approving national research programs. The program on chemistry started in 1983 with a government subsidy of 365 billion Lire (about $270 million). The pharmaceutical chemistry program started in 1985 with a subsidy of 276 billion Lire (about $200 million) of which only $78 million are allotted. Advanced biotechnologies started in 1987 for a total of 400 billion Lire (about $300 million)...$209 million are allotted. New materials started in 1989 for a total government subsidy of $275 million.

Italian Technology Parks and Research Areas

A recent review of initiatives aiming to create new technology parks and research areas throughout Italy listed several projects:

- Olivetti jointly with the U.S. Connor Peripherals Europe is starting a technocity in the region of Aosta. The facility will produce and conduct research on magnetic memory units and is expected to employ 287 persons between researchers and technicians. Estimated cost is 40 billion Lire ($30 million); the Aosta regional administration will supply 23 billion Lire.
- In the next 5 years, SNIA BPD will invest 1.55 trillion Lire (about $1.15 billion) in the newly formed parks in the southern towns of Matera and Brindisi. Employing 300 researchers, 270 billion Lire will be earmarked exclusively for research. The park near Matera will see SNIA BPD research activity focused on fibers, new materials, and fine chemicals. The park near Brindisi will be used by SNIA BPD to develop bioengineering research.
- Milan will use the already operating Technology Park of Bicolla to establish an incubator that in 3 years can host about 40 high technology industries to solve problems in research like building technology, environment, energy, space, telecommunications, biotechnologies, robotics, artificial intelligence. The center will be supported by participating industries and by financing made available by the Lombardy Regional Administration, the Province of Milan, and the local Chamber of Commerce.
- The regional administration of Sicily is promoting the creation of a technological scientific park near the town of Catania. The aim of the park is to advance the production system of the island to catch up to advanced regions elsewhere in Europe.

Several Sicilian and national industries have already agreed to participate in the formation of the park joined by the Universities of Palermo, Catania, and Messina. Each park member will contribute 50 percent of the expenditure for research projects presented, while the three universities will be exempt from any financial commitment. The park is counting on an initial financial funding of 1,600 trillion Lire (about $1.18 billion).

Ph.D Courses Poorly Attended

For several reasons, postgraduate interest in Italian Ph.D courses is low. The Italian Ph.D title does not impart a well-defined value or legal effect to applicants for positions in industry or elsewhere. An exception is to apply for a job as a researcher. In the screening, Ph.D holders are entitled to 10 points more than other applicants.

Physics and Archeology Joining in Research

The Italian National Institute for Nuclear Physics is sponsoring and financing the recovery of 33 tons of lead ingots from the hull of a Roman vessel that was shipwrecked near the coast of Sardinia at the beginning of 1 A.D. The long-submerged lead is practically unaffected by any natural terrestrial nuclear radio activity; in fact, it is 1,000 times less radioactive than the lead found on the Earth's surface. The Roman ship lead is thus appropriate for experiments and tests to identify the passage of very elusive particles like neutrinos. The Gran Sasso laboratory will use it for an experiment called Doppio Betta, which will study a new type of radioactivity linked to a very rare case of nuclear disintegration. The Ministry of Cultural Assets is pleased that its ship recovery efforts will be financed by a scientific institution in a very rare wedding between archeology and physics.

Solar Energy in Decline

During the late 1970s, water to be obtained with solar energy was well publicized in Italy. In 1986, the Italian industry producing solar panels sold 40,000 sq.m of them. But right after this peak, sales decreased dramatically and now has fallen to an average of 8,000 sq.m annually. Many companies producing solar panels have diversified their production or have abandoned altogether this type of activity. Today only three or four companies produce solar panels in Italy, each with a maximum of about 1,500 sq.m of solar panels while the remainder of production is supplied by companies working under the 1,500-sq.m target. The government has tried to change this situation by concentrating on photovoltaic energy.

The government has grants available for anyone that intends to build a photovoltaic plant. In addition, whenever solar energy produced by private enterprises is sold to the national electricity board, the government will pay for each kW hr an attractive 170 Lire instead of 130 Lire which is the price for electricity obtained by traditional methods.

Italy Builds Thermal Wind Tunnel

In the town of Capua, a laboratory, named Sirocco, will be built to conduct testing for Hermes. The main feature of the Capua laboratory is a high-temperature ionized gas tunnel that will simulate the thermal conditions that Hermes must face when it reenters the atmosphere. In practice, the tunnel will be the testing ground for Hermes thermal protection. The laboratory will be completed by 1993 and cost about 80 billion Lire (about $59 million), 40 percent of which will be financed by ESA and the remainder by the Italian government.

Ignitor Fusion Project Stops

The ignitor fusion project, devised by Professor Bruno Coppi, seems to have lost its impetus. Early in 1990, the Italian government allotted 20 billion Lire (about $16 million) to the project. Other financing came from local government in the Piedmont region which was supposed to host the whole apparatus in its capitol of Turin.

Spain

For further information on Spain items, contact Mr. Leroy C. Simpkins, Office of Science Attaché, American Embassy, Madrid, APO New York 09285

Nuclear Waste Piles Up

The Spanish repository for low- and medium-level radioactive waste is nearly filled to its present capacity, as are on-site storage facilities at five of the ten nuclear power plants. The repository is at El Cabril in Cordoba Province. The five plants are Vandellos I (now closed), Asco, Jose Cabrera, Almaraz I, and Santa Maria de Garonya. They ranged from 80 to over 100 percent full of low- and medium-level waste.

The unfinished facility at El Cabril will eventually have 43,000 m^3 of storage space. Compacted waste placed in steel drums goes into concrete containers near or on the surface of the ground. Expansion of the facility begun in 1989 is not expected to be completed before the end of 1992.

New Polar Research Vessel Delivered

Spain took delivery of its first Polar research vessel May 16, 1991, the Hesperides, built here for the Ministry of Education and Science at a cost of $90 million. Equipped with 12 laboratories, the ship can carry 30 scientists along with its crew of 40. A strengthened hull will enable it to break ice of thickness up to 40 cm. Spain will use the ship for its Antarctic research in conjunction with the Spanish base Juan Carlos I in the South Shetlands. The ship will also participate in the European Community (EC) Arctic Research Program. The Hesperides joins a converted tug, Las Palmas, that has been Spain's main polar vessel until now. The Hesperides' displacement is 2,700 tons; it has a speed of 15 knots and a range of 12,000 miles.

Spain and the People's Republic of China Sign Science and Technology Accord

Spain and the People's Republic of China (PRC) signed an agreement for science and technology (S&T) cooperation in Beijing in April, 1991. Main features of the accord are the exchange of senior scientists on sabbatical-year programs and the exchange of junior scientists--postdocs up to 45 years old--for 6-12 months. The accord lists priority areas of cooperation: astronomy, biotechnology, molecular biology, high-energy experimental physics, microelectronics, new materials, health, agriculture, Antarctica, and the environment.

The Spanish delegation to Beijing included Juan Rojo, Secretary of State for Universities and Research, Ministry of Education and Science, and Luis Oro, Secretary General for the National Research and Development Plan.

Condensed-Matter Physics at the Autonomous University of Madrid

Thirty thousand students study with 1,500 professors at the Autonomous University of Madrid, founded in 1968. The faculty of science is the largest of the six faculties, with 6,000 students and 350 professors working in four departments: biology, physics, chemistry, and mathematics. Medicine, law, economics, philosophy and letters, and psychology are the other faculties. There is no school of engineering. Professors generally teach 30 percent and do research 70 percent of their time. The Autonoma is also site of four main National Research Centers operated by the Higher Council for Scientific Research (CSIC): molecular biology, catalysis, biotechnology, and materials. The university research budget for 1990 was $16 million (excluding salaries). The share of research paid for by industry is small but significant; pharmaceutical firms are the main contractors. Specialties in physics include fundamental, theoretical, and applied physics (particles, nuclear physics, electronics); optics and the structure of matter; and solid state physics, or condensed-matter physics.

One showpiece of the condensed-matter laboratories is a tunnel microscope for observing atomic structure. 1986 Nobel Prize winners Binnig and Roehrer collaborated on its installation. Arturo Baro is a principal researcher; he worked in 1990 on isolation of electrons in insulators.

Sebastion Vieira showed visitors the low-temperature laboratory, with two 0.3-K refrigerators and millidegree capability. Vieira's own work has included superconductivity and high-temperature superconductors. Workers in the surface physics laboratory are making and studying superlattices by molecular beam epitaxy, mainly of silicon and III-V compounds. Other recent work looks at ferromagnetic-antiferromagnetic transitions in cobalt-copper superlattices as a function of layer thickness. Rodolfo Miranda is a principal scientist.

National Microelectronics Center Created

In the late 1980s, the National Microelectronics Center (CNM) was created. This was accomplished by a combination of new science and technology initiatives and reconstruction of existing institutions set into motion by the 1986 science law and the formation of the interministerial committee for science and technology. Operated by the Consejo Superior de Investigacions Scientificas, the CNM is not all in one place; it has departments in Barcelona, Seville, and Madrid. There are 70-80 persons working at all three branches. The annual operating budget is $7 million dollars, supplemented by funds for research assistantships and professional salaries.

Dedicated in 1991, Barcelona is the largest operation, with three departments in its own building at the Autonomous University. The process laboratory department boasts the biggest and best-controlled clean room in Spain. A second department at Barcelona is devoted to the technology of silicon wafers and fabrication of chips. Work includes mask design for photolithography and fabrication of diodes and CMOS/INMOS test structures. The third Barcelona unit is the design department. Computer equipment includes a VAX 8810, a VAX 11/750, two VAX 3100 stations, a Sun 3/280 file server, three Sun 3/60 stations, and two Hewlett-Packard Models 9000/350. The department also does chip testing and works on ASIC projects.

A single department of analog design forms the branch of the national center located in Seville. The branch grew out of the microcircuits group at the University of Seville that first became a joint CSIC-university center, then a department of CNM.

The Madrid subunit is devoted to semiconductors, mainly III-V compounds, including gallium arsenide (GaAs). Temporary quarters are in another CSIC center in downtown Madrid, but it will be moved to Madrid Technological Park in the suburb of Tres Cantos.

Much of Spain's current work in microelectronics is in projects with other EC countries under ESPRIT programs, allowing it to interact with such European microelectronics firms as SGS-Thomson, Alcatel, Matra-Harris, and Phillips. The CNM also works with small and medium enterprises not previously users of microelectronics. For them it designs integrated circuits and provides training.

Spain has a large technology trade deficit (mainly in technical assistance and patent and design royalties). In 1990, it bought $2 billion worth of technology more than it sold, a figure equal to half of its total expenditures on research and development (R&D). Most importers of R&D do no in-house R&D. Multinationals do very little research in Spain, a reflection of their respective corporate strategies. The main exception is IBM; it has a research facility associated with the Autonomous University of Madrid. Employing 2,000 workers, ATT's large chip plant in the Madrid Technological Park uses technology developed elsewhere. Alcatel has contracts with Spanish universities for some research, but one scientist commented that this was just to "use cheap labor." Mitsubishi is reportedly interested in some of the work in Madrid's compound semiconductor department.

In the 1980s, Phier, a private Spanish company, produced macroelectronic components and began making chips, but ran afoul of the U.S. export control regulations and went bankrupt. An exporters publication lists only five exporters of integrated circuits--prominent are Alcatel and Telefonica. The others are small and specialized. The publication lists 146 firms, but only about 60 may be considered electronics. Only 20 are microelectronics firms (makers of diodes, thryistors, integrated and printed circuits, components, detectors, and TV monitors). Government reports refer to microelectronics as Spanish industry's Achilles heel.

Two successful firms in the electronics systems business related to microelectronics are the state-owned electronics group Inisel and the private defense electronics firm Cecelsa. Cecelsa specializes in flight simulators, radar, avionics, and electronic warfare; it also has interests in the U.K. and France. In 1990, Cecelsa had profits of $6 million in sales of $150 million. Competition and jealousy between private- and state-owned firms in Spain contributed to the recent failure of negotiations to merge these two firms. Public funds have not yet seeded much private microelectronics R&D. Private venture capital is available, but more often goes for less risky ventures than high technology. Banks are reportedly very conservative in funding new firms in areas like microelectronics.

Basic research is a priority CNM function in which it works closely with universities in the three locations. Together with the Autonomous University of Barcelona, CNM has designed a new degree--master in microelectronics. In Madrid, CNM personnel contribute to the master of materials degree program in semiconductors and thin films. Doctoral students in related programs like physics and microelectronics also work in the departments in both Barcelona and Madrid.

The most recent CNM report claims that projects and contracts contributed 29 percent of its total budget of 1989; the goal is to finance CNM 40 percent from these sources. Private funds were only 7 percent of the total. Available funds for 1989 totaled just under $7 million.

During 1989, CNM scientists published 25 journals and directed 9 doctoral theses. The CNM participated in the following EC programs: Smile (smart lighting), ESPRIT Phase II with SGS-Thomson, Philips, NMRC (Ireland), and the Universities of Pisa and Genoa.

Six intra-Spain national projects were carried out with other government institutions, and eight mostly small joint projects were with firms in Spain, including one with Fujitsu Espagna on information coding and decoding. Fujitsu also participated in the CNM MPA (multiproject ASIC, applications-specific, integrated circuits) program. This program also drew support from the European Comett project.

Center for Microelectronics, Madrid Moves

The Centro Microelectronics of Madrid, actually the III-V compound semiconductor department of the CNM, occupies one floor of a building in downtown Madrid, but will move to Madrid's Technological Park. Part of the building was once used to develop and build radar sets for the Army. A recent visit provided an update on the national effort in microelectronics, as well as details on the local operation.

Director of the department is Fernando Briones Fernandez-Pola, who has worked and studied around the international circuit: Xerox, Hewlett Packard, Max Planck, and Nippon Telephone and Telegraph (Japan). He heads a group of 20; the permanent staff all work for CSIC. Although there are no joint university appointments, some members do give courses at one of the three universities in Madrid in addition to directing the Ph.D. students. This group alone published 17 R&D papers in 1990, compared with 25 for all 5 departments for the past 2 years.

Briones modestly describes the departments work as studying phenomena with easy applications. For example, they look for optoelectronic applications of GaAs to study in fiber optics and communications, biosensors, and integrated sensors. The latter are for medical, ecological, and agricultural use. The group has a biochemist to help in this effort. The group carries out the olives work in the optical interconnect project with GaAs on silicon substrates. Briones admits that in the back of his mind is the use of such techniques in optical computing.

A main effort is making junctions, heterojunctions, and CMOS integrated circuits on silicon wafers. (CMOS complementary metaloxide semiconductor, a basic configuration technique for making chips; its main disadvantage is slowness, which GaAs, with its special properties, may overcome.) The fabrication is carried out by means of computer-controlled, low temperature, molecular beam epitaxy on wafers 3 inches in diameter.

A technique developed at the laboratory is atomic layer molecular beam epitaxy. The technique uses a pulsed molecular beam to control the epitaxy (crystalline layering) down to individual atomic planes. Besides GaAs on silicon, focus of the work has been on heterostructures and epitaxal systems containing AlAs, AlGas, InAs, InGas, InP, GaP.

Briones gave visitors some recent papers submitted to *Japanese Journal of Applied Physics, Physical Review, Journal of Crystal Growth, and Journal of Applied Physics* (all in English). Two were superlattices, one on optical properties of GaAs/GaP structure, and the other on the AlAs/InAs system.

Rather introspectively, Briones offered some personal comments on basic microelectronics in Spain. There are not yet enough students to make the subject go, he lamented. He considers a research/industry relation or reaction indispensable to development of the field, yet sees little evidence or prospect of it. A great believer in exchange and cooperation, Briones said that in his opinion too many Spanish scientists had indeed gone overseas to work and are not returning. Nevertheless, Briones left and did come back, full of energy, supplied with contacts, and equipped with both zeal and determination to develop (against great odds) basic microelectronics in Spain.

U.S. and Spain Sign Space Agreement

The U.S. and Spain signed a space cooperation agreement in July, 1991. Availability of Spanish air bases and airports as emergency landing sites for the U.S. space shuttle is again firmly founded. The signing marked the end of 2 years of negotiations, and resulted from Spanish acceptance of the U.S. government position for liability to damages related to an emergency landing. The agreement also notes that there are several promising areas for joint efforts to strengthen cooperation in space and science technology. In this respect, NASA representatives who took part in the final preparations for the signing initialed, *ad referendum*, two draft agreements with counterpart agencies setting out procedures for possible cooperative activities.

Space Notes

The Council of Ministers approved Spain's entry into the Cospas Sartat satellite organization dedicated to locating and dealing with land and sea emergencies. In 1991, Spain is contributing about $107 million to European Space Agency (ESA) projects. In ESA voluntary programs, Spain pays 4.5 percent of the Hermes and 6 percent of the Columbus programs. Since Norway has dropped out of Hermes, Spain plans to increase its participation. Spain also expects that the landing fields for Hermes will be in Almeria. Meanwhile, the first launch of Hermes will be delayed until 2000, with a manned launch set for 2001. Space station Freedom's stormy path through the U.S. congressional budget process does not go unnoticed in Spain, but does pass practically unmentioned in a country that feels its own science budget squeeze. Spain's representative to ESA downplayed the possibility of the U.S. killing the shuttle since there is an international agreement preventing it. Spain's contribution to a military observational satellite named Helios, to be built in cooperation with Italy and France, will cost $100 billion this year. Scheduled for launch by ESA in 1994, Helios will transmit optical images from a heliosynchrous orbit first to the Mesapalomas tracking station in the Canary Islands, then to a $25 million processing facility.

Nuclear Energy Not Dead

A study conducted for the Nuclear Safety Council (CSN) shows between 60 and 70 percent of the Spanish public opposed to nuclear energy. These results, similar to those of a 1987 study, were obtained by the center for sociological research. In another poll, the Spanish public condemned nuclear energy as the most contaminating, even ahead of thermal. The government's recent reaffirmation of the 1984 nuclear powerplant construction moratorium and extension of it until 2000 thus appears to be based on wide public support.

Power companies representatives, nevertheless, still speak of nuclear energy in the future. One executive recently said that it is certain and inevitable that Spain will construct nuclear powerplants, since they will be safe and low cost. He accepted the termination of construction plants like the one at Valdecabelleros that used "expensive, obsolete technology."

At the same time in Spain, through its utility Unidad Electrica (UNESA), will cooperate with French, Belgian, British, and German utilities in the development of the " year 2000" reactor. The UNESA and Electricite de France want to join the similar U.S. program Westinghouse, GE, and the Electric Power Research Institute (EPRI). Japan is expected to be a member of that group as well. Since 1989, Westinghouse and three Spanish firms have been planning an advanced, 1000-MW, pressurized-water reactor.

Spain and Argentina Sign Antarctic Research Accord

Delfin Colome, successor to Miguel Arias in the foreign ministry as Director General for Cultural and Scientific Relations, recently signed an agreement for Antarctic cooperation with Argentina. Juan Pablo Lohle, Argentine Ambassador to Spain, signed for his country. Under the terms of the agreement, Spanish scientists can use Argentine Antarctic bases. Similarly, Argentine researchers will have access to the Spanish base and to the new Spanish Antarctic research vessel, Hesperides.

Many Beaches Cleaner

Of 1,200 Spanish beaches analyzed in 1990, 147 were reported unsuitable for swimming. This compares with 178 black zones out of 1,100 surveyed for the year before. At the same time, award of the "blue flag" to especially clean beaches reached a total of 170, up 33 from the previous year. Dirty beaches are surveyed every year by EC governments to Brussels according to community norms. The blue flags are awarded by the European Foundation for Environmental Education. Cleanest areas are Cantabria, Alicante, Murcia, Gerona, the Balearics, and the Canaries. Andalucia and Valencia have some of the least clean beaches. Some offenders from previous years have been cleaned up; others no longer serve as beaches. Beaches remain the number one tourist attraction in Spain and figure heavily in Spain's income from visitors, which amounts to nine percent of GDP.

IBM and Barcelona's Autonomous University Develop Digital Cartography

The Autonomous University of Barcelona and IBM Espagna are cooperating on project Geokronos, an initiative in digital cartography taken within the EUREKA program. The purpose is total geographical analysis of a given region by application of information technology. The goal is development of an information system for rational management of the region on the basis of a geographical data base. Manipulation of the database will bring (1) study of natural resources and meteorological characteristics, (2) agricultural and urban assessment, and (3) determination of area fitness for industrial and tourist uses. The Ministry of Industry and Energy also contributes to this project, but is most noticeable for its considerable support by private industry.

Spain Participates in EUREKA

The June EUREKA meeting in the Hague revealed that Spanish participation is fourth among the 19 countries, after France, Germany, and Italy. Of 507 total projects, Spain has taken part in 132 (26 percent), with a total investment of about $700 million. Despite this high proportion of participation, the Spanish contribution to the total cost has only been 6.5 percent. Forty percent of Spain's participating industries are small or medium sized.

Spanish OECD Science Committee Chairman Elected

Spain's first elected chairman of the Committee on Science and Technology Policy (CSTP) is Paloma Sanchez, professor of Economics at the Autonomous University of Madrid, who also works in the Ministry of Industry. Professor Sanchez has served as Spanish representative to the CSTP since 1983, and was elected chairman in March 1991.

Spanish Professor from UC-Davis Becomes Head of CSIC

Elias Fereres Castiel is president of the Consejo Superior de Investigations Cientificas (CSIC) (Superiot Council For Scientific Research, sometimes referred to as the National Research Council). He succeeded Emilio Munoz. The CSIC is the main governmental organization directing R&D in Spain. Fereres has a doctorate in Agronomic Engineering from Madrid's Polytechnic University and one in Ecology from UC-Davis. From 1972-1982, he was professor and researcher at UC-Davis, returning to Spain to become coordinator and director of special programs at the advisory committee for scientific and technological research until 1987. He has also been a consultant for U.N. bodies, the U.S. Office of Technology Assessment, and the governments of the U.K., Australia, Mexico, and Brazil. At the time of his appointment as president of CSIC, Fereres was a professor of Agronomic Engineering at the University of Cordoba Zappala.

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Aerospace

European Space Developm... and Programs at the 29th Farnborough International Aerospace Exhibition, by CDR Robert C. Treviño. (91-1-C) This report is based on the 29th Farnborough International Aerospace Exhibition, the largest aerospace event of 1990. This major biennial aerospace event is organized by the Society of British Aerospace Companies and emphasized that the trend is toward more international joint ventures among European space organizations and companies. International space cooperation both in the scientific and commercial areas will continue, but European space autonomy in manned and unmanned programs is the long-term goal.

Materials

Workshop on Explosive and Propellant Combustion Mechanisms, by R.W. Armstrong. (91-2-W) This report is based on a workshop held on June 3-4, 1991, which was sponsored by the Société Nationale des Poudres et Explosifs (SNPE), with the Office National d'Etudes et de Recherches Aérospatiale, and the Office of Naval Research European Office. The workshop was held at the SNPE Centre de Recherches du Bouchet, Le Bouchet - B.P. no. 2, 91710 Vert-le-Petit, France. Abstracts of presentations were submitted by several participants and compiled for this report by Dr. Armstrong.

MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between January 1, 1991 and May 31, 1991. The MAS Bulletin is an account of accomplishments in European naval research, development, and evaluation. Request copies by number from ONREUR.

01-91 Bofors Presented at the Bofors Effect Symposium 90

02-91 Harwell Tests New Legionella Killer System

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08-91 Papers Presented at Advisory Group for Aerospace Research and Development (AGARD) Symposium on Aircraft Ship Operations

09-91 Papers Presented at Advisory Group for Aerospace Research and Development (AGARD) Symposium on Machine Intelligence for Aerospace Electronic Systems

10-91 Papers Presented at Advisory Group for Aerospace Research and Development (AGARD) Symposium on Software for Guidance and Control

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