nizations provided information on transformation parameters between the national reference systems and the European Terrestrial Reference System ETRS89. For the International Steering Committee for Global Mapping (ISCGM) it produced a seamless and unified pan-European data set at the scale of 1:1,000,000 on the basis of national databases (Global Map). By 2000 it was considering production of a 1:250,000 pan-European vector data set (EuroRegionalMap). The overarching structure of all EuroGeographics activities, called EuroSpec, was designed to implement full operability of geospatial reference information produced by national mapping agencies and to create a European Spatial Data Infrastructure (ESDI). By 1999 the EU was also planning to add a third global satellite navigation network, Galileo, to the two existing networks, Russia's GLONASS (Global'naya Navigatsionnaya Sputnikovaya Sistema) and the U.S.'s GPS (Global Positioning System).

During the second half of the twentieth century the member countries of the EU collaborated on various cartography-related projects, including publication of maps and atlases; coordination of regional planning; creation of land cover, boundary, and other databases; and planning a new global satellite navigation network. Those geospatial tools and data sets were generated to facilitate the governance of an increasingly unified Europe.

FERJAN ORMELING

SEE ALSO: Comité Européen des Responsables de la Cartographie Officielle (European Committee of Representatives for Official Mapping; International); Geographic Information System (GIS): Metadata; Intellectual Property; Standards for Cartographic Information

BIBLIOGRAPHY:

Bernath, H. 1977. *Study of the Possibilities of Using Automated Cartography: The Selection of an Automated Mapping System to Meet the Needs of the Working Group Job Specification*. Strasbourg: Council of Europe.

Council of Europe. European Conference of Ministers Responsible for Regional Planning (CEMAT). 1975. *Seminar on Regional Planning Cartography, 12–16 May 1975, Enschede, the Netherlands: Proceedings*. Ed. E. S. Bos, C. A. van Kampen, and Ferdinand J. Ormeling. Enschede: ITC.

———. 1976. *Urbanisation and Regional Planning: Problems Encountered during the Preparation of a Set of Urbanisation Maps with Regard to the Harmonisation of Cartographic Methods and Statistical Data*. Strasbourg: Council of Europe.

European Commission and European Environment Agency. 1997–99. *CORINE Land Cover: Technical Guide*. Online publication.

European Commission, Joint Research Centre, Space Application Institute. 2000. *Spatial Reference Workshop, Marne-la-Vallée, 29–30 November 1999, Short Proceedings, Conclusions & Recommendations*. [Marne-la-Vallée, France]: MEGRIN (Multipurpose European Ground Related Information Network). Online publication.

Leonard, John. 2000. "Europe's Official Mappers—Quo Vadis?" In *Quo Vadis International Conference*, Proceedings of the FIG Working Week 2000, 21–26 May, Prague. Online publication.

Rimbert, Sylvie. 1979. *The Scope for Using Automated Cartography in Regional Planning*. Strasbourg: Council of Europe.

Exclusive Econonomic Zone. See Law of the Sea

Experimental Cartography Unit, Royal College of Art (U.K.). The Experimental Cartography Unit (ECU) was a cartographic research unit funded through the Natural Environment Research Council (NERC) of the United Kingdom. From the late 1960s through the 1980s, the ECU was the primary European research organization involved in the development of computer-assisted cartography and was a pioneer in high-quality computer mapping and early geographic information systems (GIS) work. David P. Bickmore, a cartographer for the Clarendon Press, proposed the idea for a research unit in automated cartography to the NERC in 1965. Bickmore's experience in creating *The Atlas of Britain and Northern Ireland* had convinced him of the need for computerized cartographic methods to improve the efficiency of cartographic production (Bickmore 1968; Margerison 1976, 4). The council approved Bickmore's proposal, and by 1967–68 the ECU was fully operational, with Bickmore heading the new research unit and Sir Michael James Lighthill appointed as the chair of the steering committee.

London's Royal College of Art was the original home of the ECU, but it also maintained links to the Imperial College of Science and Technology of the University of London and the Clarendon Press. While the Royal College of Art may seem like an untraditional location for a cartographic research unit, it was chosen intentionally in an effort to break from cartographic traditions, and to embrace new theories and technological advances in graphic design. To support the development of the new theories and technologies necessary for the automation of cartographic design and production, the ECU was staffed by individuals with expertise in a wide range of areas such as computer science, software engineering, geography (including David Rhind), graphic design, and optical physics.

Research at the ECU was project based and primarily tied to Bickmore's interests in automating cartographic design and map production. Some of the ECU's early collaborators were the British Ordnance Survey, the Institute of Oceanographic Studies, the Institute of Geologic Sciences (later the British Geological Survey)—another component of the NERC—and several local government agencies. The cartographic needs of these agencies were influential in setting the research agenda for the ECU.

The primary research activities at the ECU can be divided into three categories: data capture, computer processing of data, and data output. In the early years, the work of the ECU was focused on developing the hardware technology and software necessary to digitize and create reusable computerized databases. Some of the earliest projects of the ECU were based on translating digitizer coordinates to global coordinates, projecting digitized coordinates, creating database structures for indexing digitized features, and developing the tools necessary to edit the digitized databases. This work resulted in the creation of a new database structure for geographic information involving only points and lines, with a complicated set of feature codes signifying the relationship of points and lines as well as relating lines to one another in order to form complex objects. The initial work on data structures and digitizing hardware resulted in the development of a large cartographic database of entries from *The Atlas of Britain and Northern Ireland*. This effort also resulted in the publication of "the first map proper to be produced by automation (crude lineprinter or tabulator-produced maps had been published earlier)" (Experimental Cartographic Unit 1971, 72). This was a bathymetric chart of the Gulf of Aden in the northwest Indian Ocean (figs. 264 and 265) published in October 1968. In addition to developing their cartographic database, the ECU actively worked on routines for processing digitized data and for simplifying the transfer of data. In particular, the ECU created a set of recommendations for standardizing data transfer and produced a significant literature on computerized contour creation and smoothing and on theories of scale-dependent generalization.

While much of the work of the ECU was focused strictly on the design and implementation of new cartographic technologies, it was all guided by the need to produce cartographic products for the agencies with which they collaborated. Bickmore felt that little was known about effective cartographic design and that the cartographic conventions in use may not have been optimal for cartographic communication. The use of automated cartographic methods allowed for greater flexibility in customizing maps, and it facilitated testing the effectiveness of different cartographic design elements. From the early 1970s through the 1980s, the ECU conducted empirical map design studies with human research subjects, including perceptual studies of symbols, typefaces and sizes, and color schemes (e.g., Hill 1974). While this research did not produce any particular general theory, it led to the design of "innovative and provocative maps" (Rhind 1988, 286) for the ECU's collaborating agencies.

In 1978, the ECU moved from London to Swindon, U.K. During the period of the move, the ECU was renamed the Thematic Information Service (TIS) of the NERC. Around this time, Bickmore retired as the head of the ECU, and Dr. Michael Jackson was appointed director. In 1985, the research component of the TIS moved to the Geography Department at the University of Reading and became the Natural Environment Research Council Unit for Thematic Information Systems (NUTIS). This was eventually renamed the Environmental Systems Science Centre, which was still active in the early twenty-first century.

SARAH E. BATTERSBY AND DANIEL R. MONTELLO

SEE ALSO: Electronic Cartography; Software: Geographic Information System (GIS) Software

BIBLIOGRAPHY:

Bickmore, David P. 1968. "Maps for the Computer Age." *Geographical Magazine* 41:221–27.

Experimental Cartography Unit, Royal College of Art, London. 1971. *Automatic Cartography and Planning*. London: Architectural Press.

Hill, Adrian R. 1974. *Cartographic Performance: An Evaluation of Orthophotomaps*. N.p.: European Research Office, United States Army.

Margerison, T. A. 1976. *Computers and the Renaissance of Cartography*. London: Natural Environment Research Council, Experimental Cartography Unit, Royal College of Art.

Rhind, David. 1988. "Personality as a Factor in the Development of a Discipline: The Example of Computer-Assisted Cartography." *American Cartographer* 15:277–89.

Exploratory Data Analysis. John W. Tukey was the father of exploratory data analysis (EDA). The publication of his book *Exploratory Data Analysis* in 1977 marked the recognition of EDA as a field of study with an emerging methodology. Tukey continued to shape this new field by coauthoring and coediting several books and by writing papers that further fleshed out the associated concepts and methods.

Tukey (1977, v) said EDA is about "looking at data to see what it seems to say." EDA methods include use of resistant statistics, such as the median, that change little if the data contain a few anomalous values, and data transformations (reexpressions) that simplify appearance, increase symmetry, and facilitate comparisons of data subsets. EDA methods also include decomposing data into fit plus residuals. Either may reveal patterns when shown in the context of additional variables. For time series, local smoothing provides fitted values and residuals. For analysis of variance there is an exploratory analog. EDA fitting often uses resistant statistics and iterative procedures to progressively separate structure from noise.

Tukey (1977, v) noted that "a basic problem about any body of data is to make it more easily and effectively handleable by minds." He laid out two key tasks: simplifying descriptions and making descriptions more effective by looking below previously described surfaces. Tukey's box plots provided a simple univariate description that spread around the world. His automated cartography suggestions for looking below surfaces included adjusting mortality rates for known sources of variation beyond sex and age before mapping. EDA made available focusing methods and linked views that