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TÍTULO : MODELO DE GESTIÓN CIENTÍFICA PARA  
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SCIENTIFIC MANAGEMENT MODEL FOR GEOGRAPHIC  
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# Modelo de Gestión Científica para las Ciencias de Información Geográfica

*(A scientific management model for geographic information sciences)*

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CentroGeo

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### Abstract

The term "Geographic Information Sciences (GIS)" has existed in scientific literature for more than a decade, but an overall consensus on the definition of this emerging discipline has not yet been found. The knowledge domain of GIS has developed in the "interaction space" among converging disciplines (e.g. geographic information systems, cartography, remote sensing, geodesy and photogrammetry), with borders that are "complex and fuzzy".

CentroGeo is a Mexican public research center funded by the National Council of Science and Technology (CONACYT) and is dedicated to research, education and technological innovation in GIS. Since 1999, CentroGeo has produced relevant scientific work in a short period of time and, as a result of empirical research has designed, produced and inserted dozens of technological artifacts in diverse organizational and community environments nationally and internationally.

Since its conception, CentroGeo and its chief architects have acknowledged that in order to advance research in GIS it is necessary to design and apply a scientific management model. The building blocks of CentroGeo's scientific project are: the science of Cybernetics and Knowledge. The purpose of this paper is to share the conceptual framework and the good practices derived from this successful scientific management model.

### Background

In the nineties, in Mexico as in the rest of the world, there was a lack of human capital with strong scientific background in GIS. In the case of Mexico it was clear that software vendors were getting their jobs done selling partial solutions and technology. However, Mexican society lacked the necessary skills and education to take advantage of the technological innovations in GIS. As it is well known, the task of establishing a critical mass of human capital in any discipline can take several decades to achieve. It was the right time to start a "seed project" that would allow us to have a group the right people (including students and other members of society), a place to exchange ideas, together with an institutional setting that would preserve the advances that were to be built upon, piece by piece and day to day.

As sometimes happens, random circumstances have a positive or negative effect on the development of any enterprise. In the case of CentroGeo, the right people, the correct needs and wills came together at the right time. Almost a decade ago, a small group of scientists proposed to the Mexican Commission of Science and Technology (CONACYT) a tangible solution to one of the country's many needs. A need to create a place that would develop research and educational projects in GIS. CONACYT, who at the time was coordinating more than twenty research centers funded by the Mexican government, had the vision regarding the importance of such an initiative for the well being of the country. In January 1999, CentroGeo was established with a very small budget and a very small group of people.

Almost ten years later, CentroGeo's budget has increased by a factor close to ten; it has almost forty permanent positions, and more than sixty collaborators and a network (RedGeo) of over 300 national and international experts. More than eighty GIS projects have been successfully developed and more than sixty technological prototypes are in place, among other achievements.

#### A Point of Departure for the Scientific Project

One can identify various driving forces in the design of CentroGeo scientific project. Some are contextual, others institutional and the ones that will prevail throughout time are those based on ideas.

From a theoretical perspective, the two driving hardcore scientific ideas have been:

- Geo-cybernetics and
- A knowledge based approach to GIS

Geo-cybernetics. - The prefix "cyber" is commonly used in reference to something belonging to the internet or other computer software. In the scientific world the meaning is certainly much broader. Norbert Wiener, an American mathematician who obtained a Ph.D. at the early age of 18 and worked most of his professional life at MIT, published in 1948 a book named Cybernetics. The background of the main researchers involved in CentroGeo includes an understanding of the Science of Cybernetics. It is therefore not a coincidence that in the initial empirical development of the cybercartographic artifacts the main ideas of Wiener were implicitly embedded in the solutions. Moreover, the processes designed and adopted for the advancement of the ideas were essentially of a cybernetic nature.

The incorporation of the Cybernetics into GIS is certainly a new idea that has surfaced at CentroGeo. As an example in the discipline of Geographic Information Systems, the theoretical foundations incorporate Spatial Analysis, Systems and Information Theory and Geo-computing but certainly not explicitly the Science of Cybernetics. In this regard, theoretical and practical efforts are being made by CentroGeo's researchers and graduate students to advance in what has been named a Geo-cybernetic approach to GIS (Reyes, 2005, 2006). Project after project, these essential concepts have been applied and have been strongly embraced by society.

A Knowledge Based Approach. - The Triangular Irregular Network (TIN) concept has been one of the pillars of the scientific and technological development in GIS. It was proposed by Tom Poiker and his team in the 70's (Peucker, 1976). The TIN can be analyzed from different points of view. In our perspective, what we have found to be interesting is the cognitive process by which the original concept came to be.

The fact that the point of departure for the TIN is a knowledge framework has profound meaning. The way in which the team took geomorphology concepts, built a GIS solution for the modeling of the terrain and later transformed this into technological expressions singles out what could be called a "knowledge based approach".

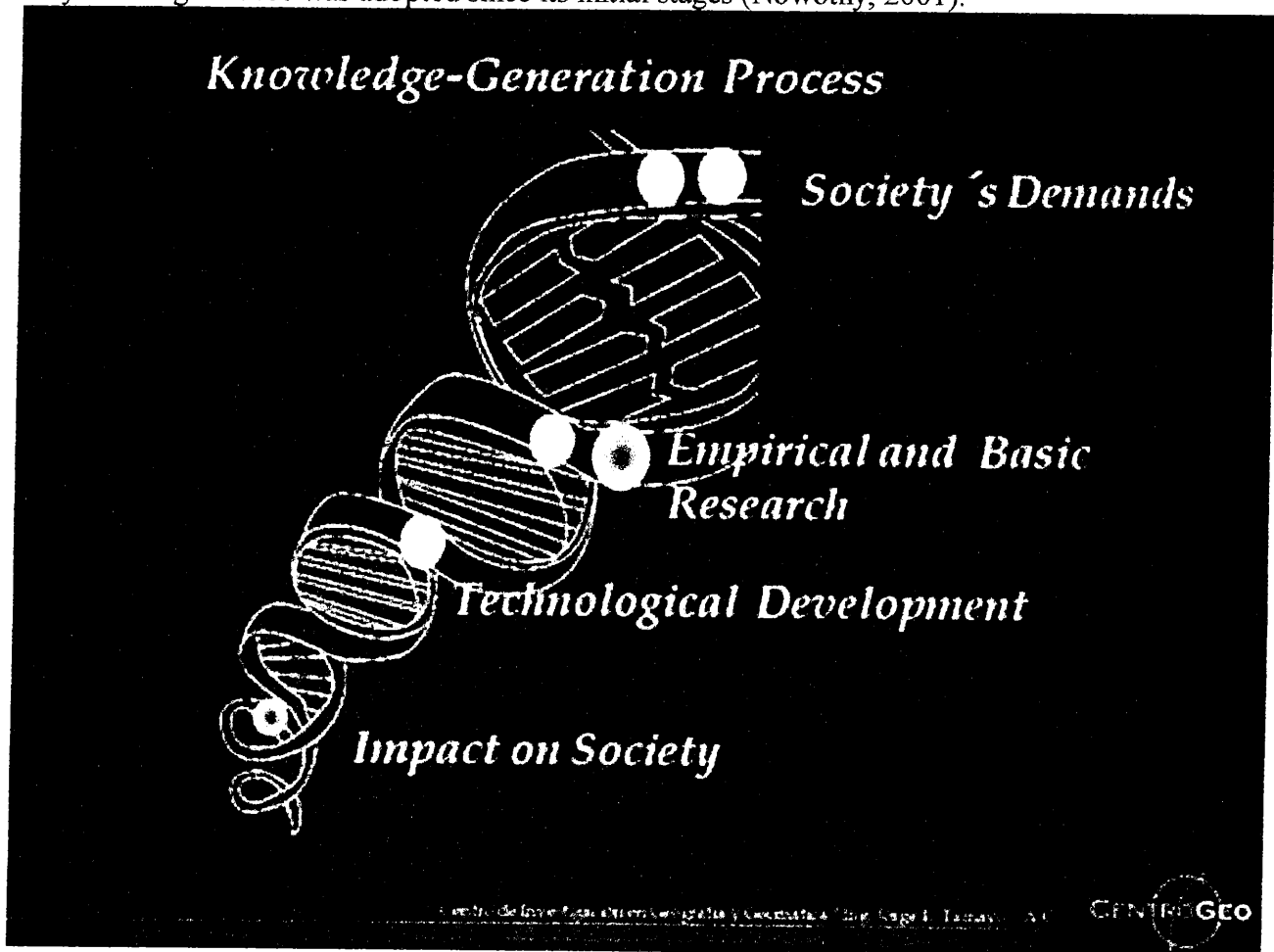
#### A Scientific Management Model for GIS

In a very broad sense we understand a management model as a collection of good practices that assures the success of a scientific project. Some of the components of the model include aspects related with human capital, strategic alliances, strategic planning and an innovative organizational framework, among others. As a consequence of this CentroGeo has adopted an approach that is holistic, collaborative and transdisciplinary.

Furthermore, CentroGeo can be described as a GIS agora (that includes its building and a network of social networks) where people interact and engage in conversations to clear their heads, gain knowledge, advance and contrast ideas, establish benchmarking, discuss the design of technological artifacts or simply explore technical issues. This "chaotic" organizational framework (understanding chaos from a scientific perspective) has been a key condition for innovation and the emergence of new ideas.

Each specific project is organized around heterhierarchical groups. Each group has a coordinator that is responsible for the management component of the project (quality, time-frameworks, resources, etc.), scientific and technological leaders, advisors and other trandisciplinary team members (Sánchez, 2001).

The research and innovation process can be described as a "helix" (see figure 1) where the starting point is a demand placed by society around a specific set of problems. As in any emerging science, in GIS, the interaction with society is a key issue. What has been called in the literature a "mode 2" way of doing Science was adopted since its initial stages (Nowotny, 2001).



As shown in the helix, during the initial stage, a strong effort is undertaken towards "empirical" research. Mexican and international organizations have been the main Laboratories where these empirical undertakings are run. In subsequent stages, theoretical frameworks have been developed and research teams have been strengthened through scientific publications.

The technological innovation component in GIS software has played a key role both in responding to societal demands and to support research. The geo-cybernetic "oeuvres" (technological artifacts

+ geo-spatial knowledge models and information) have been successfully embedded into a large variety of social environments.

At the end as in the beginning of the helix, we find societal demand a consequence of the impact of the GIS solutions and social feedback.

#### The State of the Project

- The GIS agora is the point of departure to advance in consolidating a "school of thought in GIS".
- The empirical processes are well established (in other words our laboratory is in good shape).
- The Geocybernetic oeuvres that are in place are the roots of an ever growing knowledge tree with many branches and which may grow even more.
- New seeds can be spread from this tree and completely new avenues of research can arise.

Human capital is at the kernel of the scientific management model at CenterGeo. Since its foundation it began a constant transfer of knowledge and in the year 2003 a graduate program was formally established. Incoming students have different academic backgrounds including basic, social and biological sciences; they are full-time students and all of them have scholarships. Forty four students have graduated from a one year diploma, around twenty students have either graduated or are well advanced with their master's thesis, one Ph.D. student has graduated and currently five Ph.D. students are enrolled in the program.

#### Some Thoughts on the Future

- Many new avenues of research in GIS within this new approach have been identified either by researchers or students.
- Technology has played a key role in the success of the CentroGeo project. In house software development has reinforced the implementation of tailor-made GIS solutions allowing a fruitful dialogue between science and society. Multiple avenues of research have generated and guided new developments and are continuously opening new challenges for the technological researchers and programmers (e.g. Geo-WEB., interoperability, etc.)
- The demand for educational programs is increasing and CentroGeo is consolidating its academic program, broadening its professional master's program and exploring distance education using telecommunication infrastructures such as the Internet.

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#### Biographies

Dr. Carmen Reyes is a researcher and expert in Geographic Information Sciences. For more than thirty five years she has worked in different fields including Spatial Analysis, Geographic Information Systems, Computer Cartography, Cybercartography, Geo-cybernetics and GIS and Society. She has lead and participated in more than sixty national and international projects and in the development of more than sixty technological artifacts. In January 1999, she founded CentroGeo, a Centre for Research and Education in Geomatics. CentroGeo is funded by the Mexican National Council of Science and Technology (CONACYT). For ten years she was the General Director of CentroGeo, a highly successful enterprise. As well as being a graduate level teacher she has participated in dozens of conferences and presentations.

Dr. Margarita Parás is a researcher and an expert in Geomatics. She has held several government positions in her area of expertise as well as had her own economic studies consulting firm. She has participated in various expert groups in Mexico and abroad, including the U.N., and has presented her work and results in multiple settings around the world. She has done research in territorial issues, sustainable development, social, environmental, spatial and economic phenomena. She has also led and coordinated multiple Geomatics projects successfully throughout the years. She is currently CentroGeo's General Director after several years as a researcher.