International Association of Geodesy Symposia

Fernando Sansò, Series Editor

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A Window on the Future of Geodesy

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Fernando Sansò

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Preface

Every four years the International Association of Geodesy meets at the IUGG General Assembly and this has always been an important event for IAG to make the point on where are we going as geodesists both in terms of scientific production as well as in terms of organization.
The proceedings of IAG at the Sapporo 2003 General Assembly are the mirror of our scientific achievements, and, as Geodesy is a living entity like any other science, we could say it is a way to see the picture of what we consider our field of applications as well as of theoretical speculations. Let us examine this aspect in terms of what are: the object of our research, the methods we use, the general scientific results we can produce.

♦ **Our object:** here I would like to use a pseudo-Helmert definition; the object of Geodesy is knowing the surfaces of the earth: the geometric surface by positioning and e.m. surveying, and the physical surface, i.e the gravity field, by land, marine or satellite gravimetry, and their time variations.

This "object" is naturally interlaced with other physical properties of the earth both through deep processes affecting its surface and through the gravity field at all different scales from the global to the regional and local, where most engineering applications take place.

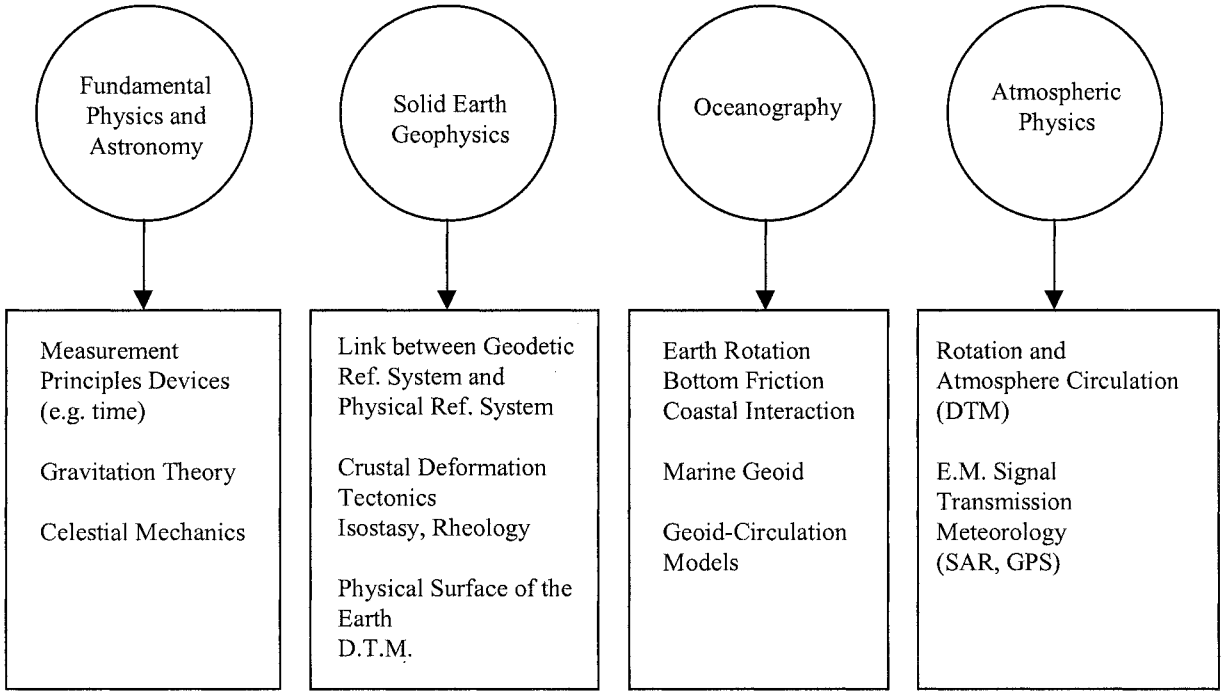
♦ **Our methods:** are typically those of modelling observation equations including as many physical effects as can be identified by specific measurement techniques and then studying the statistical nature of residuals by several means.

In the end we are then left with an optimal estimation problem where the unknowns can be either discrete in nature (sometimes even integers) or continuous like time signals or spatial fields, either governed by precise system equations or by approximated laws and henceforth either deterministic (at least in the average) or stochastic in full right.

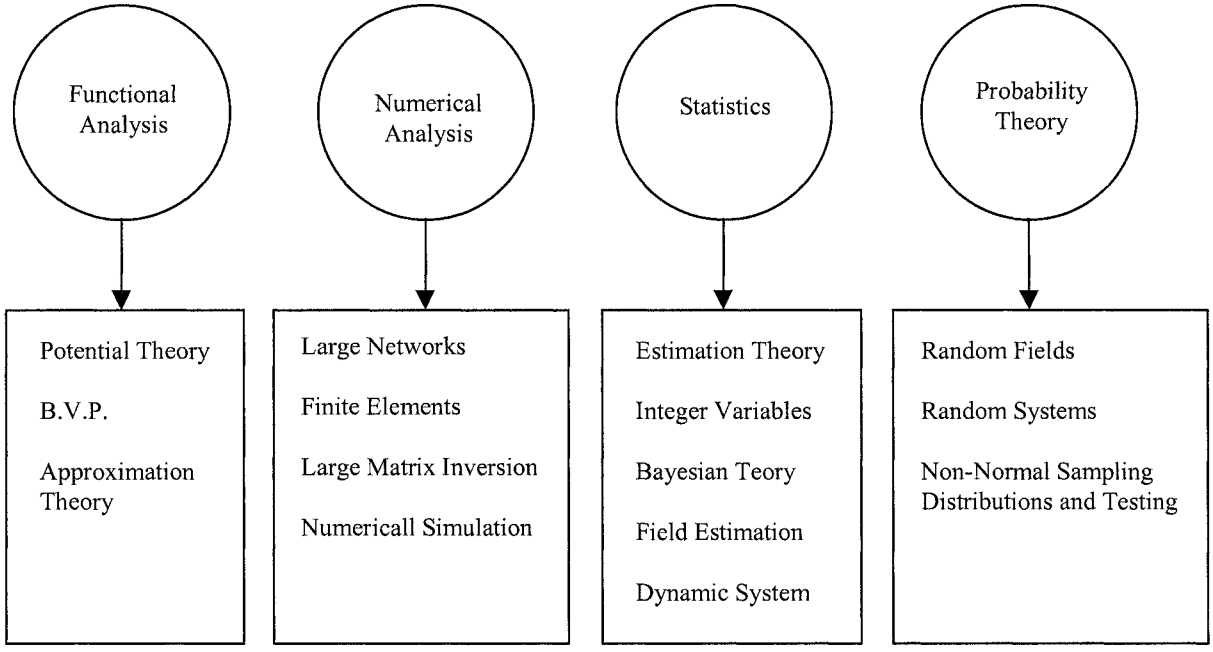
In manipulating an increasing catalogue of physical phenomena showing up into the observations of geodetic quantities we have enormously extended the baggage of knowledge which has to be in our arsenal of geodesists and the fields of their applications.

I have been trying to outline the main interfaces of Geodesy with other Sciences, which I have grouped into 3 families, Physics, Mathematics and Engineering. I'm sure this picture is far from being complete, however I hope it is representative.

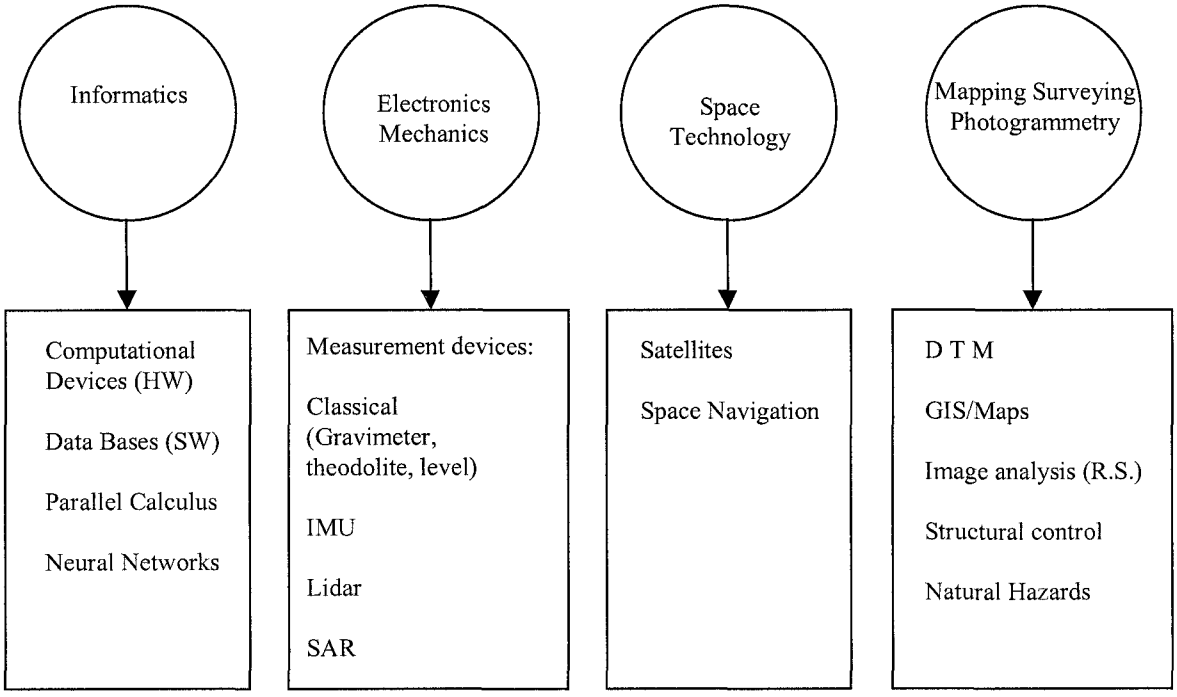
PHYSICS



MATHEMATICS



ENGINEERING



♦ **Our scientific products:** are indeed the knowledge of the objects of our investigation, i.e. the geometric surface of the earth and its gravity field jointly with their time variations.

In this respect we have to stress that knowing the geometric surface means also being able to attach precise coordinates to points lying on it and this can be done only by defining on the same time a unique reference system to which all positions have to be referred.
This is one of the most important general products of IAG, provided to all the other geo-sciences and techniques; namely how to refer any spatial event on the earth and in the surrounding space to a unique reference system attached to the earth.

In a very similar fashion, when we speak of the knowledge of the gravity field, particularly in terms of one of its equipotential surfaces, we implicitly mean that we are able to accomplish the unification of the many more or less local representations of it, for instance identifying in a unique mode the queen of these surfaces, the geoid, to serve as a unique reference surface for heights on the earth, i.e. the unified worldwide height datum.

Now that we have outlined what we think we are, we can analyze the directions from which we expect to receive strong impulses in the development of Geodesy, say in the next 10 years.

- Informatics, HW and SW development. In particular the exponential law for the development of computing power has not yet exhausted its trend and completely new technologies are close to enter into the market, opening the doors to more advanced calculations.

- More advanced technology in geodetic instrumentation with two main characteristics: one is the usual trend in improving accuracy, the other is to increase enormously the mass of information, also thanks to the diffusion of a large number of geodetic apparatus with may be a lower accuracy performance but also with a very low cost, which makes them accessible to a large community of users (as an example think of GPS).

- More advanced spatial technology for an improved surveying both at a global scale (think for instance of the new gravity missions CHAMP, GRACE and GOCE) and at a local scale (think for instance of the high resolution imagery or the InSAR surveying), to the effect of continuously growing the mass of information available to us; and all that, not only for the earth but also for the other planets, which are our job as well.

- More advanced knowledge of the physics of the solid earth, e.g. to facilitate the modelling of the crust deformation in geodetic surveying, of the ocean, e.g. in improving the knowledge of the global circulation pattern thus making more usable the satellite altimetry for the estimate of the marine geoid, of the atmosphere, e.g. providing better corrections for the effects of the propagation of our GPS signals,

- certainly a stronger progress in mathematics (e.g. in the area of dynamic systems or in that of random fields) as well as in statistics and data handling, driven by the great possibilities provided by the new electronic tools.

Of course I don't even attempt to be exhaustive but I think that the mentioned items will really impress a strong push to Geodesy. So we can ask now, what will Geodesy do for the other sciences?

First of all we shall pursue our general scopes and in that we will serve all the other geosciences by providing a global geodetic reference frame may be with an accuracy in the millimetric range and a unified height datum, may be in the centimetric range.

In this respect let me be clear; I know we are talking about the 1cm geoid since years, however we are still far from this goal in absolute sense and may be with the help of the new gravity satellite missions we will be able to approach that figure as an overall upper bound of the error.

Already being able to bridge at such a level of accuracy between the geometrically/kinematically defined reference frame and the physical reference systems, both in the sense of the gravity field and of the rotation of the earth, is an enormous step ahead in understanding the physical behaviour of this complicated "system earth" and Geodesy seems to be in pole position not only to provide the necessary experimental information but also to solve the difficult knot of modelling the interactions of the subsystems of the earth.

In addition we expect Geodesy to take the leadership of the new concept of continuously surveying the earth from space even at a regional level, exploiting its natural skill in combining different observation equations in a unique system.

To do this I'm sure that an improved structure of IAG Services will play a major role in providing data and specific products, for instance in such fields as engineering positioning and navigation, regional crustal deformation, digital elevation modelling, gravity and gravity variations surveying, atmospheric parameters monitoring, steady oceanic circulation and variability etc.

On the other hand Geodesy, with its new big challenge of optimal combination of different huge data sets, will be able to work out, as it happened in the past, original methods of field modelling and spatio/temporal signal analysis thus giving contributions to different areas of mathematics in terms of interesting problems and advanced solutions, for instance for items like satellite dynamics, boundary value problems, random fields analysis, general estimation theory with integer variables etc.

Remember that all the other sciences, including classical signal analysis, have been living for more than one century on the concept of least squares which has been worked out in a geodetic context and thus is in its full right a contribution of Geodesy to all other sciences.

I wish and I believe it will be possible that something similar will happen in the next years for instance by proposing a unified view on the very general item of field estimation, specially for inverse and improperly posed problems theory.

So for the moment it remains to me only to invite you to read the content of this book because I know that all these future developments are already starting now, and if you like to take part in them it is important that you know what is written here.

Fernando Sansò

Acknowledgement

The reviewing process of the scientific papers published in this proceedings volume has been performed by the conveners of the symposia; they have been acting as editors of individual chapters.
My warmest thanks should therefore be given to Chris Rizos, Alan H. Dodson, C.K. Shum, Pascal Willis, Michael G. Sideris, Bernhard Heck and Clark Wilson.

A sincere thanks are also due to the Local Organizing Committee, that has made of the General Assembly such a thoughtful and enjoyable event.

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C. Rizos
A.H. Dodson