

## **PRESENTATION by Giorgio V. Dal Piaz, former Director of the Department of Geology, Paleontology and Geophysics, University of Padova**

It is with great pleasure that I accepted the invitation of Alessandro Caporali to write a short presentation of this monograph dedicated to the birth of Space Geodesy at the University of Padua and its development in the last thirty years. This is an important anniversary, shared with the thirtieth anniversary of the "Giotto mission", conceived by the genius of Giuseppe "Bepi" Colombo, the mission which in 1986 had reached the Halley comet. The first part of the monograph, the historical approach, recalls the figure and work of Giuseppe Colombo and the exhibit "The Italian Space Scientific Activity" held in Padua in 1986 and devoted to His memory. The development of the Space Geodesy at the University of Padua is closely linked to the activity of the Centre for Space Studies and Activities (CISAS), established on 29 January 1991 on the initiative of Professors F. Angrilli, C. Barbieri, P. Bernacca and twenty other scholars of the Faculty of Science and Engineering. The monograph describes in detail and illustrates with tables and pictures the development of the Space Sciences in Padua, research projects, their passionate creators – scientists, technicians and students – increasingly sophisticated and precise instruments, national and international collaborations, the difficulties, the way to overcome them and expectations, in a relentless progression, increasingly rich in significant results and new horizons.

Alessandro Caporali was and is one of the main actors in this fascinating adventure, but speaks little of himself, with the humility of the true researcher. Therefore I like doing the task of recalling His career. I am culturally far from the hard background of Space Sciences, but I am proud to have promoted the involvement of the "Department of Geology, Paleontology and Geophysics" in the birth of CISAS, and especially to have facilitated the return of Alessandro Caporali from the University of Bari back to Padua, on the position of Associate Professor of Geodesy in our Department of Geosciences.

Born in Padua in 1952, Caporali graduated in Physics at the University of Padua (1975) and obtained a PhD in "Relativistic Gravitation" at the Max Planck Institut für Physik und Astrophysik of Munich, Germany. From 1979 to 1983 he worked as a research fellow in "Gravitational Physics" in the United States, at the Marshall Space Flight Center of NASA and at the Department of Earth and Planetary Sciences at the Massachusetts Institute of Technology, majoring in "Satellite Geodesy" by laser telemetry and microwave radio interferometry, with extragalactic radio sources and with the first GPS satellites, under the guidance of Profs. Giuseppe Colombo (Padua and Harvard) and Irwin Shapiro (MIT).

As a Telespazio S.p.A. employee in Rome (until 1984), Caporali contributes to the creation of the Matera Space Geodesy Centre, part of the National Space Plan (today ASI). His academic career began at the University of Padua as a researcher at the Department of Physics (until 1987), continues as Associate Professor of Experimental Physics at the University of Bari (until 1992) and, as mentioned, he returned to Padua as Geodesy professor in the Department of Geology, Paleontology and Geophysics (now Department of Geosciences) and later as a full professor of Solid Earth Geophysics at the Faculty of Engineering (from June 2010). In Padua he installed a GPS permanent station (1994), in support of the International GPS Service (CalTech / JPL), and is responsible for the GPS Data Processing Center (UPA), for the maintenance of European Geodetic Network (EUREF). From 1987 to 1998 he participated in some campaigns of gravity measurements in China, Nepal and Pakistan, creating a new map of gravity anomalies in the western Himalayas. National coordinator of a CNR project on Alpine-Mediterranean Geodynamics, he participates in various EC-funded projects. He serves as geodetic coordinator of National Projects (2006-2010) of the

Institute of Geophysics and Volcanology and the Department of Civil Protection dedicated to "the assessment of the seismic potential and probability of strong earthquakes in Italy", with the task of estimating velocity and surface crust deformation rate in Italy based on GPS data, and assess the relationship between displacements of GPS sites and the seismicity of the main Italian seismic zones. He further serves as Co-chairman (until 2009) and Chairman (2010-2015) of the Central European Geodynamic Research Network, as permanent member of the Technical Working Group dell'EUREF, as Secretary of EUREF (from 2011 to 2015), and finally as honorary member of EUREF from 2015. He participates in the Thematic Working Group 1-2 (Reference Frames, 2D and 3D grids) of the European Directive INSPIRE for the harmonization of spatial geodetic data. He is member of the Solid Earth Geophysics Group of CNR, the European Geosciences Society and the American Geophysical Union.

Finally, it is also important to mention its activity in the field of Applied Research for public and private organizations, conducted generally in the CISAS, including: i) scientific satellites orbit determination (1994-1996, in collaboration with Alenia), ii) implementation of the GPS Network of Regione del Veneto and innovative solutions in the regional mapping (since 2005), iii) three-year contract (2005-2007) with the Military Geographical Institute for research and development of new procedures for the processing of the national geodetic network and the training of civilian and military personnel in the field of precision GPS data processing, and management of permanent GPS networks for geographic / cartographic purposes; iv) research into the development of a real-time satellite interferometric sensor for detecting displacements and deformations in structures or areas at risk of landslide or subsidence (2006-2008, for SEPA Spa and Torino Wireless Consortium, v) responsible (2007 -2010, together with the Polytechnic of Milan and the University of Bologna), for the validation of calculation of the National Dynamic Network, the new geodetic network of IGMI consisting of permanent GPS stations, evolution of the IGM95 system, in line with European standards ETRS89. More details in the CISAS site.

Turning to the geological-structural field, my relevance, its scientific production documents, among other things, the importance of GPS precision measurements to estimate, on a global scale, the current pattern of lithospheric plates and, on a regional scale, the parameters which help to evaluate the seismogenic behavior of specific structures.

Giorgio Vittorio Dal Piaz

## **Presentation by Stefano Debei, Director Centro di Ateneo per gli Studi e Attività Spaziali CISAS ‘Giuseppe Colombo’, University of Padova**

The strength of CISAS rests on its capability of addressing several aspects of Space Sciences and Technology, from Exploration of the Outer Space to Observations of the Earth from Space. These scientific domains are very broad, and different Research Centers generally address and specialize in specific aspects. Prof. Giuseppe Colombo, who inspired most of the activities being carried out at CISAS, considered Space Geodesy with particular attention. He liked orbital mechanics, and he was aware that reconstructing the orbit of a terrestrial satellite implied a deep knowledge of the Earth gravity field, tides, atmospheric drag, ionospheric effects on the propagation of radio waves. Last but not least, the coordinates of tracking sites needed an accuracy comparable with that of the satellite orbit. As satellite laser ranging was heading to centimetric or subcentimetric accuracy, station coordinates had to be known at the same level. Plate tectonics implies displacements of a few centimeters per year. Consequently, satellite tracking was going to be an extraordinary occasion to improve the understanding of the Earth from several view points: from plate tectonics to models of the Earth gravity field, which mirrors the inhomogeneous and little known distribution of the masses in the Earth's interior.

While several Research Centers have considered the theme of Earth Observations from space from the point of view of imaging the Earth's surface, following Colombo's view CISAS concentrated on a somewhat unconventional approach based on precision spacecraft tracking, orbit dynamics, detailed models of the force field on the satellite, algorithms of data reduction.

This book gives the details of the research and achievements on the past thirty years. Alessandro Caporali has taken up the challenge to continue the ideas of Colombo, and provides evidence of significant steps forward, towards both a better monitoring of processes on the Earth, particularly in seismic areas, and the exploitation of the use of navigation satellites for several technological developments, including innovative instrumentation for heading and strain measurements. Proper credit is given to the contribution of several young researchers who developed skills later appreciated by industries and research institutions in Italy and abroad. Very important is also the collaboration with the Regione del Veneto, which has seen in CISAS its partner to develop and run a technical infrastructure such as the GPS network. Nowadays several professionals contact daily the servers at CISAS to obtain data on GPS satellites, in both real time and offline mode, which are then used for surveying and mapping, fleet management, clock synchronization, terrestrial, maritime and aircraft navigation. As Director of CISAS I am very pleased to see an increasing impact and role of CISAS in exploiting the benefits that Space Research is bringing to the professional life of so many individuals.

Stefano Debei



# Foreword

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In 1986, October 2 to 7, an exhibit was organized at the Institute of Applied Mechanics of the University of Padova with the title 'L'Attività Scientifica Spaziale Italiana' (The Italian Scientific Activity in Space). The exhibit was in memory of the late prof. Giuseppe Colombo, who so much influence had in the development of Space Science and Technology. If the momentum he so energetically and enthusiastically gave in so many areas of Space Research was going to continue in time, all those who had the fortune and privilege to work with Prof. Colombo should have found in this exhibit their scientific road map for the next years or decades.

As a visiting scientist at Harvard Smithsonian Astrophysical Observatory in Cambridge, Mass. and at Jet Propulsion Laboratory of NASA/Caltech in Pasadena, California, Colombo was in close contact with those scientific communities which, in the late 70's early 80's, were developing technologies and analysis programs for Satellite and Lunar Laser Ranging (SLR/LLR), Very Long Baseline Interferometry (VLBI) and Global Positioning System (GPS). It was already at that time clear that both SLR and VLBI data would have been able in a matter of few years to provide direct evidence of the drift of major lithospheric plates, while low cost GPS receivers would have been able to provide that densification which was necessary to detect in nearly real time strain changes in seismically active areas. This is exactly what happened, although Colombo could not witness this significant advancement of knowledge.

This document summarizes for the time frame 1986-2016 the development of the research activity in the field of Space Geodesy at the University of Padova. The University of Padova, particularly through the synergy between CISAS and the Department of Geosciences, has been on the frontline of this exciting research area, with scientific production, technological development and training of young scientists and engineers. The rest of this document attempts to describe how all this happened.

Alessandro Caporali  
Padova, March 2016