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Recent activities of the FP7-ESPaCE consortium

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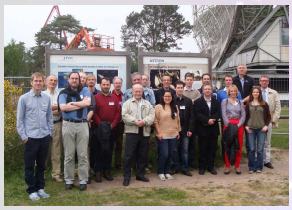
The European Satellite PArtnership for Computing Ephemerides (ESPaCE) is an EC-FP7 program which aims at strengthening the collaborative activities in the domain of the development of ephemerides and reference systems for natural satellites and spacecraft.

*The consortium ESPaCE (European Satellite Partnership for Computing Ephemerides) is composed of seven European institutes: **IMCCE** ((Institut de Mécanique Céleste et de Calcul des Ephémérides, Paris Obs.), **ROB** (Royal Observatory of Belgium), **TUB** (Technical University of Berlin), **JIVE** (Joint Institute for VLBI in Europe), **TUD** (University of Technology of Delft), Observatoire Midi-Pyrénées (**CNES**) in France and German Aerospace Center (**DLR**) in Germany. The objective of this FP7 European project is to provide new accurate ephemerides of natural satellites and spacecraft. For this goal many astrometric data issued from ground-based observations as well as from space observations have been analyzed and reduced. On the other hand new technologies applied to the positioning of spacecraft are also studied. The ESPaCE project addresses also data related to gravity and shape modeling, control point network and rotational parameters of natural satellites. The accuracy improvement of these ephemerides makes them a powerful tool for the analysis of space missions or the preparation of future missions, or for the determination of some physical parameters.*

The concept and objectives

The first purpose of the ESPaCE project is to explore and understand the physical phenomena, the physical structure and the dynamical processes of the Earth's Moon, the Martian moons Phobos and Deimos, as well as the numerous moons of the Solar system, and of Jupiter and Saturn in particular, their origin, their dynamics and their evolution. The second purpose of this project is to link celestial mechanics, dynamics, space science (Radio-science, LLR (Lunar Laser Ranging), VLBI (Very Long Baseline Interferometry) and astrometry. The main output are the Martian, Jovian, Saturnian and Uranian satellites and spacecraft ephemerides, as well as constraints on the interior and dissipation processes associated with these planetary systems.



The main part of the activity is focused on the extraction and analysis of astrometric data from spacecraft measurements that have not yet been used in the orbit dynamic reconstruction and on the combination of these data with ground-based astrometric data. The project will also advance the European expertise in ultra-precise tracking of planetary probes. By these means, we intend to provide new dynamical models for several natural satellites, a characterization of their rotation properties, and improve spacecraft orbit determination methods for space science.

This 4 year project, which began on 2011 June 1st, is organized in 12 work-packages: co-ordination (management), Radio-science, laser ranging, VLBI *(Very Long Baseline Interferometry)*, digitized data handling, astrometry, definition of coordination reference frames and improvement of planetary coordinate knowledge, methods for determination of spacecraft and satellites ephemerides, formation of databases, data access and distribution methods, educational, outreach activities and scientific management.

The project concentrates at achieving maximum synergy between all the work packages above in order to deliver to the professional communities and communities at large the best scientific products adequate to the present day cutting edge space science and technology.

Web pages are accessible at : http://espace.oma.be/

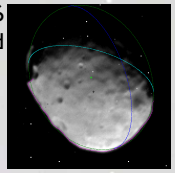
Recent results

Astrometry from digitized photographic plates and telescopic observations

The new technology ROB Digitizer (Damian) was used to digitally disclose with unprecedented precision the astrometric data archived in photographic plates of the Martian (~500), the Galilean (~550) and the Saturnian (~1000) satellites mostly taken with the 26" refractor at USNO and at the South African Yale Station. Almost 200 plates from different locations will also be considered. Other telescopic observations, mutual events of planetary satellite systems (Uranus 2007, Jupiter 2009), have been reduced.

Astrometry from radioscience data and Space images

Precise determination of S/C orbit is done thanks to Radio Science (MEX, Viking 1&2, Mariner 9 data) and will be used in a global astrometry solution of the satellite dynamical models.

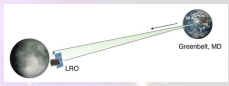


Space imaging is also used. 239 Phobos images and 136 Deimos images during flybys have been studied and lead to accuracy of 0.5-3.6 km.

Intersatellite measurements of the least distance during Martian moons encounters show also promising astrometry results.

Astrometry from LR (Laser ranging) and VLBI tracking

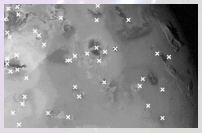
New technologies for providing high accurate astrometry of S/C through tracking or ranging data are studied. The combination of RS and VLBI observations during a flyby of spacecraft around a planet or moons is under study. Besides, we foresee to contribute to the positioning of Gaia thanks to VLBI.



Results using 1-Way LR to LRO have been obtained and show rms of 13.2cm, expected dedicated two-way system performance <1 cm. Performance study of Phobos laser ranging concept for geodetic observables is currently in progress.

Shape modeling, reference system and rotation

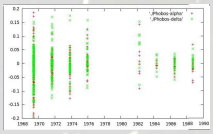
ESPaCE intends to provide coordinate systems of several satellites.



A Phobos control point network is under development. A provisional version has been used for providing space astrometry but also for providing measures of rotation parameters. Potential applications to the libration study of the Saturnian and Jovian satellites are foreseen.

The development of reference shape and reference system of icy satellites is also under study. Interior and dynamical parameters will be inferred

New satellite and spacecraft ephemerides



New ephemerides of the Martian and the Uranian moons have been developed. Ground-based astrometry and space astrometry (MEX, Phobos2, Viking data) are used for Phobos and Deimos. Post-fit residuals show typical accuracy of 65 mas (~20 km).

For the Uranian moons, residuals of micrometer observations, photographic plates and CCD frames covering 1870-2012 are obtained. Mutual events residuals of these satellites show very accurate results (20 mas). The ephemerides are accessible at ftp.imcce.fr

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