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A new consortium : ESPaCE
European Satellite Partnership for Computing Ephemerides

W. Thuillot[1], V. Lainey[1], V. Dehant[2], J.-E Arlot[1], J.-P. De Cuyper[2], L.I. Gurvits[3,7], H. Hussmann[4], J. Oberst[5], P. Rosenblatt[1], J.-C. Marty[6], B. Vermeersen[7] and the ESPaCE team[8]

[1]IMCCE, Paris Observatory; [2]Royal Observatory of Belgium; [3]Joint Institute VLBI Europe, Dwingeloo, The Nederlands; [4]DLR Berlin, Germany; [5]Tech. Univ. Berlin, Germany; [6]Observatoire Midi-Pyrénées/CNES France; [7]Delft University of Technology, The Nederlands; [8]the complete ESPaCE Team: Arlot, J.-E. (IMCCE) , Bauer, S. (DLR), De Cuyper, J .-P. (ROB), Dehant, V. (ROB) , Dirkx, D. (TUD), Gurvits, L. (JIVE), Hestroffer D. (IMCCE), Hussmann, H. (DLR), Kudryashova, M. (ROB), Lainey, V. (IMCCE), Marty, J.-C. (CNES), Oberst, J. (TUB), Pasewaldt, A. (DLR), Rambaux, N. (IMCCE), Robert, V. (IMCCE), Rosenblatt, P. (ROB), Thuillot, W. (IMCCE), Vermeersen, B. (TUD), Vienne A. (IMCCE)

The European Satellite PArtnership for Computing Ephemerides (ESPaCE) is a new 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 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 ephemerides, as well as constraints on their interior and dissipation processes.

The concept and objectives

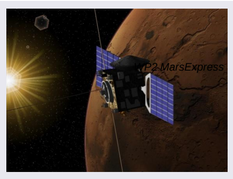
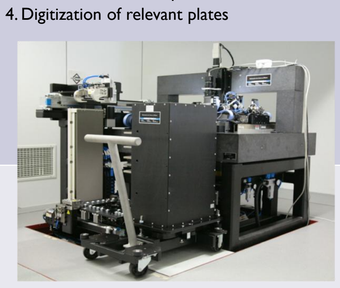
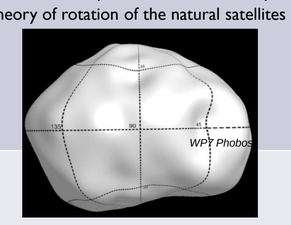
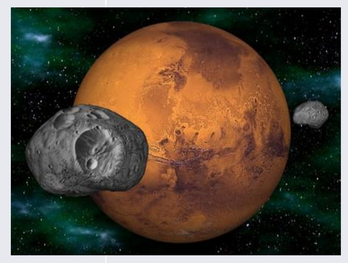
The ESPaCE project aims at strengthening the collaboration and at developing new knowledge, new technology, and products for the scientific community in the domains of the development of ephemerides and reference systems for natural satellites and spacecraft by combining expertise of main European research centers involved in space sciences and dynamics, **ROB** *(Royal Observatory of Belgium)*, **TUB** *(Technische Universität Berlin)*, **JIVE** *(Joint Institute for VLBI in Europe)*, **TUD** *(Technische Universiteit Delft)*, **CNES** *(Centre National d'Études Spatiales)*, **DLR** *(Deutsches Zentrum Fuer Luft und Raumfahrt, EV) and* **IMCCE** *(Institut de Mécanique Céleste et de Calcul des Ephémérides, Paris Obs.)*.

The main part of the activity is focused on the extraction and analysis of astrometric data from spacecraft measurements that have not yet applied 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 and other deep space science missions. 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.

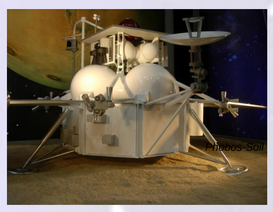
This 4 year project, which began on 2011 June 1st, is organized in 12 work-packages: co-ordination (management), Radio-science, laser ranging, VLBI *(Very Long Baseline Interferometry)*, digitized data handling, astrometry, definition of coordination reference frames and improvement of planetary coordinate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

The project will concentrate 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.

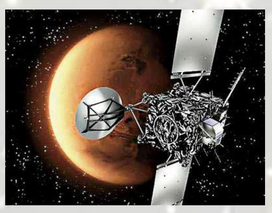
12 Work Packages

No	WP	Work to do	Tasks list	Deliveries list
WP 1	Coordination			
WP 2	Radio-science	Tracking data of probes which had flybys with natural satellites will be collected and analyzed thanks to a priori ephemerides of the objects. Several considerations upon the acting forces, gravitational and non gravitational forces, will be made in order to get the best results. These forces will be estimated and precise orbit of the probes will be computed. Other parameters such as mass of the natural satellite will be determined.	1. Collection of the Radio-science tracking data 2. A priori ephemerides 3. Strategy development for the analysis 4. Analysis of the tracking data	 • Ephemerides biases • Spacecraft orbit SPICE kernels
WP 3	Laser data	Data from laser tracking will be analyzed and their accuracy will be estimated. The data obtained during the LRO (Lunar Reconnaissance Orbiter) mapping mission will be analyzed. Software for solution of spacecraft trajectories will be developed.	1. Information collection on laser tracking, VLBI and Deep Space New. 2. Inventory of existing and required tools 3. Selection and modification of preferred tools 4. Performance studies 5. Demonstration project  *WP3 Lunar Laser Ranging*	• Report on performance parameter. Of laser tracking, VLBI, DSN • Report on software packages for solutions of satellite trajectories • Report on selected software tool and on modification. and fine-tuning for trajectory determination • Report on performance study incl. Quality estimation. Of simulated and actual results • Report on LRO Laser Tracking results
WP 4	VLBI	Applications of VLBI technologies to spacecraft tracking will be studied. VLBI tracking data will be analyzed in view of their use for various planetary science objectives. A special software will be developed and applied to planetary science spacecraft VLBI observations.  WP4 EVN Radio Telescope, Yebes, Spain	1. Installation, verification and tests of the VLBI near-field theoretical delay 2. Verification and tests of the on-purpose developed ultra-high spectral resolution correlate software for SPC VLBI correlation 3. Scheduling and performing test VLBI observation of several existing SPC 4. Post-correlation analysis of the broad-band far-field phase referencing radio sources (from ICRF and other catalogues) data and near-field narrow band SPC data. 5. Analysis of the results 6. Optimization of the observational, processing and analysis techniques, recommendation. For further development.	• Report and algorithms of ultra high spectral resolution SPC signal correlation • Measured state vectors of the SPC together with the a priori state vectors used
WP 5	Digitized data	This WP is dedicated to the scan of many photographic plates of planetary systems of satellites. We have identified in particular plates of Martian, Jovian and Saturnian satellites to be scanned. But we know that other relevant plates can be available in archives of several observatories; we shall find them and scan them. This work is made possible thanks to the recent setting up of a new digitizing machine in ORB.	1. Digitization of Mars plates 2. Digitization of Saturn plates 3. Identification of new plates 4. Digitization of relevant plates  *WP5 Digitalizing Machine, ORB*	• Digitized form of the plates of Mars • Digitized form of the plates of Saturn • Digitized form of the plates of new plates identified
WP 6	Astrometry	The data scanned in WP5 and other relevant data will be analyzed in terms of astrometry in order to obtain orbit model. Among these data, a special work will be carried out for rare events, the mutual events of the natural satellites (eclipses and occultations of satellites each other during the planetary equinoxes), which are the most accurate astrometric observations from the ground. In this WP, a special task will be devoted to the astrometry of Phobos and Deimos which have been the goal of several space missions.	1. Reduction of Phobos/Deimos images 2. Reduction of mutual events data 3. Reduction of Jovian images 4. Reduction of the Uranian images 5. Reduction of the relevant images 6. Reduction of the DAMIAN images	• Astrometric space data of Mars, Jupiter, and Saturn satellites • Mutual events data for the Uranian, Jovian and Saturn satellites • Astrometric data from DAMIAN images 
WP 7	Coordinates and Reference systems	On the basis of space observations, the shape and gravity model of the natural satellites can be obtained. The WP7 will be devoted to these tasks for the Martian satellites, the Moon, and the icy satellites. A coordinate system for these objects will be defined and a model of rotation could be deduced. These data will also be of use for physical ephemerides (precise aspect of the bodies versus the time) of the natural satellites.	1. Reference shape and gravity model for Phobos 2. Realization of the Phobos coordinate system 3. Realization of the Lunar coordinate system 4. Reference shapes of icy satellites 5. Realization of icy satellites coordinate systems 6. Theory of rotation of the natural satellites 	• Report on Phobos control point network, reference shape, and gravity model • Report on Lunar coordinates and selected base maps • Report on icy satellites control point networks, shapes and coordinate systems
WP 8	Spacecraft and Satellite ephemerides	New dynamics models of the natural satellites and improved orbit models of spacecraft will be obtained by using the digitalized astrometric data as well as spacecraft data. The dynamics models of the Martian satellites Phobos and Deimos will be improved in particular on the basis of the new analysis of the recent MEX data and the past Viking data. Combination between space observations and ground based ones, and processing of data related to the satellites and the probes, allow getting strong constraints for the dynamics of the objects. Other data from the Galileo and Voyager missions will permit also to provide new ephemerides of the Galilean and the Uranian satellites and new orbital models of the probes. Spice Kernels will be provided.	1. Arc splitting method 2. Merging data method 3. Modeling Mars SPC orbits 4. Modeling Phobos/Deimos orbit 5. Mars global inversion 6. Modeling Galileo orbit 7. Modeling Jovian satellite orbits 8. Jupiter global inversion 9. Modeling Voyager 2 orbit 10. Modeling Uranian satellites orbit 11. Uranus global inversion 	• Mars SPC, Galileo, Voyager 2 orbit kernels • Ephemerides of Martian, Galilean and Uranian satellites
WP 9	Databases	Setting up of databases and of the method to access the data and models developed in the other WPs.	1. Astrometric database 2. Rotation database 3. SPC Kernels 4. Satellite kernels 5. Map images 6. Topography	• Collecting Topography data in standard format • Collecting Satellite and SPC data in SPICE format • Collecting Rotation data in standard format • Selected image map and topographic data products including documentation
WP 10	Data distribution	Allowing the whole scientific community to access our new data available. Databases will be fed step by step, each time a new deliverable is available.	1. Astrometric database 2. Rotation database 3. SPC and satellite kernels 4. Map images 5. Topography 6. Planetary constants 7. Interface with EUROPLANET IDIS	• Implementation of the astrometric database • Implementation of the SPC/Satellite kernels • Distribution of the planetary constants • Interface method with EUROPLANET IDIS
WP 11	Education and Outreach		*WP8 Ganymede, Io, Europa & Calisto*	
WP 12	Scientific management			

The nearest event



Phobos-Soil
and
YingHuo-1 launch
8 November 2011



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