SpaceDyS

AZIENDA SPINOFF DELL'UNIVERSITÀ DI PISA

CEOD
Computational Engine for Orbit Determination of Solar System Objects

Regione Toscana

POR CReO 2007-13 PROGRAMMA OPERATIVO REGIONALE OBIETTIVO COMPETITIVITÀ REGIONALE e OCCUPAZIONE Fondo Europeo di Sviluppo Regionale

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Le ali alle tue idee

Space Dynamics Services s.r.l.
Polo Tecnologico di Navacchio
Pisa, Italy
www.spacedys.com

CEOD

An essential technology to access interplanetary space and control the circumterrestrial environment is

the ability to determine the orbit of any object, natural or artificial, orbiting in space.

This technology is essential for any space agency or aerospace company that builds or manoeuvres artificial satellites.

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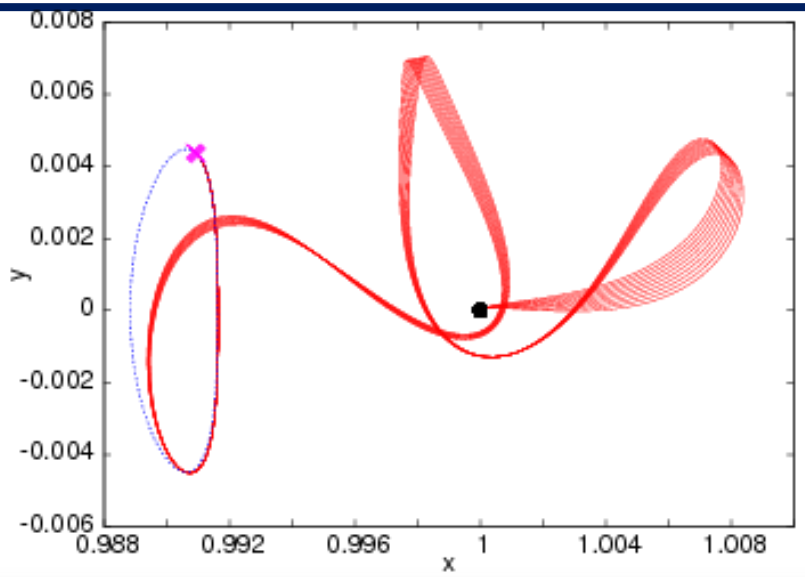
With the project **CEOD**, SpaceDyS started the research and the development of algorithms and software to the **highest level of innovation**, to build the **basic libraries** of new software tools for **orbit determination purposes**.



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Main Core Libraries

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OBSERVATION MODELS Routines for the computation of the most common measurements techniques, optical and radar, at different levels of accuracy.

DYNAMICAL MODELS Routines for the computation of the right hand side of the equation of motion of a generic object moving in the Solar System.

GENERAL COORDINATE CHANGER Routines for the Newtonian and relativistic conversion between different types of coordinates and reference systems.

NUMERICAL PROPAGATOR Accurate and efficient multistep propagator/interpolator with regularisation techniques to manage the passage between different orbital regimes.

LEAST SQUARES SOLVER Robust and fast differential corrector able to solve least squares problems with a very large number of parameters and to treat properly bad conditioned problems.

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Innovation

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The **innovative content** of the solution found involves many different aspects.

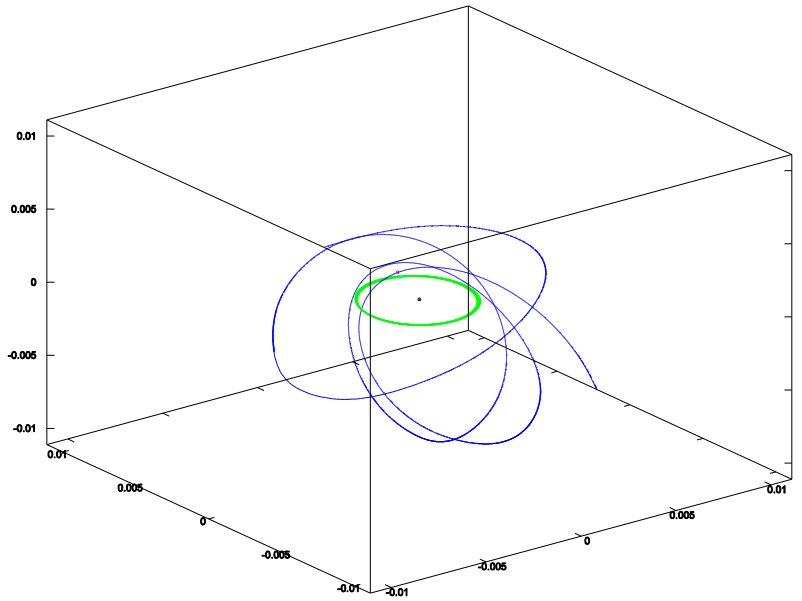
The algorithms have been studied to reach the **highest performances** in terms of

Adaptability **Efficiency** **Accuracy**

CEOD Innovation

With the use of a **multistep propagator and interpolator**, the **control of numerical error** is guaranteed, and the best step size for the problem at hand is automatically chosen.

With the proper choice of **regularization techniques**, we can improve the propagator/interpolator in managing the **passage between different dynamical environments without loss of accuracy**, resulting in a fast and reliable instrument.



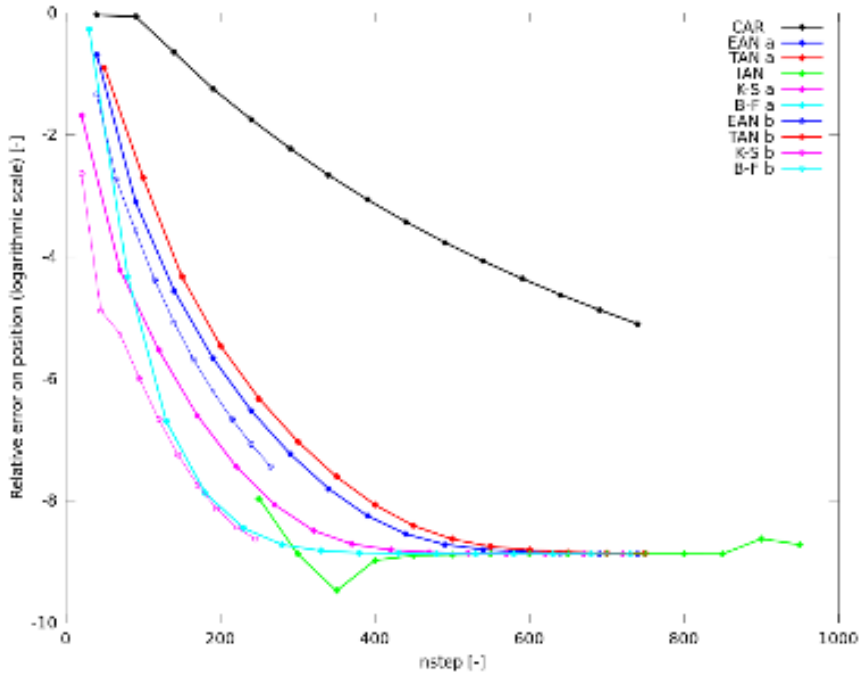
CEOD Innovation

Test showing superior performances obtained with different regularisation techniques.

Characteristics of the reference orbit:

- Geocentric orbit with eccentricity 0.7;
- Oblateness and lunar perturbations.

Multistep order 8.



Singularities in the coordinate changes are managed automatically, without crashes.

For relativistic coordinate changes, the transformation between different time scales is performed in a very fast and accurate way, by the creation of **time ephemeris** and taking into account the station position using the current Earth orientation data from IERS website.

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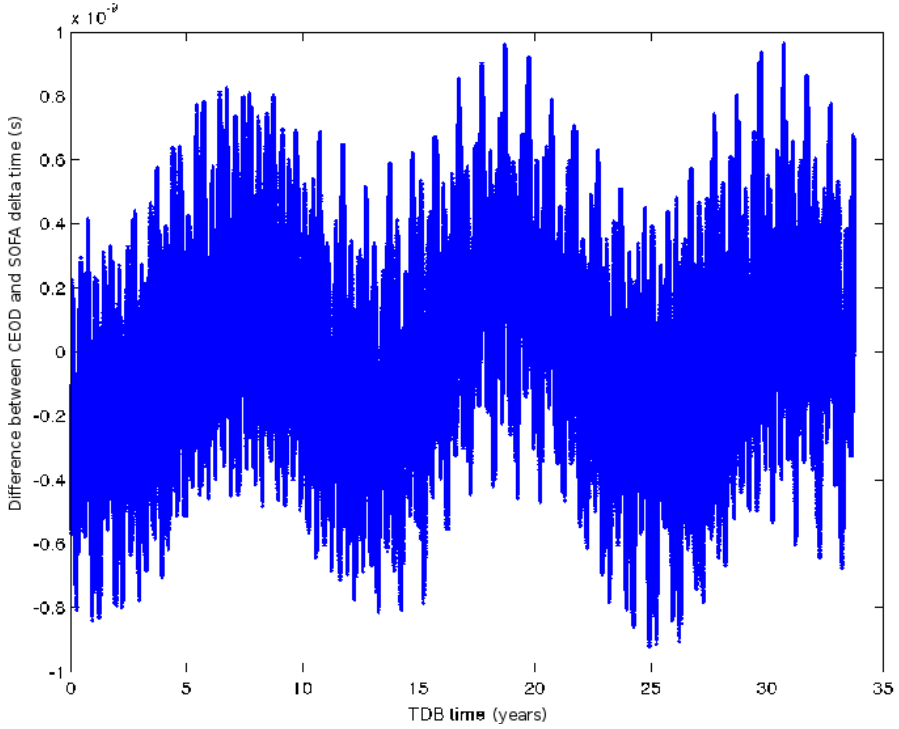
Absolute differences between CEOD and SOFA time scale converter (Solar System Barycentric to Terrestrial Time): differences are below 10^{-9} seconds.



The **least square solver** is designed to be as **general** as possible, and able to determine a very large number of parameters, both kinematic and dynamical ones, with the possibility to use linear and nonlinear constraints to **treat unstable problems**.

CEOD Innovation

The **highest level of adaptability** is reached by the possibility to activate different perturbations, choose different kinds of measurements and switch to relativistic dynamics, all of this by **managing a single file of options**.

Finally, **FORTRAN2008 programming language** is used, in order to exploit the latest features for parallel computing and object oriented programming.

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Main Software Applications

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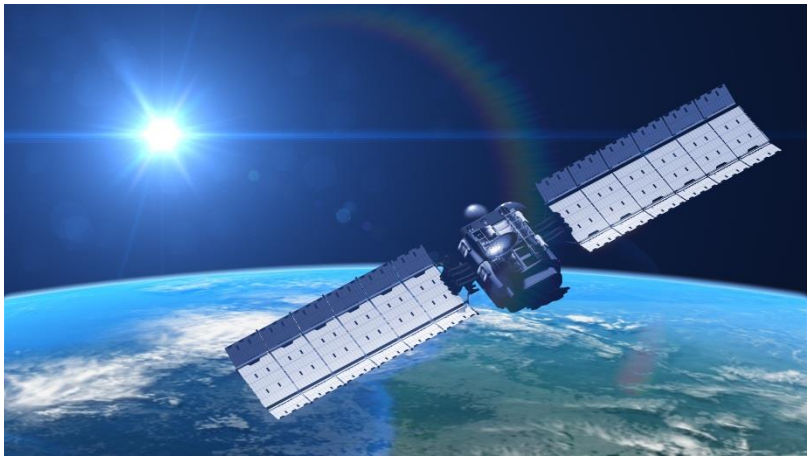
Earth Artificial Satellites Orbit Determination Tool
for radio and optical tracking and data processing. This tool will be used to perform the tracking of Satellites or Space Debris objects, to refine their orbits. It will allow also initial orbit determination with classical and new algorithms, and ephemeris computation.



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Main Software Applications

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Asteroid Orbit Determination Tool

for database complete management, with identification and cataloguing functions, and in particular for the monitoring of potentially hazardous objects. This tool is the evolution of the software OrbFit 4.2, which is currently used for the NEODyS and Ast DyS in Pisa.

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Main Software Applications

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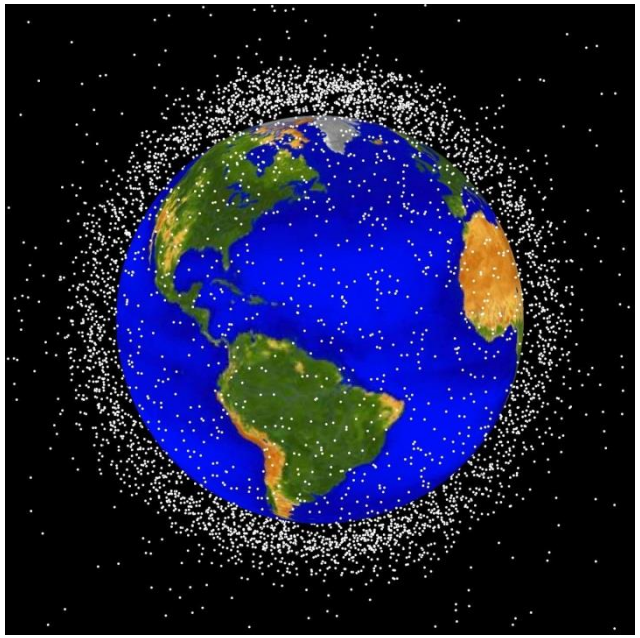
Space Debris Orbit Determination Tool,
with correlation, catalogue build-up and maintenance functions. This tool will integrate the functions of the previous ones, for the dynamics around planet Earth.



CEOD
Main Software Applications

Orbit Determination Tool for Highly Accurate Experiments for Interplanetary Missions,
for example top level radio science experiments like the ones of ESA-BepiColombo mission, NASA-Juno mission, or the future ESA-JUICE.