

RAL

DESIGN & DISCOVERY

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RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

Orbit Dynamics at RAL

The orbit dynamics group at the Rutherford Appleton Laboratory (RAL) has been involved in theoretical and operational aspects of astrodynamics since the Ariel series of satellites in the early 1970's. Software is available on the IBM 3081 mainframe, MicroVax 3800, and the CRAY X/MP-48 computers. The main areas of research and development are outlined here.

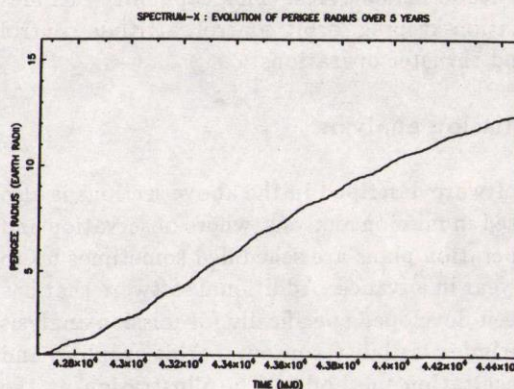
Orbit determination

Software is available for the determination of near-Earth and high eccentricity orbits. In both cases there are many kinds of input data that can be used; one example is very high accuracy laser data. For most spacecraft, the required accuracy is set by the need to track the spacecraft and reconstruct the orbit to an along-track error of a few kilometres. However, for certain spacecraft the requirement is for highly precise orbit determination to decimetre accuracy. Research into suitable methods is continuing within the group.

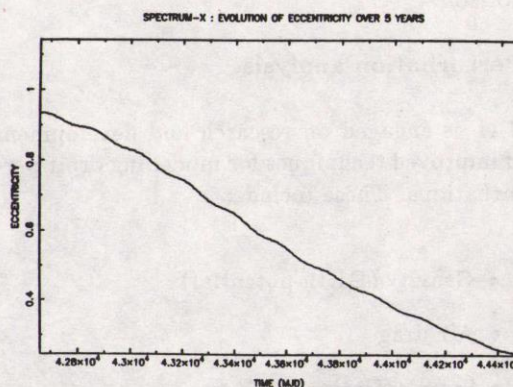
Orbit prediction

This facility is required for mission planning and analysis, data processing evaluation, preparing tracks for ground station passes, eclipse and radiation zone encounters, etc. Software is available for these tasks, including NASA's program GEODYN and RAL's program SPIRAL for orbit element and event calculations. Research work within the group continues on the development of improved algorithms in these areas. The diagrams illustrate, for the planned SPECTRUM-X satellite mission, some typical output: the change over a 5 year period of the perigee radius (perigee be-

ing the nearest point of the orbit to the earth), and for the orbit eccentricity. The x-axis in both graphs is time in Modified Julian Days.



This graph shows that the height of the perigee point of the SPECTRUM-X orbit increases with time throughout the 5 year period.



This graph shows that the SPECTRUM-X orbital eccentricity decreases with time throughout the 5 year period; the orbit is becoming more circular.

Orbit/Attitude manoeuvres

Software was developed on the AMPTE project for determining and executing both orbit and attitude manoeuvres. This capability includes station-keeping, orbit control, attitude control and thruster operations.

Mission analysis

Software described in the above sections is also used in mission analysis, where observation and operation plans are scheduled sometimes up to a year in advance. Additional software that has been developed specifically for mission analysis includes visibility contours, orbit graphics and occultation methods. The illustration at the right shows a world map in the Mercator projection, and successive orbit tracks for the earth resources satellite ERS-1; additionally it shows the coverage zones for a number of ground stations ie those regions where ERS-1 will be at an elevation of more than 10 degrees above the horizon.

Perturbation analysis

RAL is engaged on research and development of improved techniques for modelling orbit perturbations. These include:

- Gravity (Earth potential)
- Air drag
- Solar radiation pressure

Improved modelling techniques in these areas are aimed at both increasing the accuracy of the models and reducing computer run times. In particular, analysis has been made of the

maximum zonal harmonic order to be included for various classes of mission. Similarly the degree of complexity required for air drag calculations has been analysed, and an optimised model has been developed.

Simulation and operations

RAL has been involved in simulating the orbit dynamics and operating many spacecraft, including Ariel V, Ariel VI, Landsat IV, IRAS, EXOSAT and AMPTE. The orbit dynamics group has also worked on an Attitude and Orbit Control System (AOCS) simulator for ROSAT and on precise orbit determination requirements for ERS-1. Currently the group is carrying out orbital studies for the proposed CLUSTER mission, particularly into separation strategies for the four spacecraft in that mission.

List of Acronyms

AMPTE - Active Magnetospheric Particle Tracer Explorers

ERS-1 - European Remote Sensing satellite

ROSAT - Rontgensatellit

IRAS - Infra-Red Astronomy Satellite

Further information

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