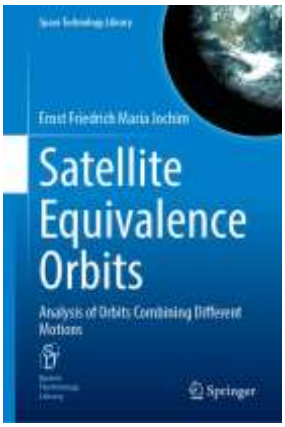

Book Preview

Satellite Equivalence Orbits
Analysis of Orbits Combining Different Motions
by Ernst Friedrich Maria Jochim

Publishing Date: Juli 09, 2024

Language: Englisch
Publisher: Springer Berlin , Space Technology Library 42
ISBN 9783031584756

This preview concludes with an *Interview* with the author Ernst Friedrich Maria Jochim.

Dr. Fritz Jochim holds a Diploma Degree (Master Degree) in mathematics and mathematical astronomy from University Würzburg, and got a Second State Degree for mathematics and physics as high school teacher in 1970. From 1970 2006 he worked a scientific employee at German Aerospace Center (DLR) in Braunschweig and Oberpfaffenhofen. His main topic was satellite orbit analysis, development of a comprehensive package of analytical satellite orbit analysis programs, which are successfully used in almost all German satellite missions and space studies.

This book **Satellite Equivalence Orbits** presents the essential characteristics of the different satellite motions. Satellite motions can be classified as anomalistic, draconitic, tropical, Hansen-, Kepler-, meridional, Sun-synodical, Moon-synodical motion, depending on the relevant reference point. When two of these types of motions (in some cases even more than two) are coupled, satellite orbits are obtained, which are called equivalence orbits in this book. They share the special properties of the different coupled motions and are therefore of particular interest in the selection of special satellite orbits.

In the book the author calculates mean equivalence orbits with secular perturbation formulas, as well as true equivalence orbits considering a complete orbit model including periodic motion effects. Some of the equivalence orbits can be determined unambiguously and with extremely high accuracy, they are stable in the long term. Others can only be found with low accuracy and reduced stability. The author investigates all possible combinations and the associated general equations of condition are derived in each case. Some well-known families of satellite orbits, such as the Sun-synchronous orbits, can be interpreted as mean equivalence orbits. The study of their stability is of great interest in orbit mechanics. Special applications and numerous numerical examples, graphical representations of all possible ranges of the Kepler elements, and detailed studies of the stability of particularly important equivalence orbits are carried out using the Brouwer orbit model as well as the modification by Eckstein.

This lays the foundation for possible refinements using arbitrary extended orbital models and for possibly required orbital corrections. Numerous problems are to deepen the treated topics and/or to stimulate for further investigations.

The book will be of interest to Astrodynamics and Aerospace Engineers as well as graduate students studying satellite orbits.

Interview with the Author Dr. Fritz Jochim
(Conducted by JSOC Editor Joachim J. Kehr)

1. *How are satellite equivalence orbits calculated?*
Fritz Jochim; Satellite equivalence orbits are satellite orbits that couple two or more types of motion. They are calculated by matching the mean motions or orbital periods.

2. *What are the special properties of equivalence orbits*
Fritz Jochim: Eqivalence orbits are stable in the long term. A distinction is made between mean orbits, which are essentially time-independent, and true orbits, which are time-dependent. There are mean equivalence orbits that are stable over years. The necessary numerical calculation is carried out with extreme accuracy and is reversibly unambiguous. There are also equivalence orbits that can only be calculated with low accuracy and are therefore not unambiguous. However, these orbits also exhibit characteristic properties of special equivalence orbits.

3. *Ninety-six (96) different types of equivalence orbits are examined in the book. Are there equivalence orbits that are of practical importance in the applications?*
Fritz Jochim: Yes. The Sun synchronous orbits can be formed as equivalence orbits by coupling mean draconitic and mean Sun synodical satellite motions. They can be regarded as patterns for equivalence orbits as point motion. The usual methods of satellite operations such as orbit determination, orbit control, orbit corrections, consideration of the influence of pointing ma-neuvers and the size and shape of a satellite are not specifically affected.

4. *Are equivalence orbits defined solely by the semimajor orbital axis?*
Fritz Jochim: No. Equivalence orbits are essentially determined by a specific combination of the Kepler elements semimajor orbital, eccentricity and inclination. The specification of two of these elements allows the calculation of the third according to the special equivalence conditions. In the book there are characterizing diagrams for each type of equivalence orbit, from which the permitted relationships can be read.

5. *How much programming effort is required to calculate the equivalence orbits?*
Fritz Jochim: Extensive programs (approx. 1.5 man-years) were incorporated into the orbit analysis program system VENI developed at DLR as part of the orbit selection process.

6. *What led you to the idea of equivalence orbits?*
Fritz Jochim: In August 2019, I was working intensively on super-synchronous satellite orbits and meridional motions. These are related to the surface of the Earth. In the vicinity of satellite orbits with an orbital period of 2 sidereal days, I was able to observe that there are exact intersections of the orbital periods on meridional orbits with orbital periods on all other types of orbits. I described this process as equivalence orbits. A systematic search for further equivalence orbits in all altitude ranges led to the 48 mean and 48 true equivalence orbits. Not all couplings of different types of motion lead to usable equivalence orbits.

Thank you for the deep insights, and JSOC wises a successful publication.