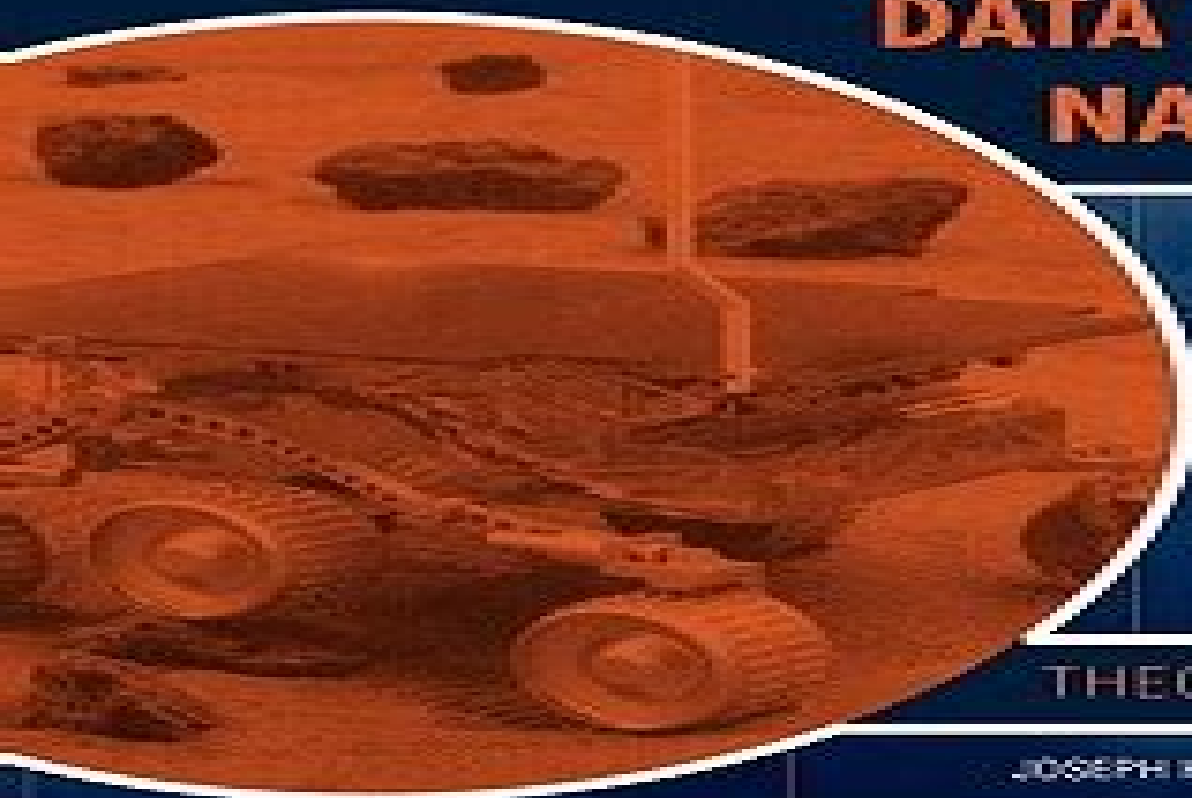


JPL DEEP SPACE COMMUNICATIONS AND NAVIGATION SERIES

# FORMULATION FOR OBSERVED AND COMPUTED VALUES OF DEEP SPACE NETWORK DATA TYPES FOR NAVIGATION



THEODORE D. MOYER

JOSEPH H. YUEN, SERIES EDITOR

# Formulation For Observed And Computed Values Of Deep Space Network Data Types For Navigation

**Jim Taylor**



## **Formulation For Observed And Computed Values Of Deep Space Network Data Types For Navigation:**

Formulation for Observed and Computed Values of Deep Space Network Data Types for Navigation Theodore D. Moyer, United States. National Aeronautics and Space Administration, Jet Propulsion Laboratory (U.S.), 2000 *Formulation for Observed and Computed Values of Deep Space Network Data Types for Navigation* Theodore D. Moyer, 2003-01-31 A valuable reference for students and professionals in the field of deep space navigation Drawing on fundamental principles and practices developed during decades of deep space exploration at the California Institute of Technology's Jet Propulsion Laboratory JPL this book documents the formation of program Regres of JPL's Orbit Determination Program ODP Program Regres calculates the computed values of observed quantities e.g. Doppler and range observables obtained at the tracking stations of the Deep Space Network and also calculates media corrections for the computed values of the observable and partial derivatives of the computed values of the observables with respect to the solve for parameter vector  $q$  The ODP or any other program which uses its formulation can be used to navigate a spacecraft anywhere in the solar system A publication of the JPL Deep Space Communications and Navigation System Center of Excellence DESCANSO Formulation for Observed and Computed Values of Deep Space Network Data Types for Navigation is an invaluable resource for graduate students of celestial mechanics or astrodynamics because it features the expertise of today's top scientists places the entire program Regres formulation in an easy to access resource describes technology which will be used in the next generation of navigation software currently under development The Deep Space Communications and Navigation Series is authored by scientists and engineers with extensive experience in astronautics communications and related fields It lays the foundation for innovation in the areas of deep space navigation and communications by conveying state of the art knowledge in key technologies

Formulation for Observed and Computed Values of Deep Space Network Data Types for Navigation Theodore D. Moyer, 2005-03-04 A valuable reference for students and professionals in the field of deep space navigation Drawing on fundamental principles and practices developed during decades of deep space exploration at the California Institute of Technology's Jet Propulsion Laboratory JPL this book documents the formation of program Regres of JPL's Orbit Determination Program ODP Program Regres calculates the computed values of observed quantities e.g. Doppler and range observables obtained at the tracking stations of the Deep Space Network and also calculates media corrections for the computed values of the observable and partial derivatives of the computed values of the observables with respect to the solve for parameter vector  $q$  The ODP or any other program which uses its formulation can be used to navigate a spacecraft anywhere in the solar system A publication of the JPL Deep Space Communications and Navigation System Center of Excellence DESCANSO Formulation for Observed and Computed Values of Deep Space Network Data Types for Navigation is an invaluable resource for graduate students of celestial mechanics or astrodynamics because it features the expertise of today's top scientists places the entire program Regres formulation in an easy to access resource describes technology which

will be used in the next generation of navigation software currently under development The Deep Space Communications and Navigation Series is authored by scientists and engineers with extensive experience in astronautics communications and related fields It lays the foundation for innovation in the areas of deep space navigation and communications by conveying state of the art knowledge in key technologies *Deep Space Communications* Jim Taylor, 2016-08-29 DEEP SPACE COMMUNICATIONS A COLLECTION OF SOME OF THE JET PROPULSION LABORATORY S SPACE MISSIONS SELECTED TO REPRESENT THE PLANETARY COMMUNICATIONS DESIGNS FOR A PROGRESSION OF VARIOUS TYPES OF MISSIONS The text uses a case study approach to show the communications link performance resulting from the planetary communications design developed by the Jet Propulsion Laboratory JPL This is accomplished through the description of the design and performance of six representative planetary missions These six cases illustrate progression through time of the communications system s capabilities and performance from 1970s technology to the most recent missions The six missions discussed in this book span the Voyager for fly bys in the 1970s Galileo for orbiters in the 1980s Deep Space 1 for the 1990s Mars Reconnaissance Orbiter MRO for planetary orbiters Mars Exploration Rover MER for planetary rovers in the 2000s and the MSL rover in the 2010s Deep Space Communications Provides an overview of the Deep Space Network and its capabilities Examines case studies to illustrate the progression of system design and performance from mission to mission and provides a broad overview of the mission systems described Discusses actual flight mission telecommunications performance of each system Deep Space Communications serves as a reference for scientists and engineers interested in communications systems for deep space telecommunications link analysis and design control Spacecraft Optical Navigation William M. Owen, Jr., 2024-10-11 UNIQUE RESOURCE EXPLORING HOW SPACECRAFT IMAGERY PROVIDES PROFESSIONALS WITH ACCURATE ESTIMATES OF SPACECRAFT TRAJECTORY WITH REAL WORLD EXAMPLES AND DETAILED ILLUSTRATIONS Spacecraft Optical Navigation provides detailed information on the planning and analysis of spacecraft imagery to help determine the trajectory of a spacecraft The author an experienced engineer within the field addresses the entirety of celestial targets and explains how a spacecraft captures their imagery Aimed at professionals within spacecraft navigation this book provides an extensive introduction and explains the history of optical navigation reviewing a range of optical methods and presents real world examples throughout With the use of mathematics this book discusses everything from the orbits sizes and shapes of the bodies being imaged to the location and properties of salient features on their surfaces Specific sample topics covered in Spacecraft Optical Navigation include History of various past spacecraft including Mariner and Viking Voyager Galileo NEAR Shoemaker and Cassini and flight hardware star catalogs and stereophotoclinometry Cameras covering the gnomonic projection and deviations from it creation of a digital picture picture flattening and readout smears Modeling optical navigation observables covering apparent directions to an object star and limbs or terminators and orientation of cameras Obtaining optical navigation observables covering centerfinding for stars

and resolved and unresolved bodies and using opnav data in orbit determination Spacecraft Optical Navigation is an ideal resource for engineers working in spacecraft navigation and optical navigation to update their knowledge of the technology and use it in their day to day The text will also benefit researchers working with spacecraft particularly in navigation and professors and lecturers teaching graduate aerospace courses      *Radio Science Techniques for Deep Space Exploration* Sami W. Asmar,2022-03-29 Explore the development and state of the art in deep space exploration using radio science techniques In *Radio Science Techniques for Deep Space Exploration* accomplished NASA JPL researcher and manager Sami Asmar delivers a multi disciplinary exploration of the science technology engineering mission operations and signal processing relevant to deep space radio science The book discusses basic principles before moving on to more advanced topics that include a wide variety of graphical illustrations and useful references to publications by experts in their respective fields Complete explanations of changes in the characteristics of electromagnetic waves and the instrumentation and technology used in scientific experiments are examined *Radio Science Techniques for Deep Space Exploration* offers answers to the question of how to explore the solar system with radio links and better understand the interior structures atmospheres rings and surfaces of other planets The author also includes Thorough introductions to radio science techniques and systems needed to investigate planetary atmospheres rings and surfaces Comprehensive explorations of planetary gravity and interior structures as well as relativistic and solar studies Practical discussions of instrumentation technologies and future directions in radio science techniques Perfect for students and professors of physics astronomy planetary science aerospace engineering and communications engineering *Radio Science Techniques for Deep Space Exploration* will also earn a place in the libraries of engineers and scientists in the aerospace industry      *Planetary Spacecraft Navigation* James Miller,Connie Weeks,2025-06-05 In this new edition the authors James Miller and Connie Weeks dive deeper into how computer programming has assisted with planetary spacecraft navigation evaluating real world results and relying on complex mathematical theory to observe advancements made in this rapidly accelerating field This textbook introduces the theories and practical procedures used in planetary spacecraft navigation Written by a former member of NASA s Jet Propulsion Laboratory JPL navigation team with his co author it delves into the mathematics behind modern digital navigation programs as well as the numerous technological resources used by JPL as a key player in the field In addition the text offers an analysis of navigation theory application in recent missions with the goal of showing students the relationship between navigation theory and the real world orchestration of mission operations      *Deep Space Optical Communications* Hamid Hemmati,2006-06-05 A quarter century of research into deep space and near Earth optical communications This book captures a quarter century of research and development in deep space optical communications from the Jet Propulsion Laboratory JPL Additionally it presents findings from other optical communications research groups from around the world for a full perspective Readers are brought up to date with the latest developments in optical communications technology as

well as the state of the art in component and subsystem technologies fundamental limitations and approaches to develop and fully exploit new technologies The book explores the unique requirements and technologies for deep space optical communications including Technology overview link and system design drivers Atmospheric transmission propagation and reception issues Flight and ground terminal architecture and subsystems Future prospects and applications including navigational tracking and light science This is the first book to specifically address deep space optical communications With an increasing demand for data from planetary spacecraft and other sources it is essential reading for all optical communications telecommunications and system engineers as well as technical managers in the aerospace industry It is also recommended for graduate students interested in deep space communications

**Autonomous Software-Defined Radio Receivers for Deep Space Applications** Jon Hamkins, Marvin K. Simon, 2006-10-13 This book introduces the reader to the concept of an autonomous software defined radio SDR receiver Each distinct aspect of the design of the receiver is treated in a separate chapter written by one or more leading innovators in the field Chapters begin with a problem statement and then offer a full mathematical derivation of an appropriate solution a decision metric or loop structure as appropriate and performance results

**Radiometric Tracking Techniques for Deep-Space Navigation** Catherine L. Thornton, James S. Border, 2005-03-04 Radiometric Tracking Techniques for Deep Space Navigation focuses on a broad array of technologies and concepts developed over the last four decades to support radio navigation on interplanetary spacecraft In addition to an overview of Earth based radio navigation techniques the book includes a simplified conceptual presentation of each radiometric measurement type its information content and the expected measurement accuracy The methods described for both acquiring and calibrating radiometric measurements also provide a robust system to support guidance and navigation for future robotic space exploration

**Bandwidth-Efficient Digital Modulation with Application to Deep Space Communications** Marvin K. Simon, 2005-03-04 An important look at bandwidth efficient modulations with applications to today's Space program Based on research and results obtained at the California Institute of Technology's Jet Propulsion Laboratory this timely book defines describes and then delineates the performance power and bandwidth of digital communication systems that incorporate a wide variety of bandwidth efficient modulations appropriate for the design and implementation of space communications systems The author compares the performance of these systems in the presence of a number of practical non ideal transmitter and receiver characteristics such as modulator and phase imbalance imperfect carrier synchronization and transmitter nonlinearity Although the material focuses on the deep space applications developed at the Jet Propulsion Laboratory the presentation is sufficiently broad as to be applicable to a host of other applications dealing with RF communications An important contribution to the scientific literature Bandwidth Efficient Digital Modulation with Application to Deep Space Communications was commissioned by the JPL Deep Space Communications and Navigation System Center of Excellence highlights many NASA funded technical contributions pertaining to deep space communications

systems is a part of the prestigious Deep Space Communications and Navigation Series The Deep Space Communications and Navigation Series is authored by scientists and engineers with extensive experience in astronautics communications and related fields It lays the foundation for innovation in the areas of deep space navigation and communications by disseminating state of the art knowledge in key technologies Low-Energy Lunar Trajectory Design Jeffrey S. Parker, Rodney L. Anderson, 2014-06-25 Based on years of research conducted at the NASA Jet Propulsion Laboratory Low Energy Lunar Trajectory Design provides high level information to mission managers and detailed information to mission designers about low energy transfers between Earth and the moon The book answers high level questions about the availability and performance of such transfers in any given month and year Low energy lunar transfers are compared with various other types of transfers and placed within the context of historical missions Using this book designers may reconstruct any transfer described therein as well as design similar transfers with particular design parameters An Appendix Locating the Lagrange Points and a useful list of terms and constants completes this technical reference Surveys thousands of possible trajectories that may be used to transfer spacecraft between Earth and the moon including transfers to lunar libration orbits low lunar orbits and the lunar surface Provides information about the methods models and tools used to design low energy lunar transfers Includes discussion about the variations of these transfers from one month to the next and the important operational aspects of implementing a low energy lunar transfer Additional discussions address navigation station keeping and spacecraft systems issues Coupled-Oscillator Based Active-Array Antennas Ronald J. Pogorzelski, Apostolos Georgiadis, 2012-07-18 Describing an innovative approach to phased array control in antenna design This book explores in detail phased array antennas that use coupled oscillator arrays an arrangement featuring a remarkably simple beam steering control system and a major reduction in complexity compared with traditional methods of phased array control It brings together in one convenient self contained volume the many salient research results obtained over the past ten to fifteen years in laboratories around the world including the California Institute of Technology s Jet Propulsion Laboratory The authors examine the underlying theoretical framework of coupled oscillator systems clearly explaining the linear and nonlinear formalisms used in the development of coupled oscillator arrays while introducing a variety of state of the art methodologies design solutions and tools for applying this control scheme Readers will find Numerous implementation examples of coupled oscillator array prototypes A continuum model that permits application of diffusion theory to the analysis of phase dynamics A demonstration of the array behavior through experimental results that validate the linearized theory Examples of how incorporating coupling delay restores causality including the latest published results Guidance on how to accurately analyze and optimize coupled oscillator arrays using modern simulation tools A review of current developments including the design of compact couple oscillator array antennas Complete with 150 diagrams and photographs Coupled Oscillator Based Active Array Antennas is a highly useful tutorial for antenna designers and a valuable

reference for researchers and engineers wishing to learn about this cutting edge technology      *Spaceborne Antennas for Planetary Exploration* William A. Imbriale, 2006-08-04 JPL spacecraft antennas from the first Explorer satellite in 1958 to current R D Spaceborne Antennas for Planetary Exploration covers the development of Jet Propulsion Laboratory JPL spacecraft antennas beginning with the first Explorer satellite in 1958 through current research and development activities aimed at future missions Readers follow the evolution of all the new designs and technological innovations that were developed to meet the growing demands of deep space exploration The book focuses on the radio frequency design and performance of antennas but covers environmental and mechanical considerations as well There is additionally a thorough treatment of all the analytical and measurement techniques used in design and performance assessment Each chapter is written by one or more leading experts in the field of antenna technology The presentation of the history and technology of spaceborne antennas is aided by several features Photographs and drawings of JPL spacecraft Illustrations to help readers visualize concepts and designs Tables highlighting and comparing the performance of the antennas Bibliographies at the end of each chapter leading to a variety of primary and secondary source material This book complements Large Antennas of the Deep Space Network Wiley 2002 which surveys the ground antennas covered in support of spacecraft Together these two books completely cover all JPL antenna technology in keeping with the JPL Deep Space Communications and Navigation Series mission to capture and present the many innovations in deep space telecommunications over the past decades This book is a fascinating and informative read for all individuals working in or interested in deep space telecommunications

**The Dawn Mission to Minor Planets 4 Vesta and 1 Ceres** Christopher Russell, Carol Raymond, 2012-07-27 Dawn is the first mission to orbit a main belt asteroid and the first scientific mission to use ion propulsion Major objectives of this mission include mapping of the surfaces of 4 Vesta and 1 Ceres determining its topography from stereo measurements determining its mineralogy measuring its elemental composition and obtaining gravity data This book describes the Dawn mission its exploration and scientific objectives the instruments that accomplish those objectives the operations plan and the education and outreach plan It is directed to those studying asteroids and the evolution of the solar system This volume will be a valuable reference for anyone who uses data from the instruments of the DAWN mission Previously published in Space Science Reviews Vol 163 1 4 2012      **China Satellite Navigation Conference (CSNC) 2017 Proceedings: Volume III**

Jiadong Sun, Jingnan Liu, Yuanxi Yang, Shiwei Fan, Wenxian Yu, 2017-05-02 These proceedings present selected research papers from CSNC2017 held during 23th 25th May in Shanghai China The theme of CSNC2017 is Positioning Connecting All These papers discuss the technologies and applications of the Global Navigation Satellite System GNSS and the latest progress made in the China BeiDou System BDS especially They are divided into 12 topics to match the corresponding sessions in CSNC2017 which broadly covered key topics in GNSS Readers can learn about the BDS and keep abreast of the latest advances in GNSS techniques and applications      Sciences of Geodesy - II Guochang Xu, 2012-08-01 This series of



reference books describes the sciences of different fields in and around geodesy Each chapter is written by experts in the respective fields and covers an individual field and describes the history theory the objective the technology and the development the highlight of the research the applications the problems as well as future directions Contents of Volume II include Geodetic LEO Satellite Missions Satellite Altimetry Airborne Lidar GNSS Software Receiver Geodetic Boundary Problem GPS and INS VLBI Geodetic Reference Systems Spectral Analysis Earth Tide and Ocean Loading Tide Remote Sensing Photogrammetry Occultation Geopotential Determination Geoid Determination Local Gravity Field Geopotential Determination Magnet Field Mobile Mapping General Relativity Wide area Precise Positioning etc      **China Satellite**

**Navigation Conference (CSNC) 2013 Proceedings** Jiadong Sun,Wenhai Jiao,Haitao Wu,Chuang Shi,2014-07-08 China Satellite Navigation Conference CSNC 2013 Proceedings presents selected research papers from CSNC2013 held on 15 17 May in Wuhan China The theme of CSNC2013 is BeiDou Application Opportunities and Challenges These papers discuss the technologies and applications of the Global Navigation Satellite System GNSS and the latest progress made in the China BeiDou system especially They are divided into 9 topics to match the corresponding sessions in CSNC2013 which broadly covered key topics in GNSS Readers can learn about the BeiDou system and keep abreast of the latest advances in GNSS techniques and applications SUN Jiadong is the Chief Designer of the Compass BeiDou system and the Academician of Chinese Academy of Sciences CAS JIAO Wenhai is a researcher at China Satellite Navigation Office WU Haitao is a professor at Navigation Headquarters CAS SHI Chuang is a professor at Wuhan University      **100 Years of**

**Chronogeometroynamics: The Status of the Einstein's Theory of Gravitation in Its Centennial Year** Lorenzo Iorio,Elias C. Vagenas,2018-07-10 This book is a printed edition of the Special Issue 100 Years of Chronogeometroynamics the Status of the Einstein s Theory of Gravitation in Its Centennial Year that was published in Universe      *Gravity: Where Do We Stand?* Roberto Peron,Monica Colpi,Vittorio Gorini,Ugo Moschella,2015-12-14 This book presents an overview of the current understanding of gravitation with a focus on the current efforts to test its theory especially general relativity It shows how the quest for a deeper theory which would possibly incorporate gravity in the quantum realm is more than ever an open field The majority of the contributions deals with the manifold facets of experimental gravitation but the book goes beyond this and covers a broad range of subjects from the foundations of gravitational theories to astrophysics and cosmology The book is divided into three parts The first part deals with foundations and Solar System tests An introductory pedagogical chapter reviews first Newtonian gravitational theory special relativity the equivalence principle and the basics of general relativity Then it focuses on approximation methods mainly the post Newtonian formalism and the relaxed Einstein equations with a discussion on how they are used in treating experimental tests and in the problem of generation and detection of gravitational waves Following this is a set of chapters describing the most recent experiments techniques and observations on the testing of gravity theories in the laboratory around the Earth and in the Solar System The second part is dedicated to

astrophysical topics deeply linked with the study of gravitation namely binary pulsars and the perspective of direct detection of gravitational waves These cases are paradigmatic in that the gravitational signals act at the same time as messengers helping us to understand the properties of important and wide classes of astrophysical objects The third part explores the many open issues in current knowledge of gravitation machinery especially related to astrophysical and cosmological problems and the way possible solutions to them impact the quest for a quantum theory of gravitation and unified theory Included is a selection of the many possible paths giving a hint to the subtleties one is called upon Whenever possible a close link to observational constraints and possible experimental tests is provided In selecting the topics of the various contributions particular care has been devoted to ensure their fit in a coherent representation of our understanding of gravitational phenomena The book is aimed at graduate level students and will form a valuable reference for those working in the field

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