Asteroid Retrieval Feasibility Study

Perlombongan asteroid adalah eksploitasi bahan mentah dari asteroid dan planet kecil lain, termasuk objek bumi dekat. Berdasarkan rizab terestrial yang diketahui, dan penggunaan yang semakin meningkat di kedua-dua negara maju dan membangun, unsur-unsur penting yang diperlukan untuk industri moden dan pengeluaran makanan boleh habis di Bumi dalam tempoh 50 hingga 60 tahun. Sebagai tindak balas, telah dicadangkan bahawa platinum, kobalt dan unsur-unsur berharga lain dari asteroid boleh dilombong dan dihantar ke Bumi untuk keuntungan, digunakan untuk membina satelit tenaga suria dan habitat ruang, dan air yang diproses dari ais untuk mengisi bahan api yang mengorbit depo propelan. Melangkaui Bima Sakti, terdapat sekurang-kurangnya 2 trilion galaksi lain di alam semesta yang dapat dilihat. Penjajahan ruang secara kasar boleh dikatakan mungkin apabila kaedah penjajahan ruang yang diperlukan cukup murah untuk memenuhi dana kumulatif yang telah dikumpulkan untuk tujuan itu, di samping keuntungandianggarkan dari penggunaan ruang komersial. Perjalanan intergalaktik sama ada perlu melibatkan pelayaran yang berjuta-juta tahun, atau mungkin lebih cepat daripada kaedah pendorong cahaya berdasarkan fizik spekulatif, seperti pemacu Alcubierre. Walau bagaimanapun, tidak ada alasan saintifik untuk menyatakan bahawa perjalanan intergalactic tidak mungkin pada dasarnya. Pemikiran manusia yang dimuat naik atau AI boleh dihantar ke galaksi lain dengan harapan beberapa kepintaran akan menerima dan mengaktifkannya.

This book analyzes the commercial space activities and commercialization processes of the last fifteen years and maps the future challenges that NewSpace companies will face developing commercial space markets. What is new and what has happened in these markets up till now? Is there a business case for private companies for commercial space? What are the targeted commercial space markets? Who are the future customers for commercial space transportation markets? How can NewSpace companies attract investors? Can we learn lessons from traditional space industries or other companies in other areas? In what way have the last fifteen years made a difference in the evolution of space markets? Is there a future for in-situ resource mining, space debris services, in-orbit satellite servicing and sub-orbital transportation? What are the lessons learned from ISS commercialization? In addition the reader will find a synopsis of several space transportation programs, commercial space markets, future Moon and Mars missions, in-situ resource exploitation concepts, space debris mitigation projects and sub-orbital commercial markets. Major lessons learned are identified, related to the attraction of first time customers and long term R&D funding, managing technological and market risks and developing new markets and applications.

The Earth-Moon neighborhood is the scene of a large variety of applications that concern asteroids, lunar exploration and space debris in Earth orbit. In particular, recent efforts by the scientific community have focused on the possibility of extending the human operations beyond the radiation belts; of exploiting in-situ resources, either on the lunar surface or on asteroids retrieved to the vicinity of the Earth; and of mitigating the space debris concern by taking advantage of the lunar perturbation. The characteristic dynamics in the cislunar space represents an opportunity for the mission designer, but also a challenge in terms of theoretical understanding and operational control. This Research Topic covers the Earth-Moon dynamics in its complexity and allure, considering the most relevant aspects for both natural and artificial objects, in order to get a new comprehension of the dynamics at stake along with the operational procedures that can handle it.

A unique, wide-ranging examination of asteroid exploration and our future in space Human travel into space is an enormously expensive and unforgiving endeavor. So why go? In this accessible and authoritative book, astrophysicist Martin Elvis argues that the answer is asteroid exploration, for the strong motives of love, fear, and greed. Elvis’s personal motivation is one of scientific love—asteroid investigations may teach us about the composition of the solar system and the origins of life. A more compelling reason may be fear—of a dinosaur killer–sized asteroid hitting our planet. Finally, Elvis maintains, we should consider greed: asteroids likely hold vast riches, such as large platinum deposits, and mining them could provide both a new industry and a funding source for bolder space exploration. Elvis explains how each motive can be satisfied, and how they help one another. From the origins of life, to “space billiards,” and space sports, Elvis looks at how asteroids may be used in the not-so-distant future.

The Space Race was a rivalry of the twentieth century between two great Super Powers in the Cold War, the Soviet Union (USSR) and the United States (USA), aimed at achieving the highest positions in space flight capabilities. It derives from the ballistic missile-based nuclear arms race that followed the Second World War. The technological advantage needed to quickly achieve milestones in space flight was considered essential for national security and combined with the symbolism and ideology to time. The Space Race led to pioneering efforts to launch artificial satellites, unmanned space probes to the Moon, Venus and Mars, and human space flights in low Earth orbit and the Moon.

Over the past decade, asteroids have come to the forefront of planetary science. Scientists across broad disciplines are increasingly recognizing that understanding asteroids is essential to discerning the basic processes of planetary formation, including how their current distribution bespeaks our solar system’s cataclysmic past. For explorers, the nearest asteroids beckon as the most accessible milestones in interplanetary space, offering spaceflight destinations easier to reach than the lunar surface. For futurists, the prospects of asteroids as commercial resources tantalize as a twenty-first-century gold rush, albeit with far greater challenges than faced by nineteenth-century pioneers. For humanity, it is the realization that asteroids matter. It is not a question of if—but when—the next major impact will occur. While the disaster probabilities are thankfully small, fully cataloging and characterizing the potentially hazardous asteroid population remains unfinished business. Asteroids IV sets the latest scientific foundation upon which all these topics and more will be built upon for the future. Nearly 150 international authorities through more than 40 chapters convey the definitive state of the field by detailing our current

astronomical, compositional, geological, and geophysical knowledge of asteroids, as well as their unique physical processes and interrelationships with comets and meteorites. Most importantly, this volume outlines the outstanding questions that will focus and drive researchers and students of all ages toward new advances in the coming decade and beyond.

This contributed volume addresses the future development of space law in light of our ever-growing space activities, the multiplicity of new space actors and the challenges posed by novel space technologies. Unlike existing space law literature, it sets its sights on the future, envisaging how space law could and should evolve in coming decades. Written by experienced professors, academics and practitioners in the field, this edited volume constitutes a valuable tool for understanding the current state of space law, the challenges it is called upon to address and the new phase it is about to enter. In addition, this book initiates a discussion de lege ferenda, addressing the letter and spirit of space law in the world of modern and future space activities. These papers were presented at “The Space Treaties at Crossroads: Considerations de lege ferenda,” held on August 28 to 29, 2015, in Athens, Greece. The conference was jointly organized by the National and Kapodistrian University of Athens and the Institute of Air and Space Law of McGill University

Near Earth objects (NEOs) have the potential to cause significant damage on Earth. In December 2018, an asteroid exploded in the upper atmosphere over the Bering Sea (western Pacific Ocean) with the explosive force of nearly 10 times that of the Hiroshima bomb. While the frequency of NEO impacts rises in inverse proportion to their sizes, it is still critical to monitor NEO activity in order to prepare defenses for these rare but dangerous threats. Currently, NASA funds a network of ground-based telescopes and a single, soon-to-expire space-based asset to detect and track large asteroids that could cause major damage if they struck Earth. This asset is crucial to NEO tracking as thermal-infrared detection and tracking of asteroids can only be accomplished on a space-based platform. Finding Hazardous Asteroids Using Infrared and Visible Wavelength Telescopes explores the advantages and disadvantages of infrared (IR) technology and visible wavelength observations of NEOs. This report reviews the techniques that could be used to obtain NEO sizes from an infrared spectrum and delineate the associated errors in determining the size. It also evaluates the strengths and weaknesses of these techniques and recommends the most valid techniques that give reproducible results with quantifiable errors.

Asteroids IVUniversity of Arizona Press

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Asteroit madencili?i, hammaddelerin asteroitler ve Dünya'ya yak?n nesneler de dahil olmak üzere di?er küçük gezegenlerden kullan?lmas?d?r. Bilinen karasal rezervlere ve hem geli?mi? hem de geli?mekte olan ülkelerdeki artan tüketime dayanarak, modern sanayi ve g?da üretimi içinihtiyaç duyulan temel ö?eler 50 ila 60 y?l içinde Dünya'da tükenebilir. Buna cevaben, asteroitlerden platin, kobalt ve di?er de?erli elementlerin madencilik yap?p, kar amac?yla, güne? enerjisi uydular? ve uzay habitatlar?n? ve buzdan yak?t ikmali yapan yekpare depolara kadar i?lenen suyun yap?m?nda kullan?labilecek ?ekilde madencilik yap?p, Dünya'ya gönderilebilece?i önerildi. Samanyolu'nun ötesine bakarken, gözlemlenebilir evrende en az 2 trilyon di?er galaksi var. Alan kolonizasyonunun, gerekli alan kolonizasyon yöntemleri, mekan?n ticari kullan?m?ndan elde edilen tahmini karlara ek olarak, amaç için toplanan kümülatif fonlar? kar??layacak kadar ucuz hale geldi?inde kabaca mümkün oldu?u söylenebilir. Galaksiler aras? yolculuk, milyonlarca y?l süren yolculuklar veya Alcubierre sürü?ü gibi spekülatif fizi?e dayanan hafif iti? yönteminden daha h?zl? bir olas?l?k içermelidir. Bununla birlikte, galaksiler aras? seyahatin prensipte imkans?z oldu?unu belirtmenin bilimsel bir nedeni yoktur. Yüklenen insan zihni veya AI, baz? zekan?n onlar? al?p aktive etmesi umuduyla di?er galaksilere bula?abilir.

In Robotic Exploration of the Solar System, Paolo Ulivi and David Harland provide a comprehensive account of the design and management of deep-space missions, the spacecraft involved – some flown, others not – their instruments, and their scientific results. This fourth volume in the series covers the period 2004 to the present day and features: coverage of the Rosetta and Curiosity missions up to the end of 2013 coverage of Mars missions since 2005, including the Mars Reconnaissance Orbiter, Phoenix and Fobos-Grunt, plus a description of plans for future robotic exploration of the Red Planet coverage of all planetary missions launched between 2004 and 2013, including the Deep Impact cometary mission, the MESSENGER Mercury orbiter, the New Horizons Pluto flyby and the Juno Jupiter orbiter the first complete description of the Chinese Chang’e 2 asteroid flyby mission ever published extensive coverage of future missions, including the European BepiColombo Mercury orbiter and international plans to revisit the most interesting moons of Jupiter and Saturn.

In 2013 several scientific activities have been devoted to mathematical researches for the study of planet Earth. The current volume presents a selection of the highly topical issues presented at the workshop “Mathematical Models and Methods for Planet Earth”, held in Roma (Italy), in May 2013. The fields of interest span from impacts of dangerous asteroids to the safeguard from space debris, from climatic changes to monitoring geological events, from the study of tumor growth to sociological problems. In all these fields the mathematical studies play a relevant role as a tool for the analysis of specific topics and as an ingredient of multidisciplinary problems. To investigate these problems we will see many different mathematical tools at work: just to mention some, stochastic processes, PDE, normal forms, chaos theory.

This book provides answers to the questions of why human-kind should go into space, and on the relative roles of governments and markets in the evolution of the space economy. It adopts an interdisciplinary approach to answer those questions. Science and technology define the boundaries of what is possible. The realization of the possible depends on economic, institutional, and political factors. The book thus draws from many different academic areas such as physical science, astronomy, astronautics, political science, economics, sociology, cultural studies, and

history. In the literature, the space economy has been analyzed using different approaches from science and technology to the effects of public expenditures on economic growth and to medium term effects on productivity and growth. This book brings all these aspects together following the evolutionary theory of economic change. It studies processes that transform the economy through the interactions among diverse economic agents, governments, and the extra-systemic environment in which governments operate. Its historical part helps to better understand motivations and constraints - technical, political, and economical - that shaped the growth of the space economy. In the medium term, global issues - such as population changes, critical or limited natural resources, and environmental damages – and technological innovations are the main drivers for the evolution of the space economy beyond Earth orbit. In universities, this book can be used: as a reference by historians of astronautics; for researchers in the field of astronautics, international political economy, and legal issues related to the space economy. In think tanks and public institutions, both national and international, this book provides an input to the ongoing debate on the collaboration among space agencies and the role of private companies in the development of the space economy. Finally, this book will help the educated general public to orient himself in the forest of stimuli, news, and solicitations to which he is daily subjected by the media, television and radio, and to react in less passive ways to those stimuli.

Asteroidbrytning är utnyttjande av råmaterial från asteroider och andra mindre planeter, inklusive föremål nära jorden. Baserat på kända markreserver och den växande konsumtionen i både utvecklade länder och utvecklingsländer kan nyckelelement som behövs förmodern industri och livsmedelsproduktion uttömmas på jorden inom 50 till 60 år. Som svar har det föreslagits att platina, kobolt och andra värdefulla element från asteroider kan brytas och skickas till jorden för vinst, används för att bygga solkraftsatelliter och rymdmiljöer, och vatten sombearbetas från is för att tanka kretsar kring drivmedelsdepåer. Ser man bortom Vintergatan finns det minst 2 biljoner andra galaxer i det observerbara universum. Rymdkolonisering kan grovt sägas vara möjlig när de nödvändiga metoderna för rymdkolonisering blir tillräckligt billiga för att möta dekumulativa medlen som har samlats in för ändamålet, utöver beräknade vinster från kommersiell användning av rymden. Intergalaktiska resor måste antingen innebära resor som varar miljoner år, eller en möjligare snabbare än lätt framdrivningsmetod baserad på spekulativ fysik, till exempel Alcubierre-enheten. Det finns dock inga vetenskapliga skäl för att säga att intergalaktiska resor i princip är omöjliga. Uppladdade mänskliga sinnen eller AI kan överföras till andra galaxer ihopp om att någon intelligens där skulle få och aktivera dem.

Complete story of the human lunar experience, presenting many interesting but little-known events in lunar science for the first time.

In recent years of the 21st Century the author of this book and other scientists as well, have instigated and described many new ideas, researches, theories, macro-projects, USA and other countries patented concepts, speculative macro-engineering ideas, projects and other general innovations in technology and environment change. In aerospace these include air catapult transportation, hypersonic ground electric AB engine, protection of the Earth from asteroids and delivery of asteroids to the Earth, re-entry space apparatus to Earth, airborne wind turbines, electronic wind generator and propulsion, long distance shells, new self-propelled penetration bomb, inexpensive mini thermonuclear reactor, etc. In technology these include new ideas and innovation in space sciences and Earth technologies: Underground explosion nuclear energy; Electron hydro electric generator; Electron super speed hydro propulsion; Electric theory of tornado; Protection from tornado; and so on.

Argues that the depletion of the earth's natural resources, as well as the overpopulation of the planet, are solvable problems by using technology that already exists or will exist in the near future

Aunque sus raíces se encuentran en las primeras tecnologías de cohetes ylas tensiones internacionales que siguieron a la Segunda Guerra Mundial, la carrera espacial comenzó después del lanzamiento soviético del Sputnik 1 el 4 de octubre de 1957. La carrera espacial se convirtió en una parte importante de la rivalidad cultural y tecnológica entre URSS y Estados Unidos durante la Guerra Fría. La exploración espacial moderna está llegando a áreas increíbles. Marte es el punto focal de la exploración espacial. A largo plazo, existen planes tentativos para misiones orbitales tripuladas y de aterrizaje a la Luna y Marte, estableciendo puestos de avanzada científica que luego darán paso a asentamientos permanentes y autosuficientes. La exploración adicional implicará potencialmente expediciones y asentamientos en otros planetas y sus lunas, así como el establecimientode puestos avanzados de minería y abastecimiento de combustible, particularmente en el cinturón de asteroides. La exploración física fuera del sistema solar será robótica en el futuro previsible.

The book speaks to the need for a regulatory framework with regards to space resource utilization. In doing so, significant elements of the subject matter have been explored, taking into account the different phases of a space mission and the perspectives of the various actors and participants in the space arena. The book tackles the subject matter from a number of angles. An analysis of the current national and international governance frameworks is performed, with regards to resource extraction and utilization in space. The view of established and emerging space nations is analyzed next, specifically with extraction and utilization in mind, and in light of the new United State (US) Commercial Space Launch Competitiveness Act (CSLCA) of 2015. A brief analysis of the various budgets allocated to space exploration is given.

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Penambangan asteroid adalah eksploitasi bahan baku dari asteroid dan planet kecil lainnya, termasuk benda-benda dekat Bumi. Berdasarkan cadangan terestrial yang diketahui, dan meningkatnya konsumsi di negara maju dan berkembang, elemen kunci yang dibutuhkan untuk industri modern dan produksi pangan dapat habis di Bumi dalam 50 hingga 60 tahun. Sebagai tanggapan, telah disarankan bahwa platinum, kobalt dan elemen berharga lainnya dari asteroid dapat ditambang dan dikirim ke Bumi untukkeuntungan, digunakan untuk membangun satelit tenaga surya dan habitat ruang angkasa, dan air yang diolah dari es untuk mengisi bahan bakar yang mengorbit depot propelan yang mengorbit. Melihat melampaui Bima Sakti, setidaknya ada 2 triliun galaksi lain di alam semesta yang dapat diamati. Kolonisasi ruang secara kasar dapat dikatakan dimungkinkan ketika metode kolonisasi ruang yang diperlukan menjadi cukup murah untuk memenuhi dana kumulatif yang telah dikumpulkan untuk tujuan tersebut, disamping perkiraan keuntungan dari penggunaan ruang secara komersial. Perjalanan intergalaksi harus melibatkan perjalanan yang berlangsung jutaan tahun, atau mungkin

lebih cepat daripada metode propulsi ringan berdasarkan fisika spekulatif, seperti drive Alcubierre. Namun, tidak ada alasan ilmiah untuk menyatakan bahwa perjalanan intergalaksi pada prinsipnya tidak mungkin. Pikiran manusia yang diunggah atau AI dapat ditransmisikan ke galaksi lain dengan harapan sejumlah intelijen di sana akan menerima dan mengaktifkannya.

This book produces convincing evidence that exploiting the potential of space could help solve many environmental and social issues affecting our planet, such as pollution, overcrowding, resource depletion and conflicts, economic inequality, social unrest, economic instability and unemployment. It also touches on the legal problems that will be encountered with the implementation of the new technologies and new laws that will need to be enacted and new organizations that will need to be formed to deal with these changes. This proposition for a space economy is not science fiction, but well within the remit of current or under development technologies. Numerous technologies are described and put together to form a coherent and feasible road map that, if implemented, could lead humankind towards a brighter future.

At last, here is a book peering behind the veil of Congressional politics which force NASA to do the bidding of regional interests that cripple the nation's capabilities in both exploring outer space and exploiting its enormous economic potential. Presenting the opinions of astronauts, prominent rocket scientists and space policy analysts while also revealing unpublicized studies conducted by NASA, industry and universities, The Plundering of NASA: An Expose combines into one book many of the facts the major media have either ignored or not discovered. Expert sources explain modern and economically practical solutions that can allow NASA to exceed its former Apollo glory within its current budget. In short, the book relates how honest misconceptions, greed, and an outdated faction within NASA itself cause our nation to get less for its space agency tax dollars than it could and should.

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There are few industries in today’s world as dynamic and dramatically changing as the space sector, with new ventures and initiatives being announced on a daily basis. As well as emerging countries improving their launching and manufacturing capabilities, private actors are beginning to join public bodies in the space race, and participating in what is frequently being referred to as the new space era. With fantastic opportunities arising for business and economics, this book provides a comprehensive overview of the space sector, exploring recent initiatives, and the most important areas of investment in the industry, including emerging fields of activities such as asteroid mining and space tourism. It also addresses traditional and non-traditional security issues in the sector, together with discussing their legal implications. This interdisciplinary book provides insights for practitioners and researchers alike, particularly those involved in technology and innovation management, emerging markets, international relations, and security studies.

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Several project teams from NASA, ESA and other organizations have investigated the possibility of establishing a colony in orbit. They found that the Moon and near-Earth asteroids have enough materials available, that solar energy is readily available in large quantities. The advantages of this system are its proximity to the Earth and its lower escape velocity, which facilitates the exchange of goods and services.

La minería de asteroides es la explotación de materias primas de asteroides y otros planetas menores, incluidos objetos cercanos a la Tierra. Según las reservas terrestres conocidas y el consumo cada vez mayor en los países desarrollados y en desarrollo, los elementos clave necesariospara la industria moderna y la producción de alimentos podrían agotarseen la Tierra dentro de 50 a 60 años. En respuesta, se ha sugerido que el platino, el cobalto y otros elementos valiosos de los asteroides pueden extraerse y enviarse a la Tierra con fines de lucro, usarse para construir satélites de energía solar y hábitats espaciales, y el agua procesada a partir de hielo para repostar en depósitos de propulsores en órbita. Mirando más allá de la Vía Láctea, hay al menos 2 billones de otras galaxias en el universo observable. Se puede decir que la colonización espacial es posible cuando los métodos necesarios de colonización espacial se vuelven lo suficientemente baratos como para satisfacer los fondos acumulados que se han reunido para ese propósito, además de las ganancias estimadas deluso comercial del espacio. Los viajes intergalácticos tendrían que incluir viajes que durarían millones de años, o un posible método más rápido que el de propulsión ligera basado en la física especulativa, como el manejo de Alcubierre. Sin embargo, no hay razones científicas para afirmar que el viaje intergaláctico es imposible en principio. Las mentes humanas o IA cargadas pueden transmitirse a otras galaxias con la esperanza de que alguna inteligencia allí las reciba y las active.

A different kind of politics for a new kind of society--beyond work, scarcity and capitalism In the twenty-first century, new technologies should liberate us from work. Automation, rather than undermining an economy built on full employment, is instead the path to a world of liberty, luxury and happiness—for everyone. Technological advance will reduce the value of commodities—food, healthcare and housing—towards zero. Improvements in renewable energies will make fossil fuels a thing of the past. Asteroids will be mined for essential minerals. Genetic editing and synthetic biology will prolong life, virtually eliminate disease and provide meat without animals. New horizons beckon. In Fully Automated Luxury Communism, Aaron Bastani conjures a vision of extraordinary hope, showing how we move to energy abundance, feed a world of 9 billion, overcome work, transcend the

limits of biology, and establish meaningful freedom for everyone. Rather than a final destination, such a society merely heralds the real beginning of history.
Although its roots lie in early rocket technologies and the international tensions that followed World War II, the space race began after the Soviet launch of Sputnik 1 on October 4, 1957. The space race became an important part of the cultural and technological rivalry between the USSR and the United States during the Cold War. Modern space exploration is reaching unbelievable areas. Mars is the focal point of space exploration. In the long term, there are tentative plans for manned orbital and landing missions to the Moon and Mars, establishing scientific outposts that will then give way to permanent and self-sufficient settlements. Additional exploration will potentially involve expeditions and settlements on other planets and their moons, as well as the establishment of mining and fueling outposts, particularly in the asteroid belt. Physical exploration outside the solar system will be robotic in the foreseeable future.
Varios equipos de proyecto de la NASA, la ESA y otras organizaciones han investigado la posibilidad de establecer una colonia en órbita. Descubrieron que la Luna y los asteroides cercanos a la Tierra tienen suficientes materiales disponibles, que la energía solar está fácilmentedisponible en grandes cantidades. Las ventajas de este sistema son su proximidad a la Tierra y su menor velocidad de escape, lo que facilita el intercambio de bienes y servicios.
The Earth has limited material and energy resources while these resources in space are virtually unlimited. Further development of humanity will require going beyond our planet and exploring of extraterrestrial resources and sources of unlimited power. Thus far, all missions to asteroids have been motivated by scientific exploration. However, given recent advancements in various space technologies, mining asteroids for resources is becoming ever more feasible. A significant portion of asteroids value is derived from their location; the required resources do not need to be lifted at a great expense from the surface of the Earth. Resources derived from Asteroid not only can be brought back to Earth but could also be used to sustain human exploration of space and permanent settlements in space. This book investigates asteroids' prospective energy and material resources. It is a collection of topics related to asteroid exploration, and utilization. It presents past and future technologies and solutions to old problems that could become reality in our life time. The book therefore is a great source of condensed information for specialists involved in current and impending asteroid-related activities and a good starting point for space researchers, inventors, technologists and potential investors. Written for researchers, engineers, and businessmen interested in asteroids' exploration and exploitation.
Keywords: Asteroids, Asteroid exploration, Asteroid exploitation, Energy sources, Space Resources, Material Resources, In-Situ Resource Utilization, Mining
Impacts by asteroids or comets on Earth may lead to natural disasters of catastrophic dimensions. This book addresses legal and policy aspects of ‘planetary defence’ activities by space agencies and other actors aiming at the prediction and mitigation of Near-Earth Objects (NEOs).