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BOOK REVIEWS

Groupoids inverse semigroups and their operator algebras by Alan L. T. Peterson, Birkhauser Verlag AG, Klosterberg 23, CH-4010, Basel, Switzerland, 1999, pp. 296, sFr. 98.

As the title indicates, the book under review focuses primarily on the inter-relationships between the notions of groupoids and inverse semigroups and the operator algebras associated with them.

The initial introductory chapter introduces the definitions of the two basic notions above and discusses (in a 'non-formal way', as the author himself says) the connections between them and their associated operator algebras, using the illuminating special case of the so-called Cuntz groupoid, the Cuntz semigroup and the Cuntz C*-algebra. The quickest definition of a groupoid is 'a small category with inverses'. An illuminating example is that of the fundamental groupoid of (homotopy classes of paths in) a topological space; thus composition is restricted, but there are inverses. The occurrence of quasicrystals and Penrose-tilings might be cited as reasons for the inadequacy of just groups to describe 'all possible symmetry in nature'.

Similarly, 'inverse semigroups' are a precise abstraction of 'partial bijections', and not surprisingly, they admit representations as classes of partial isometries in Hilbert space (rather than unitary operators, as in the case of groups). The second chapter discusses inverse-semigroups in detail and their natural 'left-regular representations' and the naturally associated (reduced as well as universal) C*-algebras (defined as the completions of the complex 'semigroup-algebras' with respect to appropriate norms, as in the case of groups). In order to discuss the representation theory properly, the author then goes on to discuss the classes of *r*-discrete groupoids, locally compact groupoids and finally Lie groupoids (as well as the important special cases of the holonomy and tangent groupoids).

The third chapter is primarily devoted to the representation theory of locally compact groupoids; and the book strives to strike an acceptable balance between wanting to give enough detail, and not wanting to get too entangled in a morass of detail, which is not too easy in a subject which is intrinsically fraught with various technical problems and complications. (For instance, unlike the group case, neither existence nor uniqueness of Haar measure is available in the general case.)

For this, the author uses the device of paying a lot of attention to the so-called *r*-discrete groupoids in which several potential problems either vanish or considerably diminish.

The final chapter is devoted to the problem of determining the representation theory of an inverse semigroup in terms of associated *r*-discrete groupoids. Using this machine, the author proves in the last section that the von Neumann algebra generated by the left-regular representation of an inverse semigroup S is amenable, if every maximal subgroup of S is amenable.

Finally, the book ends with an Appendix containing six sections, devoted to various topics treated in the body of the book.

The author has attempted the difficult task of presenting a technically demanding subject in as reader-friendly a manner as possible. For this, he certainly deserves a pat on the back. If the

reader finds the going a little rough and seemingly esoteric at times, (s)he might take solace in the fact that some of this material is what is needed to understand some of the meatiest examples relating to foliations or Penrose tilings, for instance, of Alain Connes' noncommutative geometry!

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Space flight mechanics 1997, Parts I and II, edited by Kathleen C. Howell *et al.*, Published for the American Astronautical Society by Univelt Inc., P. O. Box 28130, San Diego, California 92198, 1997, pp. 1168, $240.

The AAS/AIAA Space Flight Mechanics Conference is one of the most popular annual events in aerospace industry drawing scientists and engineers from all over the world. The seventh annual conference has drawn nearly 100 papers contributed by more than 200 authors. The proceedings published in two parts contains 71 full-length papers and 14 abstracts arranged under 14 sessions. Part I includes six sessions on: Orbital mechanics; Global positioning system; Attitude dynamics; Satellite theory; Navigation/tracking/debris; Multi-body dynamics/tethered systems. Similarly, part II holds 30 papers and 13 abstracts under eight sessions on: Trajectory design and optimization; Control theory; Mission design–near earth; Attitude determination and control; Mission design–Lunar and interplanetary; Dynamics and control of flexible structures; Orbital transfers, Orbit determination and filtering theory. Therefore, six sessions are devoted to spacecraft orbit, five to rigid and flexible spacecraft attitude motion, two to spacecraft missions and one to applied control theory. Majority of the technical papers are indicators of the latest developments in their respective field.

The orbital motion of heavenly bodies (i.e. planets around Sun and Moons of Earth, Jupiter, Mars, Saturn, etc) are studied ever since the days of Kepler for over 300 years. However, the dawn of space era and evolution of digital computers spurred the sharpening of time-tested method of orbital analysis and emergence of new techniques. During the space age that exceeds four decades (first artificial satellite was launched four decades ago), a large number of computer software was produced. A very systematic compilation and assessment of orbit analysis software (1998 updates) from leading software firms from USA and west European countries has been presented as a first paper of the conference (rightfully so). This paper is certainly very useful reference for researchers from space industry and faculty of academic institutions. The first session on orbital mechanics also contains six more papers on alternate representation of orbital elements, comparative study of asteroid collision avoidance on to the earth, closed loop guidance control of a satellite around a small primary, control of satellite constellations, analysis of halo orbits around Sun-Earth Lagrange points defined by the restricted three-body problem. The two-orbit control-related papers and the four-orbit analysis papers are only of academic interest and are unlikely to be used in the near future. On the other hand, the last five papers on orbit analysis and orbit control in the session on Satellite theory have significant practical utility. These papers represent the progress made on improving the

state-of-art on-orbit analysis and control. Similarly, orbit transfer problems are also studied extensively in the past, and a certain level of maturity is attained by early 80s. Two sessions on Trajectory design and optimization, and orbital transfers have five papers which are samples taken from low-key research topic being pursued at present. A paper on optimal maneuver sequence for recovery of satellite from the lower launch orbit (due to under-performance of the launch vehicles) to desired final orbit through a series of optimal orbit-raising maneuvers using the onboard fuel shows that a systematic study of maneuver can improve the emergency maneuvers conducted by the practising engineers from industry. In future too, there exists need for using fuel optimal transfers and hence the need for even more optimal solutions. With increase in space-activity-related permanent space stations and space colonies, soon satellite rendezvous will become important activity. A run-down of space rendezvous between two satellites in close by orbits is surveyed well by Thomas Carter. This author also presents a simplified approach for obtaining solution to terminal rendezvous described through linearized equations of motion. These papers indicate that there is still a little scope left for researching into orbital transfer problems.

Orbit determination of planets, moons, asteroids and other objects in space has been undertaken from time immemorial. Beginning of Kepler's era and satellite era saw quantum jump in the development of orbit/trajectory determination know-how. With the increase in the population of earth satellites (low to high altitude), and associated space debris, and also arrival of debris from outer space as a random event, navigation/tracking of satellites vis-à-vis debris (and their population count) has become need of the hour. The seven papers in the session on Navigation/Tracking/debris cover diverse spectrum of issues on the theme topic and are useful to researchers. The advent of Kalman Filter-based orbit-determination algorithms has helped in getting highly accurate estimates by rejecting the bios and systematic errors and smoothening of the effects due to noise in measurements. The last session on orbit determination for life-extended Topex/Poseidon mission, ill-conditioning of covariance matrices of the two-step nonlinear estimator for orbit navigation problem, and development of the modified detection filter for sensor faults (failures). However, three plus seven papers on two sessions on Mission design-near Earth and Lunar and interplanetary are likely to disappoint some readers.

The papers presented in five sessions on spacecraft attitude dynamics and control are well focussed (partly due to the fact that they deal with only one aspect of space flight mechanics). Out of six papers in the session on Attitude dynamics, there are two interesting papers on attitude motion with varying mass plus two papers on formulation of attitude motion. Even though lots of research has been done in this field, these four papers indicate that there is further scope for research. With the ground work on building the International space station under progress, academic research on tethered satellite dynamics and control has turned out to be of practical value in the near future. The last three papers on the session on Multi-body dynamics/tethered systems are representative of the continuing investigation on tethered satellite by the academia. Hopefully, such systems will be successful in future not withstanding the past failure of such mechanisms in orbit. Amongst the five sessions on satellite attitude dynamics and control, papers presented in the two sessions on Attitude determination and control and Dynamics and control of flexible structures are the most interesting ones and are also useful in the ongoing spacecraft development. The paper on airborne vehicle attitude determination using GPS is a fine example of spin-off of space technology to allied area of research.

The progress of mankind and its well being hinges on the success in the pursuit of excellence. Space mechanics is one such branch of technology where the frontier research and development can make a qualitative and quantitative difference. The proceedings of space flight mechanics over the years have maintained the tradition of bringing out the samples of state of the art. These proceedings certainly meets the expectations of the readers.

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The Case for Mars V, AAS Science and Technology Series, Vol. 97, edited by Penelope J. Boston, Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 93198, USA, 2000, pp. 552, $80.

The Case for Mars conferences were started as informal fora for the discussion of human exploration of Mars in 1981. Interest in Mars exploration grew steadily in the US in the Post-Apollo days. In 1969, the Space Task Group recommended the goal of a manned Mars Mission before the end of the 20th century, but was deferred. Again in 1989, the then US President Bush constituted the Space Exploration Initiative (SEI), which advocated for a program to send humans to Mars but the US Congress didn't approve. Interest in Mars was waning fast in 1993 when the Case for Mars V was organized to maintain a continuous dialogue amongst people to explore the red planet. The title volume is a collection of the papers of the proceedings of the *fifth* Case for Mars conference held in Boulder, Colorado. The 33 papers in the volume are covered in six chapters. It has two appendices. Relevant aspects like Planning for missions to Mars, Surface exploration and Human missions to Mars are covered in this issue.

The chapter on Planning for missions to Mars opens with an article on Mars colonization by the former NASA Chairman and a visionary, Dr. Thomas Paine (now deceased), as a gesture to honor him. This paper was published earlier in Vol. 86, AAS Science and Technology Series, 1996, which the present viewer had the privilege of reviewing for this journal. Unlike the Moon, Mars is too distant; going there is too risky and expensive. Americans landed man on the Moon essentially, 'to beat the Russians'. With the ending of the Cold War, the political justification of the case for Mars is over. A human mission to Mars will not be undertaken simply because it is a good idea from an international standpoint, says D. A. Day in his carefully crafted article, 'The third era of space exploration'. He cites several scientifically sound, nonpolitical justification in favor of going to Mars, but concludes with a pessimistic note that 'the only thing likely to change the situation and lead to an increase in human exploration efforts and a decision to send humans to Mars is the discovery by robotic probes of past or present life there. But such a discovery many never happen and, unless it does, the likelihood of a human mission to Mars in the near future is grim indeed'.

Is there a short-term economic and social justification for manned solar system exploration? The question is not answered. Rather, the article provides a rationale for initiating coordinated efforts by the exploration community to convince the government and the public. An-

other article examines the question, Is bone loss in space a problem? Skeletal mineral loss experienced by humans in micro-gravity has been considered as one of the primary medical concerns which could limit mission duration. After a careful analysis of the bone mass of the Russian cosmonauts who have flown on space station Mir for long periods, it is concluded however, that the bone loss occurs in space at a relatively slow rate compared to the time frame of planned mission operations to Mars.

The Space Exploration chapter describes an interesting proposal for a global reconnaissance of Mars using super-pressure balloons. The purpose of the so-called 'Mars aerial platform' mission is to generate high-resolution pictures of the Martian surface, map the global circulation of atmosphere, and examine the surface and sub-surface with ground penetrating radar, and other remote-sensing techniques, which are carried by balloons flying about 7 km over the Martian surface. The balloon probes could last for thousands of days producing an immense amount of data. Other issues dealt in this section include identification of a preliminary site list for Mars Exobiological exploration, a 'jumper' having possibility to make jumps over the natural obstacles of the rugged Mars surface, systems for Mars Extravehicular Mobility Unit (or space suit) design, and over-the-horizon communications on Mars via HF radio propagation.

Novel transportation concepts have been proposed to save propellants during the return journey from Mars. The idea of magnetobraking to dissipate hyperbolic excess velocity for Mars return vehicles has been proposed. The Earth's magnetic field produces a force on electric current in the tether deployed from the spacecraft, which can be used to brake the spacecraft speed without expending the reaction mass. Another concept makes use of the liquefied inert gases from the Martian atmosphere as inert reaction mass to inject into the combustion chamber of an Earth-return vehicle. The process results in a greater mass of propellant used, but can reduce the requirement for fuel brought from the Earth.

A significant fraction of the duration of a human exploration mission occurs in the Earth-to-Mars transfer orbit. Failures during this period may require immediate orbital maneuvers in order to ensure the safe return of the crew. An investigation of a powered abort to the Earth orbit as an emergency response to life or mission-threatening failures not affecting the propulsion system is presented.

Methanol is an excellent candidate fuel for both Earth and Mars because it can be produced from atmospheric carbon dioxide and is a source of hydrogen on Mars, and industrial carbon dioxide waste on the Earth, biomass and methane. It can be used in fuel cells to produce electricity for Martian habitats and surface vehicles, and as a rocket fuel for the return journey to the Earth. Its relevance to rocket propulsion and production on the Mars and the Earth by various techniques has been discussed in detail.

A major objective of the human exploration of Mars might be the permanent settlement on the planet. This has been a consistent theme of The Case for Mars conferences also. An elaborate article on the long-term habitation of Mars examines the issues of acquisition of matter and energy on Mars and their organization in life-support systems. Several aspects of the life-support systems needed for long-term habitability are discussed. It is argued that although any

initial life-support system for Martian colonists is going to be a small, enclosed biosphere, the notion of eventually terraforming (endowing Mars with a biosphere that mimics that of the Earth) will be debated by the earliest settlers. Various approaches to terraforming and paraterraforming Mars have been discussed. Paraterraforming differs from terraforming in that the intention is to achieve conditions suitable for human habitability even though the transformation of the planet to a fully Earth-like gravity-bounded state may either be impossible or is not achievable on a realistic time scale. Transforming Mars for terrestrial life appears to be a favorite topic of several authors. The AAS Science and Technology Series, Vols 91 and 92, lists many papers on this topic, which were reviewed by this reviewer earlier. Apparently, terraforming Mars represents a distant, perhaps an improbable, dream—ethically too controversial, and not worth giving too much of an importance, at present.

Undoubtedly, the construction of a Mars base is one of the major tasks the travelers to Mars confront. Careful planning is definitely required before an actual base development is realized. A report to evaluate mission design and exploration technology proposals to ensure that *the means support the goals* and do not obstruct them numerates the factors that may detract from success. The success of a Mars Mission architecture depends on how well it defines the problem, then solves it, while combating institutional inertia and political entropy, according to this report.

A Mars base study proposes the presence at the surface, rather than in a hollowed-out cave dwellings. Concrete construction may be used on Mars for permanent enclosures. Portland cement material has been identified in soil samples, and may be recovered to provide building materials. Another article describes ways by which impact craters, abundant on Mars, could be converted into living biomes by providing them with a flattened dome-like cover consisting of an underlying plastic or fiber glass seal and loaded down with Martian soil to balance the atmospheric pressure trapped within. Yet another type of base proposed is a mobile or 'roving' base. The Nomad Explorer, primarily designed as a lunar base, is claimed to vastly improve the exploration range.

Abstracts (93 in all) of all the presentations of the conference are put together in Appendix A. Appendix B lists all the major publications of the AAS. In general, the papers compiled in the present volume are well chosen. However, because of the delay in publication of this volume, some papers have already appeared elsewhere while a few others, like the lengthy status report on the mission Mars Pathfinder in 1993, have become redundant as the mission is already completed.

Interest in Mars was dimmed when the images from Mariner spacecraft in the 1960s revealed barren, lunar-like landscapes, and no canals! Mars seemed geologically lifeless, its meager portion of water locked beneath a deeply frozen surface. Stunning images from the Mars Global Surveyor (MGS) which has been in orbit since 1997 are breathing new life into the red-planet. Camera aboard MGS had spied signs of geologically recent–possibly even ongoing–water seeps has caught everyone's attention. From these findings, it is imminent that interest in Mars exploration will grow steadily in the coming years. As a matter of fact, the enthusiasts expect the first manned flight to Mars in the first half of this century. In this context, I am sure

text, I am sure The Case for Mars V conference papers will make an interesting reading to the space researchers and students.

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The Case for Mars VI: Making Mars an affordable destination: AAS Science and Technology Series, Vol. 98, edited by Kelly R. McMillen. Published for the American Astronautical Society by Univelt, Inc., P.O. Box 28130, San Diego, California 92198, 2000, pp. 560, $80.

The title volume is a collection of 42 papers and 12 abstracts presented in the *sixth* Case for Mars Conference held in 1996 at Boulder, Colorado. Grouped into five chapters, these articles cover issues like Building support for low-cost missions to Mars, Essential technology and proposed infrastructure, Reducing the cost of precursor missions, Designing a habitable planet, and Working group reports. A couple of the abstracts were earlier published as full-papers in the AAS Science and Technology Series, Vol. 92 (1997), which was reviewed by this reviewer for this journal.

The volume begins with an interesting article describing the heritage and legacy of the Viking mission to Mars by two of its main architects, G. Morgenthaler and W. Lowrie. The two Viking spacecraft, which successfully landed on Mars in 1976 within a span of 40 days covering 460 million miles, were designed, built and landed on Mars by Martin Marietta Company by its own launch vehicle, Titan III. In the next paper, Robert Zubrin, an ardent protagonist of the Case for Mars, portrays the significance of the Martian frontier, advocating strongly for terraforming Mars. He foresees the use of deuterium available on Mars as fuel for thermonuclear fusion reactors by the Martian colonists.

Issues like How to 'sell' Mars to the public? What set of conditions will align to enable human exploration of Mars? Who funds it? are the topics of several articles. While there cannot be a single answer to these questions, it is argued that premises like 'exploration for exploration's sake', 'pioneering spirit', 'human destiny' or 'because it is there' as rationales for Mars exploration wouldn't work for the public at large. Ways suggested to gain a high level of public support include persuasive discussions of pivotal audiences including children, media personnel, and opinion leaders. Large-scale public support, however, is only expected if there is a commercial motive in settling on Mars.

Unlike a trip to Moon, the human exploration of Mars will be a complex undertaking involving commitment for several years, and there is a very narrow window within which return is possible. NASA has formulated a 'Reference Mission' addressing human exploration of Mars using approaches that are technically feasible, have reasonable risks, and have relatively low cost. The plan emphasizes the surface exploration of Mars; the crew will travel to and from Mars on fast transit (4 to 6 months) and will spend long time (18 to 20 months) on the surface. The single largest mission cost is transportation. The Marshall Space Flight Center has developed a Space Transportation Plan to explore ways to enable a low-cost human Mars ex-

pedition by 2018, at a program cost of no more than $25 billion. The most cost-effective means of transport proposed is a nuclear thermal propulsion system. However, in 1996 the Congress terminated the last remaining US space nuclear research and development program, the TOPAZ International Program. It will take a major and costly effort to resurrect the thermonuclear rocket programs.

'One-way to Mars' is a new slogan. A few authors believe that bringing back the crew after sending them millions of miles and landing on Mars negatively affects the cost and risk. Besides, any return sample from Mars could cause a microbiological disaster on Earth. Tomas Gunn, an expert in managing large-scale space projects, warns sternly of this possibility and argues that humans on Mars must and *should* be one way for the foreseeable future. According to him, no agreeable case can be made for the need to bring anything but the data back to Earth.

The chapter on reducing the cost of precursor missions lists some novel means and technologies that may be cost-effective. A comparison of alternative methods for the Mars sample return mission reveals that the one employing *in-situ* (produced on Mars) propellant offers the lowest cost, as well as risk. A high-power Mars subsurface radar operating from an orbiting spacecraft is described which could map the planet in search for underground ice, water and other geologic phenomena up to 1 to 5.6 km below the surface. A study of human Mars exploration alternatives using *in-situ* propellant production and current technology, carried out at the University of Washington, examines two scenarios to provide an economically feasible approach to manned Mars exploration. Both use carbon monoxide as an *in-situ*-produced propellant, and three Energia launches, but differ in other details. Another article relates to prospects for using CO_2/metal propellants in Mars missions.

The use of the International Space Station in preparing for the human exploration of Mars is explored in detail. Another paper reviews the design of the surface mission for a Mars Exploration program. The mission goals being to perform scientific exploration and to assess the habitability of Mars. These could be achieved by (a) using pressurized rovers capable of supporting a crew of three for up to a month duration and (b) by growing food and using *in-situ* resources to support the base. It is surmised that 'Being There on Mars' will turn out to be much like being in remote places on Earth.

As in The Case for Mars V (AAS Science and Technology Series Vol. 97), which the present reviewer had reviewed here, and other Volumes, Nos. 86 and 92, reviewed earlier by him, there are several papers on terraforming (transforming for terrestrial life) Mars, in this volume also. An ethical perspective of terraforming Mars points out various issues in detail. One view is that humans should terraform Mars, if and only if, there is no indigenous Martian life. Contrary to this, R. Zubrin is strongly opposed to any ethic which would allow moral standing on Martian biota. "...bacteria don't have rights... And the idea of denying humanity a new world to provide a reservation for extraterrestrial bacteria is – simply ludicrous." Another paper reviews the ongoing research on terraforming Mars. The main premise of terraforming is that Mars might be transformed into a habitable planet by planetary engineering, which could alter the environment so that terrestrial organisms could survive and grow.

As pointed out in one of my earlier reviews, terraforming is a pet topic of many authors. It basically involves warming the climate of Mars to cause a green-house effect. Methods sug-

gested for warming the planet are most fascinating to say the least. A paper presented in this volume proposes the use of weapons-grade plutonium that has become surplus to defense needs with the end of the Cold War as a fuel for nuclear reactors for Mars exploration and terraforming. Further, it recommends to assemble such a reactor in space by injecting the fuel rods into orbit using the gas gun like that being developed at the Lawrence Livermore National Laboratory. Another paper suggests seeding by microorganisms to create a self-regulating anaerobic biosphere, thereby, facilitating the planetary engineering of Mars. Anyway, both terraforming and ecopoiesis (creation of a self-regulating biosphere) are a dream (or nightmare) of a distant future.

The volume includes extracts of the conference workshop organized to focus on ways to mount an initial mission to be assembled over an eight-year period for a total cost of $32 billion. Topics included the rationale, innovative technologies and strategies, management and organizational approaches, and international cooperation.

Of course, interest in the exploration of Mars is rekindled by NASA's recent finding that life may have once existed on the red planet. NASA has planned six robot missions to search for evidence of life and for water, and the return of rock samples by 2011. There are no current plans, however, for a manned mission. The papers listed in this volume argue for a more intensive initiative possibly by actively involving the academic institutions, private industries and international participation. Several relevant ideas have been put forth to reduce the mission cost. However, too much importance is being given to terraforming and ecopoiesis aspects, which are not going to matter in a foreseeable future. Overall, the plans and projects described for the exploration of Mars are informative and make a highly interesting reading. I am sure space scientists and students will enjoy going through this volume.

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