J. Indian Inst. Sci., May–Aug. 2004, **84**, 113–122

Book Reviews

Martian expedition planning, AAS Science and Technology Series, Vol. 107, edited by Charles S. Cockell. Published for the American Astronautical Society and the British Planetary Society by Univelt, Inc., P.O. Box 28130, San Diego, California 92198, 2004, pp. 506, $90 (Hard cover plus a CD ROM).

The volume presents the Proceedings of the Martian Expedition Planning Symposium of the British Interplanetary Society held in 2003 at London, as also additional invited papers totalling 28 articles.

Human exploration of Mars is the next frontier of space science. There are good scientific reasons to go to Mars, the search for microbial life being a particularly exciting one. The main reason could simply be, because it is there and reachable with the currently prevailing infrastructure and technology. We do not know when exactly humans will land on Mars but the day may not too far. It could be within the next 50 years. With this premise, the main working theme of the symposium covers issues relating to Mars weather, science to be carried out, tools and rovers to be used for Mars surface exploration and transportation, and concerns pertaining to human health and medicine.

It is natural to expect that Mars expedition planning will be based heavily on the information provided by the recent unmanned Mars missions like the NASA's Pathfinder, Global Surveyor and Odyssey, and also by the various Mars-analog research stations set up on Earth. The experimental data obtained from these missions will be crucial for a successful expedition. It is reassuring that several papers presented in this symposium are based on these studies.

To plan any expedition, a prior knowledge of the weather and climatic conditions is of paramount importance. Recent probes—Mars Pathfinder and Mars Global Surveyor—have provided the much needed data. Mars is perhaps the most Earth-like planet but it is markedly different in its atmospheric composition and climatic conditions. Its atmosphere contains primarily CO_2, only traces of oxygen and no moisture. It is non-conducive to human survival without protective clothing and artificial life-support systems. Besides, Mars has only about a third of the Earth gravity and very low surface pressure and temperature. The Martian atmosphere is very dry; dust storms are a frequent occurrence. Atmospheric dust scatters light very differently and as a consequence the Martian sky is not the usual deep blue but most often a bland yellow or pink in color. Fine dust (average particle size, a few microns) suspended in Martian atmosphere is likely to be a major environmental hazard. It may penetrate into small spaces, clogging up filters and machinery. A peculiar characteristic of Martian weather is the presence of sharp temperature gradients. The difference in temperature between 0 m and 5 m rises to almost 40 K around noon. An astronaut would experience a temperature difference of almost 20 K between his feet and his head, with his head much colder than his feet, which could be quite uncomfortable, and calls for adequately insulated spacesuit.

There is hardly any likelihood of liquid water being present on Mars because of its low surface pressure, which is below that of the triple point of water. It means that even if there is water in the form of ice when heated will sublime without condensing to liquid state. Pressurized vessels (easy to design) will be needed to make drinking/liquid water on Mars.

To prepare for a Martian expedition led by a human crew and assisted by robots, a substantial amount of mission definition can emerge from Mars-analog studies on Earth. A search for life on Mars will require understanding its geological setting. While the surface of Mars is harsh and probably barren of life, conditions favorable to microbial ecosystem may prevail below the surface. Sedimentary deposit locations, like lakes, craters and permafrost sediments are likely sites for exploration.

Two such locations selected for Mars-analog studies are the Houghton impact crater in the Canadian Arctic, and a desert site near Hanksville, Utah. The study conducted at Houghton describes how sampling of paleolake deposits might be accomplished from a lander, and the design of a Martian surface exobiology laboratory. The work was catalogued to develop a computer model for Mars mission planning. It concluded that it is possible to collect samples and accomplish scientific examinations within a space of one month averaging one EVA every three days in Mars-like space suits. The 30-day mission studies carried out in 2003 at Mars Desert Research Station (MDRS) in Utah tested a Mars-analog rover, a data logger and suit technologies. It had three types of research missions, geology, biology and human factor studies. Besides proving the technologies, these missions provided valuable training for scientists and engineers to carry out a long-term interdisciplinary research program in Mars-like confinement. Based on the data available thus far, another study concluded that a series of 15 Mars-analog expeditions are needed before the world is ready to go to Mars.

Since there is no surface water, Mars is a desert, all-land planet. Much could be drawn from the terrestrial desert expedition experiences, methods and equipment. A Trans-Mars expedition covering ~21,000 km, utilizing *in-situ* oxygen, water and fuel has been described. The expedition is carried out in pressurized rovers and simply designed ball tents, using space suites for extra-vehicular activity (EVA). A long-duration (over a year) expedition on Mars presents a serious problem of waste depositing without contaminating the Mars atmosphere. A crucial requirement of human exploration is the avoidance of contamination of sampling sites with Earth-origin organism. There is no way to recycle human feces into palatable food, and carrying it all along adds significantly to the cost. External depots (two or three) during the traverse are suggested, but a decision to depot is yet to be taken. Other aspects cover topics like mountain climbing on Mars. Mars possesses volcanic structures whose heights exceed the heights of the highest mountains on the Earth by several-fold, although their slopes are only a few degrees (60 or less). Another expedition examines the Martian poles. Simply designed ball-tents provide an adequate environment for de-suiting and can be used to establish temporary field camps and depots for transpolar expeditions. The equipment used could be a direct extrapolation of terrestrial polar expeditions. For long-distance expeditions in pressurized rovers, computer programs have been generated to minimize cost and chalk out suitable routes taking into account terrain variations, and also for logging data.

A 5-day Mars-analog-pressurized rover mission was conducted near MDRS to compare the science return and the amount of territory explored. The study concluded that an expedition limited to 500–600 days is insufficient for exploration. Another study details the design concepts of an analog-pressurized Mars rover. Comparative field test results of three pressurized rover prototypes are also available.

Power generation and energy uses in a pressurized Mars rover are considered major logistic issues since fuel storage capacity limits maximum travel range, and the fuel is the largest component by volume. Hydrocarbon fuels are chosen over hydrogen based on storage volume limitations. Fuel cells are selected as the optimal power source based on their superior overall performance.

Unmanned aerial exploration of Mars using remotely piloted airplanes and balloons could be an effective means to cover very large surface area in a relatively shorter period. Specially designed foldable flying devices carrying digital video and other instrumentation could be carried to Mars and released in the atmosphere to explore planetary geology, presence of life, water and other resources. Such devices could be launched on a Delta II rocket with a launch cost of just over $ 50 million/flight.

Concerns have been expressed over the microbial contamination of Mars by the terrestrial microorganisms present on all internal and external spacecraft surfaces prior to launch and carried along the trip. The fate of these microbes during the 3-year nominal mission to Mars could be a significant factor in the overall success of the mission.

Factors affecting human behavior in a small confinement of a spacecraft for long duration have been a subject of several studies. Impersonal friction and overt conflicts among crew are the inevitable consequences of these conditions. Sustained, close personal contacts with other individuals can be very stressful, and trivial issues are inevitably, and sometimes dangerously, blown out of proportion. Lessons drawn from parallel expeditions like confinement in a small ship locked in polar ice cap, a Mars analog research station and Apollo 17 lunar expedition are cited.

What kind of medicine will be required on Mars? Common medical hazards include space vacuum and radiation, micrometeoroids and Martian dust, and constitutional medical hazards. They also include human physiological adaptation to reduced gravity, prolonged isolation and confinement, and decompression resulting from accidental tearing of the space suit. The most serious threat is the microbial contamination of water supplies, which could produce gastrointestinal upset, in addition to nonpalatability. Medicine for Martian expedition would obviously be an extrapolation and modification of expedition medicine on Earth. Contents for a Martian expedition medical box are suggested.

It is apparent that over the years interest in the exploration of Mars is enhanced significantly. The unmanned robotic missions have provided incredible pictures and invaluable data of the red planet. The recent finding of concentrated salt below the surface by Mars Rover Spirit provides further evidence that water once existed on Mars. This adds further to the excitement to have a closer look. Although it is realized that to plan and execute a successful human expedition to Mars is a gigantic challenge to human ingenuity, however, perhaps it is about time to make it happen. In this context, the studies reported in this vol-

ume are highly relevant. I am sure the scientific community interested in exploration of Mars will enjoy going through the papers presented in this volume.

Formerly Professor, S. R. Jain
Department of Aerospace Engineering,
Indian Institute of Science,
Bangalore 560 012, India.
email: jainsampat123@rediffmail.com

Sampling, wavelets, and tomography by J. J. Benedetto and A. I. Zayed, published by Birkhauser Verlag AG, Klosterberg 23, CH 4010, Basel, Switzerland, 2004, pp. 365, chF 144.

Wavelets enable us to divide a complicated function into several simpler ones and study them separately. This property along with sampling techniques makes them very attractive in the implementations of analysis and synthesis problems like those in tomography. The use of sampling techniques for image reconstruction in tomography arises due to the practical constraints on data acquisition. Thus the three active areas, namely, sampling theory, wavelets and tomography, share the common roots that lie at the heart of functional analysis.

The book under review fulfils the following objectives:

1. It introduces sampling theory, wavelets and tomography to the reader.
2. It stresses the interdependence of the three main areas it covers.
3. It demonstrates the role of sampling in both wavelet theory and tomography.

The book contains 12 chapters organized in three parts. Part one, consisting of Chapters 2–4, deals with sampling problems related to frames in general function spaces. Part two, consisting of Chapters 5–8, focuses on sampling in shift-invariant subspaces of L^2 and contains new results that extend the notion of multiresolution analysis (MRA) to abstract Hilbert spaces and refine the idea of Besov spaces. The main theme of Part three, consisting of Chapters 9–12, centers around tomography and various sampling schemes in numerical analysis and medical imaging.

Chapter 1 is an introductory chapter giving short introduction to the three themes mentioned in the book's title. It provides a tutorial on interaction among sampling theory, wavelets and tomography. The good introduction and overview given in this chapter are helpful to nonspecialists.

Chapter 2 presents a broad sampling framework, for nonredundant and redundant sampling and reconstruction, that allows for almost arbitrary sampling, reconstruction spaces and input signals. The chapter, beginning with a detailed sampling framework, gives geometric interpretation of sampling and reconstruction. When dealing with nonredundant sampling schemes, the chapter illustrates the reconstruction in shift-invariant spaces and band-limited sampling of time-limited sequences. While dealing with redundant sampling procedures, the chapter introduces a generalization of dual frame vectors, referred to as the oblique dual frame vectors. Although the chapter is of undoubtful use to the readers concerned, it could have been more interesting to see the use of these techniques in practical

situations where one deals with redundant and nonredundant data. While Chapter 2 presents the concept of frames and construction of dual frames, Chapters 3 and 4 focus, respectively, on frames in L^2 as applied to Weyl-Heisenberg group and, some sampling and interpolation problems in Sobolev algebras.

In the recent treatment of nonbandlimited signals, there are a number of results on how to use sampling series both to approximately and exactly reconstruct the signals. Chapter 5 gives an overview of such sampling theorems for nonbandlimited signals. It reviews the notion of biorthogonal partners and mentions their application in image analysis and multiresolution theory. Besides, it gives good insights into nonuniform sampling of nonbandlimited signals.

Recent developments in the theory of multivariate polynomial matrix factorization have proven to be useful in the design of multidimensional multiband filter banks, which are needed in the construction of the so-called first and second generation wavelets for a variety of applications. Chapter 6 reviews the recent developments in research in this direction, paying special attention to the use of first-generation wavelets for image-sequence superresolution.

As the sparseness in wavelet expansion is key issue in signal analysis, the knowledge of distribution of wavelet coefficients is very important. Chapter 7 talks about the function spaces for which the members have sparse wavelet decompositions. It then discusses the extension of Besov spaces to study the strongest and weakest correlations among wavelet coefficients.

The notion of MRA was defined initially for L^2 space. Later on, its generalization, frame MRA (FMRA), was considered for the same space L^2 and applied in the analysis of narrow band signals with more freedom in the construction of wavelets. Using significant amount of functional analysis, Chapter 8 extends further the notion of MRA to abstract Hilbert spaces and presents a general theory, called Generalized FMRA (GFMRA), in which all orthonormal wavelets fall as a general category. Some nonmathematicians have a feeling that the mathematicians tend to generalize the latest results, obtained by pioneers, to various spaces of functions. Chapter 8 would have countered such a feeling if it had given proper motivation for the generalization of MRA to abstract spaces.

In computed tomography (CT), the question as to how many and which line integrals should be measured for better reconstruction is important. Chapter 9 considers answering this question for parallel beam tomography in 2D. It explores the use of relevant sampling theorems and provides estimates for aliasing errors caused by under sampling.

In medical imaging, fast data acquisition is important to perform a scan completely within a breath-hold period to avoid artifacts caused by patient's movement. The 3D spiral cone beam geometry is one procedure that provides the stated feature. Normally in 3D reconstruction algorithms, the cone angles are assumed to be small (which results in X-rays penetrating the patient along planes perpendicular to the axis of rotation) to facilitate the use of simpler 2D reconstruction techniques in place of complicated direct 3D reconstruction. However, the recently developed scanners, which do not use smaller cone angles, provide efficient reconstructions. Chapter 10 reviews two algorithms of back projection type.

One of them provides exact reconstruction while the other provides approximate reconstruction.

Recently, the mesh-free discretization methods for solving PDEs have received a lot of attention in different fields such as medical imaging, numerical analysis, etc. The mesh-free methods are better suited to cope with geometric changes of domain of interest. Chapter 11 illustrates the utility of adaptive irregular sampling using a mesh-free advection scheme. It explains well both passive advection and nonlinear diffusion processes. It presents numerical examples showing the good performance of mesh-free advection scheme when adaptive irregular sampling is used. Nowadays spline interpolation plays an important role in numerical applications. Chapter 12 presents cubic splines and introduces thin-plate splines as a generalization of the clamped cubic splines. It ends with the application of thin-plate splines in medical imaging.

The book places emphasis on all the three themes it considers. It presents applications with a broad perspective. In the recent literature on tomography, wavelets and sampling techniques together have been applied to interior reconstruction, incomplete data problem, etc. In view of the book's title mentioning all the three themes, it would have been more appropriate to include such applications. Secondly, some of the chapters do seem to be more abstract in nature. Proper motivation and application for the generalization of concepts will make such chapters more interesting.

Despite these minor limitations, the book, containing the contributions of some of the renowned scientists in the field, is interesting and informative and presents an insightful approach towards wavelets, sampling theory and tomography. To conclude, the book is of immense value to the mathematically inclined researchers whose works center around the applications of sampling theory.

AI Lab, Ch. S. Sastry
Department of Computer and Information Sciences,
University of Hyderabad,
Hyderabad 500 046, India.
email: chella_sastry@lycos.com

Introduction to RF stealth edited by David Lynch, Jr, SciTech Publishing Inc., 5601 N. Hawthorne Way, Raleigh, NC 27613, USA, 2004, pp. 573, £85 (hard cover plus a CD ROM). Distributed by the Institution of Electrical Engineers, Michael Faraday House, Six Hills Way, Stevenage, SG1 2AY, UK.

The objective of stealth is to keep adversary guessing. Stealth is not one item but an assemblage of techniques, which makes a system harder to find and attack. The book under review is based on the material developed in the mid-1970s for stealth weapon systems and spearheaded by DARPA (Defense Advanced Research Projects Agency) in both US Air Force and Navy Programmes. This material, although remained classified for 20 years or more, has now been made available in this book (covering the few declassified material) by the author who himself has worked in both the US Department of Defense (DoD) and industry on stealth problems.

Stealth radar and data link design involve the reduction of active and passive signatures, the former being all observable emissions from a stealth platform, and the latter, all observables on

stealth platform that require external illuminations. The active signature reduction methods are the low probability of intercept (LPI) techniques and the passive reduction techniques are the low observables (LO). Thus, the book covers these two major topics, low observables and low probability of intercept (LO and LPI) of radars and data link, which is collectively sometimes called stealth.

This is the only book focused on the complete aspects of RF stealth design, presenting and explaining first-order methods for the design of active and passive stealth properties. Everything from electronic order of battle to key component design is covered. The book is a 'How to' on the topics: estimation of RCS, emitter interceptability, IR signature with speed, emitter footprints, terrain obscuration and target visibility, ambient spectra, ambient pulse density, detection performance, antenna, filter and pulse compression side lobes, emitter location accuracy, stealthy pulse compression design, stealthy antenna design, signal processor performance, and more. Unique compilations of the leading parameters of many emitters and interceptors are included as an analytical software for each chapter.

The author, David D. Lynch, Jr was involved in almost every stealth program as technical contributor, program manager and business unit leader including LPIR, Have Blue, F-117, Tacit Blue, Sea Shadow, Advanced Cruise Missile, F-22, B-2 and many others. He was a technical contributor to dozens of radar, electronic warfare and communications systems, and is an inventor, leader and contributor to many world firsts, including manned spaceflight, telecommunications, digital signal processing, synthetic aperture radar and stealth. He has been elected a pioneer of stealth, a senior member of AIAA (American Institute of Aeronautics and Astronautics), and a Fellow of the IEEE. He worked for General Motors Hughes Electronics, and is currently president of DL Sciences, Inc.

Both the topics, LO and LPI of radars and data links, are covered in seven chapters. Each chapter has examples, student exercises, references and counterpart appendices that describe the associated software on CD-ROM. Most of the analysis has been verified by experiment or computer simulation by well-known authorities in radar and stealth area. Appendix A describes the particular analysis in the form of computer programmes on the CD-ROM. Chapter 1 provides an introduction and history of RF/microwave LPI/LO techniques and some basic LPI/LO equations. Introductory descriptions are covered on RCS and power management, LPI systems and their design, concepts on reduced detectability, LPIR (radar) programmes worldwide and their results, and the basic LPI equations with estimation of RCS component and its reduction which is the essence of LO technique. Also, there is a brief introduction to the three types of threats, viz. radar, IR and intercept.

Chapter 2 covers interceptability and analysis, based on ESM strategy and implementation utilised by threat forces. Seven main interceptability parameters or constraints are described. A simple model for these parameters, the interceptor time response, and the receiver sensitivity are covered quantitatively with relevant equations. The intercept range performance for main lobe as well as side lobe, vis-a-vis power management and intercept sensitivity, have been graphically depicted. Interceptability analysis based on intercept receiver sensitivity, side lobe range, antenna gain mismatch and detection probabilities within time and frequency constraints are discussed. Many examples of LPI radars, their modes and performance parameters pertaining to intercept threats are also covered. Another section is devoted exclusively for main lobe

footprint computation (called ‘Cookie Clutter’ method) for different geometry of antenna apertures of airborne radar systems.

Chapter 3 concentrates on current and future intercept receivers, airborne warning as well as ground based, and some of their limitations. Starting from crystal video receivers, other class of receivers, viz. instantaneous frequency measurement, auto-tunable (scanning) superheterodyne receivers, multichannel receivers, pulse compression receivers and a hybrid type are discussed along with their operating techniques. Based on these trends in intercept receiver architectures and their threats, LO/LPI system countermeasures are suggested, viz. screening, jamming and spoofing. As a data bank, typical deployed intercept receivers available world over are listed.

Chapter 4 surveys stealth strategy based on exploitation of both the natural and the threat environment and gives examples of one of the excellent thoughts of LPI/LO design, electronic order of the bottle (EOB) exploitation. The natural environment of atmospheric attenuation, clutter and terrain masking are discussed quantitatively in detail for stealth exploitation. The deployment of different types of radar, ECM and radar intercept equipment, as an EOB, is dealt in depth. Examples of the battlefield emitters, their stealth penetration scenario and deployment are also covered. The chapter ends with an extensive tabulation of the emitters deployed world over.

Stealth waveform design is covered in Chapter 5, dealing with LPIS waveforms and pulse compression for data links or radars. The chapter is very informative on linear FM/chirp as well as discrete polyphase and barker codes, frank and digital chirp codes which are all effectively illustrated. Special class of the binary polyphase codes, viz. complementary codes is also covered in greater depth in view of their wide use in LPI radars. Chapter 6 introduces some hardware techniques associated with LO/LPIS, low side lobe and low cross-section antenna and radome design. Antenna radiation, types of antennas, antenna arrays, low side lobe amplitude distribution functions are all well covered. Description on electronically scanned arrays, multibeam antennas and estimation of antenna RCS provides the background on stealth antennas, along with relevant quantitative equations. The chapter also covers the new LO antennas, which require low RCS radomes, based on proper antenna and radome integration. Composite radomes, generally employed for stealth and made of dielectrics and conductive frequency selective surface, are described in detail.

Chapter 7 describes typical LPIS low-level RF and signal processing, which is often unique relative to the conventional radar and data link processing. Stealth signal processing includes minimising straddling losses, reducing RF interference, and limiting self-noise, by choosing a waveform with the lowest inherent losses. Both airborne and ground segments of stealth signal processor architectures have been presented. Basic as well as advanced digital signal processing with emphasis on stealth has been covered concisely. The processing architectures for air target search and track with medium PRF pulse Doppler radar schemes, Doppler beam sharpening for higher angular resolution ground mapping, synthetic aperture radar (SAR) mapping and ground moving target indicator (GMTI) have been dealt with comprehensively. Finally, the author has also touched briefly on the data links associated with stealthy vehicles with LPI systems, data compression, jammer nulling and LPIS adaptive signal processing.

The book is a nice balance between theory and practical illustrations. Simple numbers indicate that this book has 368 figures, 74 tables, and 328 equations, illustrated in 573 pages. There are over 220 references, but there seem to be some overlapping. There are about 49 problems that certainly can be utilised in engineering education. A few sections tend to be mathematical but are not too difficult to follow. Many illustrations, taken from MathCAD simulations of the presented algorithm, certainly assist in understanding of the concept. The MathCAD files written along with MS Excel, MS Quick Basic programmes, on the CD-ROM look professional and are arranged methodically. Almost every chapter has its counterpart on the CD so that the reader can immediately use the equations to see the effect of various parameters on the performance of LO/LPI systems.

In essence, to offer an overall view of the book, it is invaluable to practicing engineers in the radar and electronic warfare domains, in view of its systems engineering perspective with a firm basis on new developments. The text, covering much of the unclassified stealth technology, is oriented towards undergraduate seniors and graduate engineers with some prior background in radar and communications. Also, based on some of special topics covered, university educators will find this book extremely suitable for radar signal processing-related courses.

Programme Director, U. K. Revankar
Electronics & Radar Development Establishment (LRDE),
Bangalore 560 093, India.
email: revankaruk@hotmail.com

Samagra Vikas (Development with a human face), Vivekananda Yoga Kendra, Kanyakumari, Tamil Nadu, India, pp. 356, Rs 200.

During the last half-century, there has been worldwide concern about the direction in which so-called development of humanity is progressing. The oil crisis of 1973 sent a shock wave around the globe, which made developed countries reassess their priorities. Several non-governmental organisations took up this issue seriously. The Rome Conference on 'Limits to Growth' placed the entire problem in a proper perspective. The Rio Conference in the 1990s focused on most of these issues at a global level. For a common person, browsing through all these reports and getting a comprehensive idea is almost impossible. It is in this context that one should assess the value of the book under review.

The book is divided into seven sections, dealing with education, health, industry and environment, man-machine and employment, energy, population-migration and habitat and lastly ecology-sociology and sustainability.

The book has several positive virtues, but also has a few defects. It is a compilation of articles, newspaper reports and scientific documents, collected from various sources, whose details have not been furnished. A discerning reader will find it difficult to trace the source from which the material has been taken. While transferring the various articles and reports, quite a good number of typographical errors have crept in. A more careful editing would probably have eliminated these errors. The first section on Education contains 12 articles of which only 2 deal with the subject.

In spite of these defects, the book has several virtues. Each section commences with an imaginary dialogue between the famous court jester, Tenali Rama, and his king. These preludes give us a good entry into the subject matter of the articles. As one reads through the book, one starts appreciating the sincere concern expressed by the various authors. The articles cover a wide spectrum of issues facing humanity today, some of them even suggesting possible solutions.

The book is not meant for experts, who are already well versed in their respective fields. It addresses itself more to the general reader, who wants to gain a glimpse into the issues covered. It is meant to make the reader literate about the issues and not to educate him.

The reviewer has benefited a good deal by reading through this book. He has no hesitation in recommending it to the younger generation, who are destined to face these problems very shortly in their adult life. The book prepares them to be fully ready and be aware of what the future is likely to hold for them.

The printing and the get-up are excellent and make the reading a pleasurable experience. The Vivekananda Kendra should be thanked for bringing out this timely publication.

Formerly Director, IIT Madras, N. V. C. Swamy
Atreya Apartment,
B9, No. 44, 15th Cross,
Malleswaram,
Bangalore 560 003, India.
email: nvcswamy@rediffmail.com

Printed and published by Dr S. Venkadesan, Executive Editor, *Journal of the Indian Institute of Science*, Bangalore 560 012; Printed at Ravi Graphics, Bangalore 560 044.