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BOOK REVIEWS

The Massachusetts miracle edited by David R. Lampe. The MIT Press, 55, Hayward Street, Cambridge, Mass. 02142, USA, 1988, pp. 367, $16.95. Indian orders to Affiliated East-West Press Pvt Ltd, 25, Dr. Muniappa Road, Kilpauk, Madras 600010.

New England in general, and Massachusetts in particular, was the first area in North America to industrialise: presence on the Atlantic rim providing access to cheap European labour was apparently responsible, rather than any (other) natural resource. The area was also the first to feel the effects of post-industrial decline (New England being like its trans-Atlantic parent in this respect): in the early 1970s the traditional industries of the region (textiles, leather, machine tools) were sick or dead, the newer ones that had been built on defence contracts suffered from the after-effects of the Vietnam debacle, unemployment had soared to more than 11%, and the sunbelt started sucking business away (attracting it in part by lower taxes than in what came derisively to be called the state of Taxachusetts, which at one time supported nearly one among every five residents); the outlook was decidedly bleak. However, a conscious recognition of the gloomy prospect and a serious effort at change produced the miracle of the book's title. The book is a compilation of various documents that trace the course of events from 1971, when alarm was first expressed, to 1987, by which time the situation had changed dramatically—as any visitor to Boston over the period can testify. The chief interest of the book lies in the glimpse it provides of how politics, business and science combined to produce the miracle.

The book begins with a piece put out in 1971 by (as the editor notes) an old 'Brahmin' bank of Boston, which worried that Massachusetts had 'just about run out of its wealth-creating energy', and called for a partnership between business and government to redirect the economy. This was followed up nearly a year later by another pamphlet, this time fortified with statistics and graphs and more stridently called *Look out, Massachusetts*!!!.

The recovery eventually did take place, aided by government measures (reduced taxes), by venturesome banks, by the enterprising engineers and scientists whom the Boston area produces in large numbers (out of MIT in particular), and by the emergence of the computer as an article of general usage demanding a large number of engineers to ease its 'civilianisation' (earlier it had mostly been confined to military applications). What is interesting is that more than ninety per cent of the new jobs created by the 'miracle' were in firms with twenty or fewer employees, which constituted nearly ninety per cent of all business establishments. Along the celebrated Route 128, the eastern counterpart of Silicon Valley in California, and even in such places as the old textile town of Lowell, it was high-tech enterprise that revived the Massachusetts economy.

Although we are still pre- rather than post-industrial, Indian readers will want to draw lessons. One thing that stands out is the politics-business-science triangle: it is interesting to see that this is not a solely Japanese phenomenon. The difference perhaps is that the nexus in the US is less formal and less permanent, compared say to the arrangements that the famous Japanese Ministry of International Trade & Industry presides over. However, not all the writers in the book are agreed how important politics was. Its role was very large, according to a Boston journalist; "the organisational and policy role of the state has been quite minimal", according to the bankers; the editor prefers to see the miracle as a fortunate accident, favoured by the particular culture of the region. The second thing to note is the role of defence spending After Vietnam, academic establishments hesitated to accept defence money, so many high-tech firms were set up to undertake the tasks that the academics would not. On the other hand, it is really defence that spawned the computer, which was originally built by engineers who had never read Turing or von Neumann to handle ballistic trajectories (in the US; to crack military codes, in the UK). Such present-day giants as IBM, DEC (whose humble birth-place was an old abandoned mill) and others built their technologies *via* Apollo and many less conspicuous military applications during the cold war. Thirdly, the 'natural advantage' that Massachusetts possessed in promoting its growth turned out to be knowledge—created and transmitted in the dense network of university and national laboratory that the area boasts of (Bangalore has still not learnt to exploit *its* similar advantages sufficiently well).

The book would have been more interesting if it had been more analytical, but does show what amazing things can be done if politicians work with bureaucrats, bankers and boffins.

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RODDAM NARASIMHA

Low-gravity science edited by Jean N. Koster (Vol. 67 in the Science and Technology Series). American Astronautical Society, P.O. Box 28130, San Diego, California 92128, USA, 1987, pp. 274, $55. Orders to Univelt, Inc., P.O. Box 28130, San Diego, CA 92128.

Spacecraft provide a low-gravity environment in which it might be possible to process materials in ways that are not easy on ground. This possibility, in particular the suppression of buoyancy effects even in the presence of thermal gradients in a fluid, had led to considerable research in recent decades in what the book calls 'low-gravity sciences'. In 1986, a Center for Low-Gravity Fluid Mechanics and Transport Phenomena was set up at the University of Colorado, Boulder. This Center, apart from offering courses on the subject, organized a series of 27 seminars during the year; the material presented in 14 of them is collected and published in this volume.

The volume is in three parts. The first, on fluids and transport, has 6 papers dealing, respectively, with suppressing convection in a micro-gravity environment using magnetic fields, inducing free convection, transient heat transfer and measurement of thermophysical properties, multi-phase systems, Marangoni convection on a germanium float zone and cryogenic thermal stratification.

The second part, on materials science, discusses macrosegregation in Pb-Sn alloy ingots, processing of semiconductor materials and floating-zone techniques.

The third part discusses facilities. One of the interesting ideas that has been tried out is to fly on aircraft (in this case a KC-135, the military ancestor of the well-known Boeing 707) in a Keplerian parabolic trajectory, which enables one to reduce the effective gravity to about 0.01 g (the limitation being residual vibration, turbulence, etc.). Thirty to forty parabolas can be flown in a typical mission lasting a few hours, providing each time 25-second stretches of low gravity. Interesting pictures of suppressed convection in these experiments are presented. Another paper in this part describes a 'get away special project', which enables Colorado undergraduates to place small payloads in space at very low cost. A third discusses the usefulness of optical techniques, and the last paper describes some of the programmes at the Colorado Center.

One curious feature of the book is the paucity of computer simulation studies, although these would seem to be particularly suited for the flow regimes of interest in low-gravity fluid mechanics.

Materials processing in space offers many possibilities indeed, but it has till now turned out to be too expensive. Whether the situation will change, with the Shuttle back in operation, remains to be seen. This volume will be useful for specialists in micro-gravity research interested in pursuing these possibilities.

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Technology and the civil future in space edited by Leonard A. Harris, Proceedings of the 26th Goddard Memorial Symposium (Volume 73, Science and Technology Series), American Astronautical Society, P.O. Box 28130, San Diego, CA 92128, USA. Orders to Univelt, Inc., P.O. Box 28130, San Diego, CA 92128, USA, 1989, pp. 234, $50.

This volume represents the proceedings, compiled *verbatim*, of a conference held in March 1988 at the NASA Goddard Space Flight Centre—the 26th in the series of American Astronautical Society Goddard Memorial Symposia.

Following in the pioneering tradition of the rocket scientist Dr. Robert H. Goddard, a large number of eminent persons, experts in space in various areas, have attempted to propagate American leadership in space and have discussed the various problem areas. The proceedings have not been edited accurately: some words have not been transcribed correctly from the recording. Nevertheless, the advantage of reproducing such 'pep' talks is that the reader gets a feel for the American 'dream' and the American initiative, in the face of growing world competition, specifically in the context of space. At some places, secrets of American success in the Apollo programme are discernible by careful reading. An added feature is the *question-and-answer* sessions interspersed throughout the proceedings, which present a transparent view of the innards of the American space programme managers' thought processes. This provides several valuable pointers for Indian space programme managers and policymakers.

A galaxy of professionals presented their views at the symposium. Introduction of each of the eminent speakers is, in some places, mixed with the technical material. Nevertheless, their credentials make convincing reading. It also shows how the American agencies, particularly NASA, take great pains to bring a representative population of speakers and panelists into their national symposia, ostensibly with the aim of generating a national consensus on the space programme.

The Symposium was conducted, it must be remembered, during the intermission between the tragic loss of the *Challenger* in January 1986 and the first subsequent Shuttle flight of the Atlantis in September 1988—a period during which a Presidential Commission (Rogers) was established to probe the *Challenger* disaster, and another Commission (Paine) more importantly, to work out future plans. This had resulted in the Paine report of the National Commission on Space, *Pioneering the space frontier*, which offered a very visionary agenda, a menu of activities that could cover the next 50 years. Subsequently, the NASA Administrator, Dr. James Fletcher, formed a Task Force headed by Dr. Sally Ride, the former Astronaut, which came out with a report on *Leadership and America's future in space*, in August 1987. It is in this scenario that the 26th Goddard Memorial Symposium was held. In his talk (Technology and the civil future in space – Luncheon address) James M. Beggs, the former NASA Administrator, states: "The United States is a great nation with vast resources and we're falling behind. The salvation of this country lies in space. The technologies of tomorrow will be developed on the space frontier. The nation that leads in space will lead in technology. And the nation that leads in technology will dominate the 21st century". This was the undercurrent of thought all through the Symposium.

The key technologies of the future were listed, by C. Ronald Lowry, in his talk (Technology and competitiveness—the industry view): Composite materials, very large scale integrated (VLSI) circuits, software development, optical information processing, ultrareliable electronic systems, propulsion systems, artificial intelligence and advanced sensors. But the question addressed by Thomas Paine was, how can NASA get enough budgetary support to foster these key technologies? One solution he offered was that *bold goals* should be set (perhaps based on the Apollo experience). Thomas Paine's National Commission on Space had arrived at a policy after a two-year national debate involving virtually every element of the American society: Government, industry, the universities, the mass media, policy analysis institutions, prominent and knowledgeable individuals and even the general public, in formal hearings conducted throughout the country. The National Space Policy advocated, by national consensus, the achievement of leadership in space. Towards this end, the Civil Space Technology Initiative (CSTI), or 'Return to Planet Earth' envisioned the deployment of several satellites to survey the Earth and bring home to the people the fragile nature of this planet. The 'Pathfinder' Project was more ambitious—it envisaged the development of technologies required for a wide range of missions beyond Earth orbit, including a return to the Moon and the manned exploration of Mars.

The question of budgetary cuts was addressed by L. J. Evans (Technology policy and plans–the commercial space view). In his opinion, the 3 billion dollar-a-year shortfall had to be met by finding ways to access private capital by, for example, having a Comsat-type organization to help finance private sector venture capital going into space infrastructure.

Jack L. Kerrebrock, Associate Dean of Engineering, MIT, spoke (Technology policy and plans—the University view) about the present climate in universities: "The universities are a kind of microcosm of US society in the sense that they encompass all the different kinds of activities. And in a typical university that has a fairly strong space-oriented activity with a department of aeronautics and astronautics, that department of aeronautics and astronautics as a community consists of a little group of enthusiasts, zealots if you like, who have an enormous drive to work in space-related activities, but they are embedded in a larger university that doesn't really have that same zeal. It has a much broader view and though it's sometimes a little bit difficult to believe it, the world does not turn around on space activities, even in the universities". He advocates the need for increased funding to meet the goal of (American) leadership in space, pointing out that 6 billion dollars a year amounts to only 50 dollars per individual of the American population, which is small, considering the benefits it would give in the future. He suggests making the best possible use of the fairly large and diverse pool of talent and enthusiasm that exists in the universities. The foremost problem was in launch systems, and the cost of going to orbit would reduce only when launch systems could become as efficient and reliable as today's commercial aircraft. The National Aerospace Plane (a NASA/Department of Defence project) was proposed with this in view as a single-stage to earth orbit craft with air-breathing engines and propulsion systems.

The American Astronautical Society's Student Paper Awardee, Robert Sullivan, in his paper (Comparison of aerodynamic roughness measured in a field experiment and in a wind tunnel simulation) described a study on how well aeolian roughness measured over scale models in wind tunnels correlates with actual values of aeolian roughness measured in the field, with the aim of application to Martian (and other planetary) aeolian processes. The Award, presented during the Symposium, as well as the Student Programme following it, were intended to enthuse students about space technology as a career, considering that students participated actively in the part of the programme intended for them (Your future in space: opportunities and challenges). They were addressed by a 'Blue-Ribbon' Panel comprising eminent speakers: Dr. Noel W. Hinners of NASA Headquarters (Sciences), Alan M. Ladwig, also from NASA (Civil space/Federal), Caleb B. Hurtt, President, Martin Marietta Corporation (Industry), Louis C. Marquet, Vice-President, Atlantic

Aerospace Electronics Corporation (Military), and participated in the discussion. Mr. Ladwig told the students that NASA was investigating 'Why space exploration?'. The rationale was: not for prestige, but (a) to advance science, expand knowledge, (b) to expand human civilization into the solar system, to improve international harmony, to encourage space enterprise, to prospect and to create a highway in space. Mr. Caleb Hurtt pointed out that design engineers, procurement people, test engineers, test technicians, quality control engineers and production engineers were required for the space programme. Mr. Louis Marquet emphasised innovation: "It is our innovation, the innovation of the West, that we believe is a very important and critical factor in our long-term defense".

Additionally in the Technology Session, there were four talks and a panel discussion by Edward Gabris, NASA (Mission concepts for human exploration of the solar system), Bernard P. Burke, MIT (The technology challenge of future science missions), Joseph P. Kerwin, Lockheed Missiles and Space Company (Human spaceflight at the turn of the century) and Rainer Weiss, MIT (Space science in the 21st Century). The panel discussion report yields several interesting points: the move to a 1300 nm operating wavelength for the fibre optic rotation sensor from 830 nm initially, and the use of a 320C16 radiation-hardened and single-event-upset hardened 16-bit microprocessor, after initially choosing the 80C86 radiation-hardened microprocessor.

Technology directions were addressed by Lawrence J. Ross, Deputy Director, NASA Lewis Research Centre (Introduction), Dr. William Ballhaus, Director, NASA Ames Research Centre (NASA technology—A path to the 21st Century), Dr. Raj Reddy, Director, Robotics Institute, Carnegie-Mellon University (Automation and robotics), Jerome P. Mullin, Vice-President, Sunstrand Corporation (Space power): Dr. Sanders D. Rosenberg, Aerojet Techsystems Company (Propulsion), Dr. Owen K. Garriot, Vice-President, Teledyne Brown Engineering and a veteran Astronaut (Humans in space) and Peter A. Bracken, Vice-President, Martin Marietta Data Systems (Data and information systems). A panel discussion featuring a variety of subjects follows these talks.

The volume provides somewhat light reading in view of the *verbatim* reproduction of each of the talks, the panel discussions and the question-and-answer sessions, but a careful reading brings out valuable pointers for the reader, since it presents the American process of 'symbiosis' by informal presentations and group discussions, held in a free, frank and forthright manner. The volume is well worth adding to any research institution's library collection.

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Astrodynamics 1987 (Vol. 65 in Advances in the Astronautical Sciences) edited by John K. Solder, Arun K. Misra, Robert E. Lindberg and Walton Williamson. American Institute of Astronautics and Aeronautics, New York, 1988, Vol. 65, Parts I and II, pp. 1774, $150. Orders to Univelt Inc., P.O. Box 28130, San Diego, California 92128, USA.

The Astrodynamics conferences have been held annually since mid-1960s, managed on alternate years by the American Institute of Astronautics and Aeronautics (AIAA) and the American Astronautical Society. The two volumes contain the proceedings of the AAS/AIAA Astrodynamics Conference held on August 10–13, 1987, at Kalispell, Montana, USA. They encompass practically all gamut of topics in astrodynamics and the related subjects, presented in 26 sessions. Only the abstracts of the papers contained in the microfiche supplement are included in the proceedings for the sake of completeness. The themes may be broadly categorized into: celestial mechanics, orbit determination, orbit control, interplanetary missions, spacecraft dynamics, attitude determination, spacecraft attitude and shape/flexural control. However, this classification is generic in nature, and is not to be taken by its verbal sense

The science of celestial mechanics has a history of over several centuries. The earlier studies were primarily concerned with the prediction and estimation of orbits of the planetary and stellar bodies. These methodologies are now being modified for efficient implementation on digital computer. A total of sixteen papers and five abstracts are presented in four sessions on: Special NORAD section, Satellite debris and Orbital decay, Celestial mechanics and Orbital dynamics. With the proliferation of artificial Earth satellites, the analysis and management of free-flying debris have become prominent issues for the safe upkeep of the spacecraft. For this, it is necessary to construct a catalogue of all Earth-orbiting objects comprising satellites (23%), rocket bodies (14%), debris (60%) and other particles. The effect of eccentricity of satellite orbit, before its fragmentation, results in noticeable variation in the volume of the debris cloud. The accuracy of estimation of the debris movement depends on the precise evaluation of the ballistic coefficients which depend on the size and geometry of the debris.

The motion of a spacecraft under the gravitational field of a planet or Sun depends on the geometry of the planet/Sun. The complexities required of model gravitational field depend on its utility and computational requirements such as speed and accuracy. The simplest description can be obtained by assuming the Earth to be perfect sphere. Such equations are amenable for analytical/quasi-analytical solutions. The estimate of orbital parameters over a long period of time using such a simplified model is poor. In order to ameliorate this shortcoming, it is customary to include a number of zonal harmonics represented by J_2, J_3, etc., depending upon the requirement. With the development of a number of software tools, the methods of orbit determination with different models have now matured into a full-fledged discipline. These schemes are problem-specific, *i.e.*, depend on the type of mission, type of observation and mode of measurement, and most importantly the use of end results. In recent days, space-borne platforms are gaining larger acceptance compared to Earth-based tracking networks alone. The autonomous navigation systems may typically contain any one or combination of these: altimeter, doppler range and range rate measurement system, inertial systems like Sun and/or star sensors, to name a few. The altimeters can be mounted on a single satellite or two or more satellites operating on a cooperative basis. Meter-level accuracy in orbital radius, or height has been claimed. Judicial combination of the data of different sensors is claimed to provide exceptionally good parameter by the present-day standards. Of late, highly accurate orbit determination and/or ground topology survey has been possible using the radio signal-based measurements. The GPS (global positioning system) is a glowing example of a successful system. The estimation of orbital parameters from the noisy measurements in most cases is done with the help of extended/modified gain-extended Kalman filter, or least-square estimator with modified Newton's method, or sometimes, with simple observer. The ten papers presented in two sessions on orbit and precise determination, bring out the practical difficulties in terms of hardware and software plus the complexities involved in the modern orbit determination solutions. Detailed analysis of GPS system with regard to the number of satellites required for multifold coverage of the Earth surface, strategy for better orbit determination accuracy, efficacy of Kalman filter are contained in a special session on satellite constellations.

The companion problem to satellite orbit determination relates to the methods of orbit analysis. The numerical algorithm should be able to reconstruct the orbital elements accurately with the least amount of observation data from minimal ground stations. The knowledge of true position and velocity components for the satellite which appears again over the horizon after several rotations of the Earth is important for tracking and control. The long-term prediction of the orbit in the presence of external disturbances and unmodelled dynamics is, therefore, of paramount importance. Need also exists for semi-analytic theory for speedier computation of the orbit propagation. A total of nine papers and three abstracts presented in three sessions on Semianalytic satellite theory, Orbit analysis, Tracking orbit determination, outline diverse needs and application of orbital analysis. The emphasis of these works is on the accuracy that is targeted and achieved, efficiency, and the benefits obtained thereof. The methods of analysis presented herein are the result of employing the existing techniques to newer environment.

The satellites moving under central force motion are subjected to disturbances which arise from atmosphere, the presence of external bodies like say, Sun, Moon and Jupiter, oblateness of the Earth, solar radiation pressure, to name a few. The orbits also get affected by the launch inaccuracies. Owing to these, it is necessary to have orbit control. The nature of control methodology depends on the mission requirements, type of orbit, and orbital parameters such as altitude, inclination, eccentricity, and argument of perigee. Some problems in the above subjects are covered in three sessions on Satellite drag coefficients, Geosynchronous and high altitude orbit analysis and Orbit synthesis. Most of the near-earth satellites are employed for strategic/military, scientific and application-oriented missions. For accurate orbit control, reliable estimate of the aerodynamic forces is essential. As the dimension of the spacecraft, like, for example, space station, increase, a small error in estimate can show large variation in the performance, which is evident from the case studies reported. On the other hand, for satellites moving in high-altitude orbits, the presence of Sun-Moon, solar-radiation pressure plays an important role. Though these external disturbing forces cause periodic motion about the equilibrium position, the orbit control is necessary in view of the tight pointing requirements and to avoid collisions between satellites in the crowded space.

An important application of the orbit control is to raise the orbit of the satellite. Such an orbital transfer can be achieved through the use of continuous thrusting (usually low thrust) or through two or multiple impulses. This is done under the following three scenario. In the first case, the satellite is initially launched into a lower orbit. In another case, owing to external disturbances, the loss of kinetic energy results in the reduction of orbital height. Thirdly, the rendezvous/intercept between two satellites, one active and the other passive, can be achieved through the orbit control of active spacecraft. The problem of rendezvous can be thought of as a process of bringing the supply/probe spacecraft to the vicinity of a space station/target with least and possibly zero-relative velocity. In the intercept problem, the chaser tries to reach the target with the largest possible relative velocity but with the least relative distance. Usually, the rendezvous/intercept manoeuvers are done for the two satellites which are moving in the nearby orbit. This will help to reduce the cost of orbital transfer, and the complexities of the guidance logic. Under this circumstance, the simplified linear Clohessy-Wiltshire equation can be used to describe the relative motion with the target at the centre of the moving frame of reference. Here, the complete exercise is carried out with full cooperation between the two systems. On the other hand, evasive manoeuvers can be considered as the development of conflicting strategies by two active spacecraft. Here, one satellite tries to close in, while the other tries to move away. Both players/foes try to optimize their objective, may be with minimum fuel or some other cost criteria. However, the governing relation for relative motion can still be described through Clohessy-Wiltshire equations.

Considerable attention is paid to the analysis and synthesis of interplanetary mission in the 1987 Astrodynamics Conference. This is evident since as many as six sessions, containing 21 papers and eleven abstracts, depict several important developments in the field. Four prominent subject areas of concern to these missions focus attention on: (1) the type of trajectory, (2) the type of guidance (orbit control), (3) the type of autopilot (attitude control), and (4) the type of navigation and command system. An interesting concept on round-trip space travel indicates that a substantial savings of 30–40% in the initial load (basically consisting of propellants) required of a conventional launch vehicle or shuttle can be achieved by staging the ascent orbit and leaving fuel for the return trip at various stages of the orbit. Alternatively, a practical transportation system to, say Asteroids, suggests the launch of spacecraft into parking orbit, and subsequently put the spacecraft along the escape hyperbola for rendezvous with the target. Another important technological challenge of the twenty-first century, which has caught the imagination of many, relates to lunar mining, transportation to Earth orbit and final processing at the space station/factory. High-lift launch vehicle with liquid hydrogen-oxygen as propellant seems to be realizable in the beginning of the next century for such a mission. If time is not at a premium, then the most cost-effective means of space transportation can be built using the solar sails. This is a passive transportation system in the sense that no on-board fuel is required. This scheme looks very attractive that it has prompted the AIAA to institute an international design competition on Mars exploration for celebrating the 400 years of finding Americas by Columbus. Even for the spacecraft using other means of propulsion, the solar sail can be and is used additionally. Yet another popular and more powerful passive transportation system is due to gravity-assist missions. The Voyagers, Viking, Solar maximum mission, Galileo spacecraft all benefit from this concept. The only limitation of this scheme is the relative position of the planets in the solar system which will decide the shape of gravity-assist trajectory and time of travel, and limited launch windows. The gravity-assist missions have made a number of missions possible that would otherwise have been impossible/impractical to achieve. The examples being: the Polar orbit around Sun being realized by gravity pull of the Jupiter, or sending the satellite outside the solar system towards the inter-stellar region.

The NASA Mars exploration program heralds the new era of active interplanetary mission, which will begin following the long gap after successful lunar missions. It calls for a transportation to and fro from Mars, landing and collection of sample (mainly to explore extra-terrestrial life forms) with the help of Rovers. The other missions can be divided under outer and inner planetary explorations. Major spacecraft of this decade for exploration of outer planets (*i.e.* planets lying outside the Earth's orbit) are Voyager and Galileo. While Voyager has just crossed the solar system, Galileo has been launched very recently. The latter has sensor resolution of approximately hundred times that of the successful Voyager. It will also make extensive use of the gravity-assist manoeuvers. Cassini is yet another mission towards studying the Saturn and its satellites which has drawn considerable attention. The fascinating details of these missions presented at the Conference make exciting reading. Likewise, the Magellan mission to Venus is equally captivating. The challenges of such a mission are many and varied. Investigation into the constitution of comets is believed to be capable of unravelling the mysteries of the universe. This calls for the use of inner planetary probe for rendezvous with the comet when it approaches the Sun.

The dynamics of a satellite can be completely described by coupled translational motion (*i.e.* motion of center of mass), attitude/librational motion (*i.e.* rotational motion about center of mass), and the elastic/flexural vibration. During the past three decades, extensive studies have been carried out on the dynamics and control of rigid and flexible spacecraft, with publications running into several thousands. The failure of the spin-stabilized Explorer-I due to the energy dissipation in the tiny but elastic turnstile antenna opened the flood gate of research on dynamics of spinning elastic or rigid spacecraft with flexible appendages. The pointing requirement achieved with spin stabilization is poor, but the system is robust against disturbances and parametric changes. The three-axis control and stabilization through storable angular momentum devices is accurate but less robust. The marriage between these two by assembling the two sub-systems with the above stabilization means into a single system has been proposed for the Navy Remote Ocean Sensing System (NROSS). The critical issue for this configuration relates to the balancing of spinning part (in this case an antenna) over the three-axis platform in the presence of flexibility. Dynamical modeling and analysis has formed the main theme of six papers presented in the session on dynamics and control of rotating structures.

With the advent of space shuttle, Energia and other heavy-lift vehicles, a quantum jump in terms of size and capabilities of the artificial Earth satellites can be expected. As and when the interplanetary cargo transportation system gets realised to an economical scale, it may be possible to go for lunar mining for precious materials, and subsequent processing on the space factory at low Earth orbit. Space manufacturing of critical materials, like say, gallium arsenide (GaAs) single crystal, biological/medicinal products under microgravity will open up many possibilities and usher in a new generation of technological revolution. For a large-sized space platform, zero gravity exists at only one point on the satellite, with the gravity-gradient force increasing monotonically as one goes away from the center of the gravity point. The tethered platform has been envisaged, where the cable-mounted car will glide slowly along the tether so that microgravity condition will prevail within the car. The length of such tethers can run from a few to hundreds of kilometres. The main advantages of tethered sub-satellite at low altitude are longer operating life and applications to remote sensing and military surveillance. The dynamics of tethered system has been drawing considerable attention ever since the launch of the first space shuttle. The effects of flexibility, thermal flutter (thermally induced vibrations), aerodynamic and gravity-gradient forces and torques, Earth's magnetic field, coupled libration motion of main and sub-satellite are analysed through extensive dynamical models in six papers which are presented at the session on multibody dynamics and tethered satellite.

Tremendous progress has been achieved during the past one-and-a-half decades on dynamics and control of large space structures of dimensions ranging from a hundred metres to a few tens of kilometres. The analysis becomes progressively involved as the large structure is idealized as a beam or a column or still struss-type structure. Though the dynamical model of these elastic structures calls for theoretically infinite (large) number of degree of freedom, the selection of dominant modes for truer/faithful representation in not clear even now. Secondly, it is found extremely difficult to estimte the structural properties under low-g environment, as theoretical and ground-based experimental estimates are found to be inaccurate. Several identification methods have been specially proposed for these. Since dynamics has large degree of freedom with multi-actuators and sensors, it has become imperative to use modern control theory-based state-space model. The optimal control theory has been employed extensively for this purpose.

The papers presented at the Conference embody a large number of issues related to aerospace activities, which will not be found commonly at a single source. It also brings forward to the reader an advanced and quick means of information retrieval system. Both descriptive and mathematically balanced presentations are compiled in two volumes. Considering the rapidity of the information transmission and encyclopaedic structure, these proceedings are no doubt a great asset to aerospace engineers and scientists.

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The NASA Mars Conference, Vol. 71 in Science and Technology Series, edited by Duke B. Reiber. American Astronautical Society, New York, 1988, pp. 570, $50. Orders to Univelt Inc., P.O. Box 28130, San Diego, California 92128, USA.

The NASA Mars Conference was held to commemorate the tenth anniversary of the landing of the Viking spacecraft on Mars. The proceedings were developed by the Editor from the transcripts of the presentations held on July 21–23, 1986, at the National Academy of Sciences, Washington. The themes of the presentations were: our current knowledge and understanding of Mars, the present and future unmanned explorations of Mars, issues and options for the manned exploration of Mars.

Apart from welcome and keynote addresses, the proceedings contain a total of 27 papers. This volume offers an excellent insight into the understanding of Mars and the implications of space exploration. It uncovers the success story of human innovation and ingenuity for understanding the unknown. Mars is a very exciting and interesting planet for space explorators, atmospheric scientists, geologists, life scientists and those from many other disciplines. Though the data collected by Viking and other missions are enormous compared to the knowledge gained during earlier times, they represent mole on a mountain of knowledge to be gained. The future missions including the manned flight will hopefully remove the darkness with the knowledge.

The acquisition of knowledge on Mars probably started with the human civilization. However, the great leap forward in this direction started during the 16–17th century and further accelerated with the development of spacecraft during the present century. The present understanding of Mars is the sum of all the previous efforts. The first theme begins with the history of Mars, a perspective from a planetary scientist's point of view. The other topics covered include geology, volcanoes, channels, atmosphere, meteorology, water and volatiles of Mars. Case by case it shows how the Viking missions helped to enrich the understanding. The martian satellites, Phobos and Deimos, have been known for only a hundred years because of their small size and low-reflective properties. The Viking orbiter contributed dramatic new information about them. The question of the existence of life forms outside the Earth has been dogging the mankind for many centuries. It is now almost certain, if at all such a possibility exits within the solar system, it could only be on the Mars. This is because the planet had once running water on its surface and is now extremely inhospitable to life by its dryness and radiation flux. The proposed missions of near future may decide the uniqueness of the Earth.

The objective of the future missions is to answer many questions that have arisen in the earlier study mentioned above. The presentations under the theme Future unmanned exploration explain in detail the Mars Observer and the Sample Return Mission which probably become operative in post-1992. The details of the Russian mission and the Phobos are also discussed. The data are gathered with the help of two landers, as well as remote-sensing equipment on board the mother spacecraft in orbit. The US-built Mars Observer will be placed into a 361-km circular Sun-synchronous orbit for the science mission (mapping) activity. The Mars Sample Return Mission will be the most complex of all the interplanetary spacecraft designed so far. Since the design is evolving, the pros and cons of various options are weighted, and the conclusions are expected in due course. In summary, the proposed missions offer immense challenge to the present-day technologists.

The explanation most often given for the manned exploration of Mars is the opportunity it presents for more intensive and adaptive science, establishment of a systematic and technological gateway to the outer solar system, opportunity to exploit resources of Mars and its moons, and the encouragement of international cooperation. It also provides opportunity for adventure of very high standard, as in the past. The scaling of Mount Everest, the discovery of America, and other such achievements have contributed to the satisfaction of man's desire for some thing new and test for endurance, and the development of aviation and space technology has contributed to the progress of society. The proceedings contain discussions on round trip between Earth and Mars, transportation systems, key technologies for effective transport from Earth (which is critical in the round trip, as gravity on Earth is nearly three times that on Mars), working environment to be developed, life support and evolution of long-term biological system on Mars.

This excellent book has a very wide reader appeal and encompasses tremendous wealth of information in a single source. It is an extremely useful reference manual for all libraries, scientists, technologists, and even general public.

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Space–A new community of opportunity (Advances in the Astronautical Sciences, Vol. 67) edited by William G. Straight and Henry N. Bowes. Published for the American Astronautical Society by Univelt, Inc., P.O. Box 28130, San Diego, CA 92128, USA, 1989, pp. 453, $70.

This proceedings is based on the 34th Annual AAS International Conference held in 1987 in Houston, Texas. The volume covers ten panels which deal with a wide range of topics in space technology, space science and applications. Each panel presentations are followed up by a discussion session. In addition, two keynote addresses included in the Introduction discuss many problems of the US space programme and what needs to be done in the near future. A summary of many of the major issues which were brought up during the conference appear in the concluding session.

The technical panels cover topics under the following headings: Space utilization and application; Flight mechanics/Guidance and control (i) Expendable launch vehicles and upper stage modernization and (ii) Aerodynamics and planetary missions; Rocket propulsion; Astronomy, astrophysics and solar system exploration, Life sciences; Tracking and data systems; Structures and composite materials; Automation and robotics (i) Space station, and (ii) The Moon, Mars and beyond; and Space station/Large structures. The theme presentations give the state-of-art of the subject without going into the technical details. Many papers discuss space-related investigations which are to be taken up in the near future. The US governing policies and issues are discussed in a separate panel.

At the time of the Conference the US space programme was severely affected by the space shuttle 'Challenger' disaster. A sort of diffidence prevailing in the space scientists community is reflected in the various discussions. The possibility of losing leadership in space activities in the absence of clear-cut goals and objectives in the US space programme had been a matter of concern of several speakers. It was not that the space scientists did not evolve a long-range space programme for the US. The so-called 'Dr. Sally Ride Report' recommended at least four major goals. These goals are, a space study of Earth, a manned mission to Mars, a manned lunar base and an unmanned programme of space exploration. However, there being big goals, the government had still to take a firm view on these programmes. Among the immediate missions listed, is the National Aerospace Plane. The plane designated as X-30 vehicle is a research vehicle to demonstrate technologies associated with single stage-to-orbit vehicles with a small pay-load, about 2500 lbs. These include airbreathing propulsion across the speed range from the start of roll on the run-way to orbital velocities of M25, and demonstrating this capability using horizontal take-off and landing using integral take-off and landing gear.

Another major programme is the establishment of the space station. Use space not for going to Mars or the Moon but to create better life here on Earth could be one of the main objectives of the space station. However, the reluctance of the US to throw money into the heavens shows itself in the current debate over the level of spending for the international space station. It is generally realized that private industry may get involved only after a proven demonstration of the superiority of products processed on space station under zero-g condition. So far, however, outside of communications (satellites), space business has not been commercially exploited. When the space station becomes operational by mid-1990s, it would be necessary not only to make its full use but to keep it competitive with international developments. The major emphasis would then be how to cut down the cost of the various operations. Should one use unmanned expendable launch vehicles (ELVs) or manned flights is space? For cargo transportation the Shuttle-C, C for cargo, an unmanned system, is planned. Such a shuttle is already being used by the Russians. The selling of space products and technologies to the devoloping countries is also mooted as a major objective of the space station.

Besides the long-range missions, a number of planetary exploration missions, such as Galileo, Ulysses, Magellan, Mars Observer, Lunar Geochemical Orbitor, Cassini, and Mars and Comet Nucleus sample return missions, have been planned. The planning and status of these missions along with deployment of Hubble Space Telescope gives a glimpse of the exciting happenings in the 90s. It is also realised that the long period manned missions need a careful study of the effects of zero-gravity and space radiations, and also psychological effects of long term living together in space environment on human body. The life sustenance requirements also have to be carefully estimated. The results available from the limited experience gained so far have been the subject of discussion of the Life Sciences panel.

Advanced technology missions in the field of communication, tracking and robotics have been proposed for space station as well as for Moon, Mars and beyond. Similarly the planning studies cover extravehicular activities (EVA), space constructions, dynamics of large structures, etc.

By and large, the proceedings provide a good overview of the major US space activities as contemplated at the time of the Conference. Obviously, since the plans and emphasis are time dependent, the discussions could be only of transient value. The style of presentation of the papers is quite informal. The editors could have saved a fair amount of pages by cutting down the rather verbatim introductions of the speakers! The proceedings is bound in the typical hard cover of the AAS publications, although several pages (p. 307 to 310, and p. 323 to 330) are missing in the reviewer's copy.

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Guidance and control 1988 (Volume 66, Advances in the Astronautical Sciences) edited by Robert D. Culp and Paul L. Shattuck. American Astronautical Society, P.O. Box 28130, San Diego, California 92128, 1988, pp. 560, $75. Orders to Univelt, Inc., P.O. Box 28130, San Diego, CA 92128.

The Guidance and Control series reports the proceedings of an annual fare—the Annual Rocky Mountain Guidance and Control Conference. However, this particular volume has a special significance—it marks the beginning of the second decade of holding the Conference series. In a highly dynamic and intensely active field of research and development such as space science/technology, ten years is a long time, and those who have kept touch with the conference series through the years will notice a definite maturing of the contents of the series. As the reach of the space missions consolidates its expansion from the near-earth space into the interplanetary space, the next decade in space exploration is poised to see a renewed interest in permanent manned stations, solar system exploration, highly complex satellite systems for scientific research and military applications, and the commercial exploitation of space. This first volume of the second decade already points the direction towards such developments.

Aerospace applications have always demanded the best in a host of disciplines from material sciences to computer sciences; indeed, they have spurred entirely new disciplines to appear, and others to grow fast. The theme of Section I in the volume is illustrative of this fact. Spacecraft attitude control is of course an established discipline, but such hyper-accurate systems as a twenty-milliarcsec pointing system for a rolling spacecraft based on yet-untested concepts of the relativity theory not only represent a quantum jump in technology but provide stimulating intellectual exercise. Such systems acquire a special significance in view of the 'Star Wars' programme, and those beyond. Similar is the situation with autonomous attitude control for spacecraft, in which knowledge-based systems provide human-like control capabilities to the spacecraft.

The storyboard display section of the volume continues to follow the Star-Wars-related thrust. A simple demonstration of laser beam stabilization, inertial line-of-sight stabilization using fine steering mirrors, etc., and rapid retargeting and precision pointing simulator discussed in this section cover aspects of the larger R and D effort in connection with the Star Wars programme.

'Offboard' navigation and attitude systems is an interesting coinage, and the main actor in this section is the global positioning system (GPS). With more and more of the GPS satellites being put into orbit, the system is coming ever closer to delivering its full accuracy in navigation and time signals, and it is natural that this highly capable satellite navigation system (though originally designed for surface/air navigation) be fully exploited to provide space navigation and pointing functions.

The section on space station system control techniques deals with the essence of engineering judgment especially for large systems. In such systems, usually there are a number of options, all capable of meeting the performance requirements, and a choice between these options has to be based on a comprehensive analysis of factors other than performance. In the particular case of space station system control, a tradeoff analysis at Honeywell's Satellite Systems Division using parametric methods identified as many as thirteen different arrays which could meet performance characteristics. A parametric determination of penalties in weight, power, volume, safety, maintainability, verification requirements, control requirements and life-cycle costs indicated that a single-gimbal configuration provided the best solution for the space station's active momentum exchange and out-performed equivalent double-gimbal configurations for a given level of reliability. An interesting concept in this section is that of a 'quiet structure' involving active and/or passive damping, for precision pointing of payloads.

The section on recent experiences is always an important part of the volumes in the series. Indeed, this is one part that distinguishes the series from most other conference proceedings reporting essentially on academic developments. In this particular volume, a number of actual missions are discussed, with emphasis on specific findings and experiences gained. The experiences in control system adaptation from the Voyager programme are a significant step in the important area of adaptive spacecraft control. More experiences in satellite attitude control are obtained from the in-orbit performance analysis of the Astro-C satellite. The topic of satellite control for manoeuver is discussed in an article on the in-flight experience derived from the Exosat Spaceborne Observatory. Mission guidance aspects are considered in two articles on the Delta 180 mission, describing the in-orbit guidance and the terminal guidance and control experiences, respectively. Lessons are drawn from the Titan 34D-9 failure investigation and recovery, and an experiment on the tracking of missile plumes is discussed.

All in all, the volume is a rich and diverse reportage of the latest and the best in the American space navigation, guidance and control scene, and the allied aspects of instrumentation. Coming at a time in which the US space programme in general was eclipsed by a series of costly and morale-shaking failures, and in which the popular press was sceptical of many aspects of the space programme, the volume does show that the inherent strength of continued and broad-based programs is not diminished by such temporary setbacks and that the science and engineering of space exploration remain a challenging and vigorous front from which lessons continue to be learnt and at which successes continue to be achieved.

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The Soviet cosmonaut team by Gordon R. Hooper. GRH Publications, 36, Burry Hill, Melton 1001, Woodbridge, Suffolk IP12ILF, England, 1986, pp. 320, $25. Distributed by Univelt, Inc., P.O. Box 28130, San Diego, CA 92128, USA.

Ever since the first manned flight by Yuri Gagarin, the Soviets have kept their lead in manned space missions, both in terms of the number of missions undertaken and the manhours spent by an individual cosmonaut in space. Complexities of these missions demand that the men and women selected for flying in the spacecraft should not only have immense amount of training but also impeccable careers. The details on these aspects are not adequately covered in various mission reportings. This book is a comprehensive guide to all the men and women of the Soviet manned space missions. It lists all the manned missions of the Soviet Union till date and brings together the available information on the Soviet cosmonaut team. Although only brief accounts of the various missions are given, the book concentrates on the lives and careers of the cosmonauts themselves.

The book is divided mainly into two parts. The first part, 'Background section', lists all the Soviet manned missions, their crewing, selection procedure, their support and backup assignments, the time spent in space by each cosmonaut, call signs, etc. It also includes the Intercosmos programme, which consists of cooperative ventures with other countries including India and France. The crewing policies, mission profiles and rationale behind Intercosmos flights are given. The second part, 'Cosmonaut biographies', gives fairly comprehensive biographies, most of them with photographs, of every Soviet and Intercosmos cosmonaut, including those of the only two women cosmonauts– Velentina Tereshkova and Svetlana Savitskaya. Of a total of 86 biographies, there are 21 cosmonauts from 11 different countries under the Intercosmos programme. Each biography covers in detail the educational qualification and experience, training, mission profile, hobbies, family background, etc., of the cosmonaut.

It is apparent that many details of the Soviet manned space missions remain unknown. In such instances the author has tried to put together various pieces of information to speculate the scenario. The amount of details given regarding crewing, selection procedure, mission profiles, their failures and successes, etc., is indeed exhaustive. It is noteworthy that all the cosmonauts selected have been either professional pilots or engineers. The Russians hold virtually all the world records on the amount of time spent by humans in space. Altogether they have accumulated about twelve cosmonaut-years of time in space. Of this, the two women cosmonauts' share is only 23 days. The biography section lists many interesting episodes of the cosmonauts' lives.

Overall, it is an interesting and unusual book. Unusual, in the sense that information given is not available in any another single volume. By using small script, it carries more material than expected in 320 pages. The publication of the book has been timed to mark the 25th anniversary of the world's first manned flight by the Soviet cosmonaut Yuri Gagarin in April 1961. It indeed is a fitting tribute.

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Elements of thermal science for engineers by C. P. Gupta and Rajendra Prakash. Nem Chand & Bros, Civil Lines, Roorkee 247667, 1989, pp. 452, Rs. 50.

The authors with their vast experience in teaching thermal engineering subjects at both under- and post-graduate levels have produced a nice textbook on the elements of thermal sciences that could be used by the under-graduate students of all engineering disciplines. As observed by the authors, it is only in the recent past that many universities have introduced a core course on thermal sciences to all engineering students replacing and integrating the earlier subjects like applied thermodynamics, heat engines and prime movers. Unfortunately there are very few books which could be used as a single textbook for this course on thermal sciences. Therefore the book is a welcome addition.

Following an introductory chapter on the basic concepts, the authors take up in turn the laws of thermodynamics, vapour and gas power cycles, boilers, steam engines and turbines and then heat transfer by conduction, convection and radiation. As a rule, the authors have tried to illustrate each principle and its application by a worked example. SI units have been used throughout. However, I find a conspicuous omission of the following topics: refrigeration cycles, gas turbines, critical thickness of insulation and heat exchangers. A basic knowledge of all these topics is very essential for all engineers.

In Chapter 10, a discussion on the thermal conductivity of solids is given towards the end of the chapter whereas it would have been more apt to introduce it right at the beginning of the chapter.

The text is generally clear but there are some printing errors which, I am sure, would be rectified in the next edition.

The ordering of chapters is good and the coverage is generally adequate. I believe that many students will find this book quite useful. The authors could have included a bibliography to help the students who want to do some further reading in the subject.

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