

Bulusu Lakshmana Deekshatulu

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B. L. Deekshatulu is among the very first Ph Ds in engineering in India. Born in a small town Aska in Odisha, he attended school in his native town and later joined the Banaras Hindu University (BHU) for undergraduate studies in engineering. He was at the Indian Institute of Science (IISc), Bangalore for his Master's in electrical engineering and later Ph D with H. N. Ramachandra Rao, an illustrious guru of those times. Deekshatulu encouraged many youngsters to consider research and Ph D as an option at a time when obtaining an engineering degree meant jobs in industry and public sector undertakings. Most of his M E student projects have resulted in publications in reputed journals. His academic tree with more than six sub-branches spans several continents resulting in more than 300 Ph Ds in areas such as control theory, artificial intelligence, computer science, computer vision, machine learning, game theory, power systems, manufacturing systems, remote sensing, pattern recognition, neural networks, to name a few. His scientific contributions include theory as well as building on the ground facilities. The Department of Space has benefitted immensely from his contributions. A simple person, easily accessible, frank, suspicious and careful, Deekshatulu is certainly a role model for young scientists and engineers.

His academic and research profile growth has been phenomenal starting with academic research at IISc, IBM TJ Watson Research Centre, USA, Willow Run Laboratories, University of Michigan, USA and later at the National Remote Sensing Agency (NRSA) as Head of the Technical Division, and then as its Director, Director of the Centre for Space Science and Technology Education in Asia and the Pacific (a UN Affiliated Centre), Dehradun, ISRO Visiting Professor at the University of Hyderabad, Chairman, Governing Council of the National Institute of Technology (Warangal), Distinguished Fellow of IDRBT (Hyderabad), and Chairman of Board of Governors at the College of Engineering, JNTU, Hyderabad.

Childhood

Deekshatulu was born on 31 October 1936 as a posthumous child. He was brought up by his mother and grandfather initially, and by his elder brother subsequently. He got all the encouragement from his elder brother, a Mathematics Professor with Odisha Government who noticed the potential, brilliance and capabilities of his younger sibling. He studied at Board High School at Aska till 10th class and the 2-year Intermediate course at SCS College, Puri, and SKCG College, Parlakimidi, both in Odisha. He then joined the four-year B Sc Electrical Engineering course in BENCO at Varanasi in 1953 as a stipendiary of Odisha Government.

As an undergraduate, Deekshatulu was interested in research-oriented academic activities. He once gave a one-hour colloquium on 'electric traction' after an extensive literature survey and won Rs 20 as cash prize. He wrote an article in the college magazine on 'Cutting tools and cutting tool materials' which received appreciation. His curiosity for research was driving his mind to think on topics such as: How to determine the equilibrium state for the liquid in a small partially filled bottle, perturbed by an impulsive force. Pran Nath (Paris) ignited his interest in advanced mathematical techniques, essential in engineering research. It is no surprise that he worked on nonlinear systems for his Ph D later.

Higher education

A turning point in his educational career was his admission to the M E programme in Power System Engineering with a scholarship at IISc. For him it was a dream come true as he nursed a deep desire to study and do research at IISc which has an excellent library, all-round academic ambience and a sprawling campus. He passed M E with a first class first rank and distinction. The academic success at M E level catapulted him to take up his much wanted research programme leading to Ph D in 1960. He

took up his research with P. Venkat Rao on nonlinear systems. Soon Rao had to leave for IIT Madras for a better opportunity leaving Deekshatulu without a guide. He was not disappointed but took it as a challenge. His faith in the Divine, brilliance supported by research papers and library became his guide. He was the first to arrive and last to leave the library round the week and eventually publishing research papers. John Zaborszky of Washington University, USA mentioned in his 1963 letter: '*....I would consider the sum total of your collections of papers, a suitable D Sc thesis anywhere*'. He completed his Ph D in 1964 in a record time with top class single author journal publications, in journals such as *AIEE (IEEE) Transactions on Applications and Industry* and won post-Ph D National Institute of Sciences (NIS) fellowship. He was awarded the Martin Foster Gold Medal for the best Ph D thesis by IISc for the year 1964. His trait of visiting the library continued even after he became a professor and research supervisor. He would show up at the library on Friday evenings at 6.00 PM, when the latest issues of the journals were displayed in the library, and he would make sure that his students are also present. The following Monday morning reprint requests will be sent by him and his Ph D students. In the early 60s access to computers was limited in India. There was one computer accessible at Hindustan Aeronautics Limited and one had to commute for hours to access it. There was no internet and e-mail. Postal access was the only means for scientific discovery. He grabbed the opportunity and started his research in linear and nonlinear systems, optimal control with minimal computer usage and time.

His friendly attitude, easy accessibility and connections with higher authorities provided him an opportunity to get excellent Ph D students. He was able to persuade good students to go through higher studies in India rather than going to USA which was the norm of the times. He mentored students in all areas of control: multivariable systems, time-varying systems, optimal control and stability theory to name a few. He was interested

in the budding areas of medical signal processing, pattern recognition, computer vision and remote sensing. It is true that IISc gave him the start up into high profile research activity, it is equally true that IISc got immensely benefitted by his presence to attract good students, starting state-of-the-art Master's and Ph D programmes.

Career at IISc

Deekshatulu contributed to the seeding and growth of control systems in all its aspects, both by way of research publications and by introducing M E level subjects such as nonlinear control, multi-variable, adaptive optimal control, pattern recognition, bio-control, etc. Control activities emerged from here. He planned and designed lab experiments in control using the servo analyser and CRT circuitry.

His contributions in the field of nonlinear control systems include phase plane analysis, new phase planes for analysing a variety of nonlinear and time varying systems including determination of time along trajectories and the stability aspects. His papers at J. Franklin Institute include circle approximation to the phase plane trajectory and extending the Krylov–Bogilobov method to damped oscillatory systems. He developed a novel technique for evaluating the describing function for any nonlinearity. Many papers were published by his group in the *International Journal of Control* under his guidance.

The outburst of control activities in the EE Department at IISc is mainly the research he carried out with his M E and Ph D students, and due to the invited talks by experts in these disciplines from USA, USSR and a few from India.

IISc recognized his merit by appointing him in quick succession as Lecturer, Assistant Professor, Associate Professor and Professor within a 6-year time frame, and at 33 years he was one of the youngest to become a Professor. During 1971–72, on sabbatical from IISc, he worked at the IBM TJ Watson Research Center, New York, USA, for one and half years. He also spent some time at the Willow Run Laboratory (now Environmental Research Institute), Michigan. His research on digital image processing and remote sensing was started here. He visited many facilities of remote sensing and

image processing which widened his horizon in this particular discipline. He chose to return to India, determined to utilize and propagate education in Digital Image Processing and Remote Sensing, through IISc, and worked for national interest.

Deekshatulu organized an All India workshop on Digital Image Processing (DIP) in 1973 at IISc which was attended by Fred Billingsley from JPL. During this period, remote sensing was in its infancy in India. A few experiments were conducted by P. R. Pisharoty (PRL and SAC, Ahmedabad) during this workshop.

Deekshatulu set up a colour photo processing laboratory at IISc and developed the Drum Scanners (gray scale and colour versions) for converting images into computer compatible digital form and vice versa. The scanner was built around a discarded workshop lathe machine and using a tarpaulin cloth for creating the dark room effect from 6 to 9 PM everyday. Though crude, the scanner generated sufficient curiosity in the minds of eminent people like Satish Dhawan, B. D. Nag Chaudhuri (the then Member, Planning Commission), M. G. K. Menon and others who made efforts to visit his colour photo processing laboratory after 6 PM to observe its functioning. Aerial flights were conducted using multispectral cameras fitted into a refurbished Pushpak (flying) aircraft of IISc. The flights were conducted over the GonniKoppal citrous plantation and sugarcane fields in Mandya, Karnataka, during 1973–75 under an ISRO funded (with SAC participation) MARSIS project.

A post-graduate elective subject on Digital Image Processing and Remote Sensing was started in the EE Department in IISc.

Through his passion and drive, Deekshatulu attracted talented research students who are now professors, research

scientists and Fellows of Academies. He is a great academic grandfather and his laboratory became a breeding ground for Ph Ds in the larger electrical and computer engineering disciplines.

Personal life

Around the time when he was embarking on crossing the numerous challenging academic milestones, Deekshatulu decided to cross a personal milestone. His marriage was solemnized with Kameswari in December 1967. His friends often say they remember Kameswari's hospitality and tasty food, more than the benefit they got from research.

Institutional development

Deekshatulu started several new initiatives. He contributed to the starting of the M E programme in Applied Electronics and Servomechanisms at IISc. It was a timely initiative when India was launching its rockets and missile programme and also when ISRO was starting the space science programme. He has also contributed a great deal to the establishment (initial stages) of the School of Automation at IISc. It was the first interdisciplinary department drawing people from Electrical Engineering, Electronics and Communication Engineering, Mechanical Engineering, Aerospace Systems, Computer Science and Mathematics. Both these programmes/departments are flourishing today under the updated names of System Science and Automation M E Programme, Computer Science and Automation Department, a fitting tribute to Deekshatulu's vision.

Contributions to NRSA and ISRO

The National Remote Sensing Agency (NRSA), a new operational and research institute at national level was established in 1975 under the Department of Science and Technology. In 1976, his leading expertise and research contributions in digital image processing and remote sensing brought him from IISc, Bangalore to NRSA, Hyderabad, as head of the technical division. Globally, remote sensing was an emerging scientific tool to study the Earth as a system. Again Deekshatulu found himself in a challenging situation for contributing in new areas



Young B. L. Deekshatulu and his wife Smt Kameswari: his main strength of life.

of R&D. He established one of the best computer facilities for remote sensing data processing, image processing, photoprocessing and data archival facility. He also participated in setting up of a reception and data processing facility for American earth observation satellite *LANDSAT* in 1978, which was later upgraded to receive all Indian remote sensing satellite (IRS) systems. This station enabled satellite data reception over India and neighbouring countries in real time. The large user community and departments found new opportunity for studying natural resources and providing valuable input for disasters. NRSA had a fleet of aircraft which played an important role in meeting the growing requirement for large scale mapping through aerial photography. To process the aerial films and to prepare high quality prints of aerial and satellite images, he established one of the most sophisticated photo processing laboratories at NRSA, Hyderabad.

Deekshatulu became the Director of NRSA in January 1982. His dynamic leadership, art of involving users, academicians and researchers opened new avenues for remote sensing technology and application in India. Realizing the importance of industry partnership for transfer of technology to meet the requirement of analysis and interpretation instruments among the large user community, he initiated developments of such equipment as additive colour viewer, image analyser, dual densitometry, microfiche camera, optical reflection projector, and satellite image processing systems in collaboration with small scale industries leading to technology transfer and production which ultimately saved foreign currency. He initiated many programmes to develop software and hardware to receive and process the data. Digital Image Processing (DIP) was his passion. 'A picture is equal to thousand words' used to be his common statement. He promoted DIP in remote sensing, forensic sciences, biomedical, texture design and strategic applications. He demonstrated how techniques like enhancements, compression, texture analysis, classification (parametric and non-parametric), segmentation and expert system for data analysis, add value to the image and provide information. During his visit to US (1971–72), he saw a model of drum scanner and that became his agenda for development at IISc. He knew that if this can be indigenously

developed, it can save huge foreign currency. He had a prototype ready at IISc and continued the development of an operational version and a colour version at NRSC. Finally, when the success came and the technology was transferred, the effort was recognized and won many awards. Satish Dhawan (Director, IISc and Chairman, ISRO) encouraged him in his work on remote sensing, digital image processing and development of instruments like drum scanner.

In the area of remote sensing application, he brought up many user-defined projects for the management of natural resources. He had a special approach for motivating multidisciplinary scientists and engineers with diverse background

by organizing brainstorming discussions. In a path-breaking and pioneering effort, he organized a team within NRSA to carry out the first ever forest cover mapping (suggested by Satish Dhawan) using two time periods (1972–75 and 1980–82) of datasets. Realizing the importance of forest cover monitoring and proving the base line, he guided the team with all necessary organizational support. The study reported unprecedented deforestation and loss of about 2% forest cover in a decade. The results created an open debate among the foresters and environmentalists. There was uproar in the Parliament and many people doubted the veracity of remote sensing techniques. However, the joint ground checks proved



Satish Dhawan reviewing the progress made by NRSA for developing drum scanner.



Prime Minister P. V. Narasimha Rao being briefed about the flood situation in the state in 1991, through satellite images.

LIVING LEGENDS IN INDIAN SCIENCE

the numbers by NRSA to be correct. Ultimately the technology was accepted as a scientific tool to monitor forest cover. Today the Forest Survey of India (FSI), an organization under the Ministry of Environment and Forests, provides biennial assessments of forest cover using this technology. The implementation of this project opened up the need for many new national level projects, viz. wasteland, groundwater, land use and integrated Mission for Sustainable Development and Watershed Planning with funding by user ministries under the National Natural Resource Management System (NNRMS). He encouraged scientists to undertake research in different areas to develop newer applications in the fields of agriculture, earth sciences, oceanography and water resources. He set up a programme in different thematic areas to address disasters like floods, drought, cyclone, forest fire and landslides. These areas subsequently evolved as a major initiative for operational service.

During the mid-80s ISRO planned its own Indian remote sensing satellites and launched its first satellite *IRS-1* in March 1988. It is here that Deekshatulu brought in a new era of change by upgrading NRSA earth station to receive IRS series satellite datasets and provided high quality of diverse satellite products to user community from different application areas to overcome the technology denial of computer systems to India. NRSA developed systems software to process satellite data, quality products with increasing volume and speed requirements. The Space Applications Centre (SAC) at Ahmedabad was a major participant in the total endeavour. Deekshatulu worked on scaling up research to generate operational products for potential fishing zone maps and other ocean parameters in collaboration with SAC. He spearheaded the effort for preparing real-time products on potential fishing zone and disseminated relevant information to the fishermen of east and west coast of India.

Deekshatulu successfully built three institutions as Director NRSA, namely, Indian National Centre for Ocean Information Services (INCOIS), Advanced Data Processing Research Institute (ADRIN) and Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). INCOIS under the Department of Ocean Development (DOD) has its seeding from the NRSA Oceanography Department. Deekshatulu

was instrumental in the formation of Marine Satellite Information Service (MARSIS) programme of the DOD, presently under the Ministry of Earth Sciences/DOES and Department of Space. A methodology was developed for retrieval of sea surface temperature from NOAA-AVHRR data which is a fundamental oceanography parameter and operational national SST retrieval programme when he was Chairman of the Steering Committee of the Programme. This led to an operational ocean remote sensing programme in the country executed at NRSA and SAC and supported by NIO, IITM and C-MMACS.

One of the most important societal activities of this programme is to generate potential fishing zone (PFZ) advisories to the fishermen in the country. This was given high priority by the Government of India as a social benefit programme.

After the successful completion of the first phase of the programme, an international Workshop on 'Application of satellite remote sensing for identifying and forecasting potential fishing zones in developing countries' was organized under his guidance at Hyderabad during 7–11 December 1993. MARSIS programme was continued in its second phase for further improvement under his leadership, mainly focusing on ocean microwave remote sensing programme for the development of methodologies, for retrieval of wave directional spectrum and utilization of wave spectral energy to the off-shore industry.

He was Chairman of the Steering committee on DOD's MARSIS programme, which established the National Ocean Information System (NOIS) with partnership from various ocean and atmospheric centres in the country. Ocean *in-situ* data was brought on a common platform (MARSIS systems), archived and exchanged across the national oceanographic and atmospheric centres. He also initiated retrieval of vertical profiles of temperature and humidity from NOAA-TOVS data at NRSA, which was later operationalized by India Meteorological Department (IMD) at Delhi.

Realizing the benefits of the programme, DOD established INCOIS in 1997 which was a precursor of MARSIS programme. As a member of the Governing Council of IMD, Deekshatulu emphasized the need for modernization of observation systems and effective use of satellite data for weather forecasting,

which contributed in helping IMD for generation of operational SST and retrieval of atmospheric profiles from meteorological satellites. He also chaired the Indian Ocean Argo Implementation Planning Committee for the Indian Ocean.

With this background, Deekshatulu was given the responsibility as Chairman Indian Geosphere Biosphere Programme (IGBP) during 1994–1997, with its constituent committees covering many aspects of geosphere, biosphere and atmosphere, including land cover changes. The results of these measurements and blending of *in-situ* and satellite data analysis have immensely benefited the IGBP community as whole. As Chairman, Working Group-III, ISRO IGBP, he guided actively the projects under land-ocean-atmosphere interaction. ISRO was appreciated for making most significant contributions in the Geosphere Biosphere studies in India.

He established Data Inspection and Screening Cell (DISC) leading to formation of ADRIN. His interest in precision remote sensing application has made this possible as he saw its growth under the institutional work outside NRSA.

He took great interest in shaping the programmes at Indian Institute of Remote Sensing (IIRS) which was a part of NRSC till 2010. He involved many leading researchers, academicians and natural resource specialists to revise the syllabus and the course content for post-graduate studies and research. With this background, he was entrusted with the responsibility of establishing an International Institution, viz. CSSTEAP under UN as a founder Director.

In a short span of six years, with his dynamic and never ending energy, he could establish the centre for excellence and shaped it as a role model regional centre for United Nations Office for



Deekshatulu honouring space scientist A. P. J. Abdul Kalam who delivered CSSTEAP convocation speech.



M. G. K. Menon and U. R. Rao inspecting IRS-IA satellite images received, processed and printed at NRSA.



Deekshatulu and N. S. Randhava, Director General of Indian Council of Agricultural Research.

Outer Space Affairs (UNOOSA). He could attract one of the best national and international faculties to the centre.

Deekshatulu chose to push forward the remote sensing applications which had relevance to the grass root applications and directly benefitting the society. The waste land mapping provided 13 categories of under-utilized land and had potential to increase the green cover of India.

Some of the new areas which got evolved during his leadership are: (a) Identifying agriculture crop types, acreage and yield estimation; (b) identification of saline/alkaline soils (over irrigated areas) and their monitoring; (c) mapping of potential groundwater areas through geological fractures/lineaments; (d) detecting and monitoring forest fires; (e) detection of oil slick's in oceans

surfaces; (f) estimating irrigation efficiency in command areas; (g) estimation of snow melt run-off in the Himalayan rivers; (h) mapping areas affected by floods and making damage assessment; (i) cyclone monitoring and crop damage assessment after the landfall and a host of other applications of very practical relevance. He always believed that applications of remote sensing are unlimited, limited only by our imagination. His personal research focus at NRSA was on artificial intelligence and expert systems. He established a dedicated laboratory where the best brains and researchers worked. He got recognized internationally and nationally.

He has guided 18 Ph Ds and has more than 150 research publications. He has also guided over 80 M Tech student dissertations.

Distinctions and awards

Deekshatulu is a Fellow of 15 Scientific and Engineering Academies including Fellow IEEE (USA); Fellow of The World Academy of Sciences (Italy); Distinguished Fellow IETE and Distinguished Fellow of Astronautical Society of India; Hon. Member Asian Association for remote sensing; Fellow of Indian National Science Academy, Indian Academy of Sciences, Indian National Academy of Engineering, National Academy of Agricultural Sciences, Computer Society of India, etc.

Awards: Deekshatulu was bestowed with many prestigious National and International awards: Bharat Ratna Sir M. Visveswaraya Award for 'Outstanding Engineer' in 1984; NRDC Invention Awards in January 1986 and in August 1993; Dr Biren Roy Space Science Award in 1988; Padmasri in January 1991; Brahm Prakash Medal for significant contributions to Engineering Technology; Om Prakash Bhasin Award for Science and Technology for 1995;

Sivananda Eminent Citizen Award in December 1998; Boon Indrambarya Gold Medal by Thailand Remote Sensing and GIS Association in November 1999; Aryabhata Award by Astronautical Society of India, Distinguished Alumni Award from IISc in 2006; Life time Contribution Award from ACRS, Beijing in October 2009, etc.

Deekshatulu served as Chairman of Remote Sensing Applications Missions India 1987–1996. In 1981, he served as UN/FAO Consultant in Beijing during November 1981. He was the Government representative in the UN/ESCAP/RSSP Directors' meetings and Inter Governmental Consultative Committee meetings from 1985 to 1995. He also served as UN/ESCAP Senior Consultant during September–November 1996.

He was a Member in the Quinquinal Review Team (QRT) for IARI for 1990–1995, and Chairman of the QRT for 2000–2005 for National Bureau of Soil Science and Land Use Planning, Nagpur.

Currently, he is a Distinguished Fellow, IDRBT Hyderabad and Chairman, Board of Governors (BoG), College of Engineering JNTUH, Hyderabad.

Deekshatulu is a person with childlike innocence, witty, motivator to young researchers and strong administrator who continues to be active with his passion for research, development and teaching.

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