COMPENDIUM
OF
MEMORIAL LECTURES

60 1953-2013
GLORIOUS YEARS
IN THE SERVICE OF THE NATION

IETE DIAMOND JUBILEE
सह वीर्यं करवावहै
1953-2013

THE INSTITUTION OF ELECTRONICS AND
TELECOMMUNICATION ENGINEERS

President

Dr S Pal

Dist FIETE, FIEEE, FNAE, FNASc, FIET (UK), MIAA (Paris).

IETE Publications Committee

Shri Harsh Vardhan	**Chairman**
Wg Cdr D N Misra (Retd)	Co-Chairman
Col Balraj Anand (Retd)	Member
Brig (Dr) V K Panday (Retd)	Member
Shri P K Singhal	Member
Dr S Arivazhagan	Member
Dr C Ghanshyam	Member
Col (Retd) K S Chakaravarthi	Member
Wg Cdr K C Bhardwaj (Retd)	Member
Shri S C Rudra	Member
Prof S R Jog	Member
Prof M Jagadesh Kumar	Editor-in-Chief (TR)
Prof S K Kaul	Editor-in-Chief (JR)
Prof Raj Senani	Editor-in-Chief (JE)
Prof (Dr) M L Goyal	Co-opted
Wg Cdr (Prof) P Prabhakar (Retd)	Co-opted
Prof S K Wasan	Co-opted

Diamond Jubilee Celebrations Committee

Shri R K Gupta	**Chairman**
Prof (Mrs) K Raja Rajeswari	
Lt Gen (Dr) A K S Chandele, PVSM, AVSM(Retd)	
Shri P S Sundaram	
Shri V K Singla	
Dr M H Kori	
Shri S R Jog	
Shri H O Agrawal	

Secretary General

Shri S R Aggarwal

Asstt Secy (ARP)

Mrs Sandeep Kaur Mangat

IETE MEMORIAL LECTURES

The Institution of Electronics and Telecommunication Engineers
2, Institutional Area, Lodi Road, New Delhi - 110 003

Web site http://www.iete.org

Printed and Published by Shri S R Aggarwal, Secretary General, for
the Institution of Electronics and Telecommunication Engineers,
2, Institutional Area Lodi Road, New Delhi-110003 (India)
and printed at the Dolphin-Printo Graphics, New Delhi (India)

Asstt Secy (ARP): Mrs Sandeep Kaur Mangat

CONTENTS

RAM LAL WADHWA AWARD LECTURES

FOREWORD

It is with great pleasure that IETE presents you this copy of Memorial lectures as part of the 60th Anniversary celebrations of the Institution of Electronics and Telecommunication Engineers (IETE) and as one of many tributes to the memory of some illustrious Indian scientists.

This compendium consists of a few annual Memorial Lectures organized by IETE and delivered on the platform of IETE during last ten years. IETE Annual Memorial Lectures provide a forum for eminent personalities to share their views on issues concerning society and the areas of interest to us. An Institution like ours attempts to make its vast accumulation of knowledge readily and easily available to all who seek it, in form of such publications.

I hope that the information provided in this compendium will be useful to the fraternity of IETE, researchers and stakeholders in pursuit of their higher knowledge. This is a very apt way of showing our regard to erstwhile scientists, like Homi Bhabha, Vikram Sarabhai, Sir J C Bose and Sir C V Raman, who were devoted to professionalism and it will be helpful to motivate our younger generation of scientists and engineers for indulging in constructive and path-breaking inventions.

I wish that the Institution with its clear policies strike on a progressive path unhindered and hope that such publications drive the Institution to greater heights of achievement and glory.

Dr S Pal
President
Former Prof Satish Dhawan Professor
Senior Adviser, Satellite Navigation(ISRO)
Distinguished Scientist, Associate Director
Prog Director Satellite Navigation &
Chairman GAGAN-ISRO Satellite Centre-Bangalore

Nov 07, 2013
New Delhi

PREFACE

As the Institution completes its successful journey of sixty years, the Diamond Jubilee celebrations Committee decided to bring out this admirable series of publication.

The compendium is a compilation of selective Memorial lectures delivered during past ten years at IETE. These Lectures were instituted in the memory of great Indian scientists, engineers and technologists who brought glory to this nation. The lectures have been delivered by eminent personalities, who gave an in-depth overview of the topics. This manuscript will help disseminate the knowledge & understanding to IETE fraternity and academic society.

The Memorial lectures are important features of IETE technical conventions and symposia. The first lecture-Bhabha Memorial Lecture was started in 1967 in IETE Annual Technical Convention to commemorate the memory of India's physicist and eminent engineer, Dr Homi Jehangir Bhabha. To perpetuate the memory of another eminent space scientist, Dr Vikram Sarabhai, IETE started the lecture series in 1973 and added it as a permanent feature of Mid-Term Symposia. In 1995, Sir J C Bose Memorial Lecture was started to mark the centenary of his path-breaking invention on Radio & Microwave optics. Subsequently, in 1997 IETE initiated Sir C V Raman Memorial Lecture in the honour of the first Nobel Laureate Scientist of India. Besides these Memorial Lectures, this compendium contains Ram Lal Wadhwa Award Lectures, based on the R&D work done by the awardees in the field of electronics & telecommunication engineering.

We have divided this volume in different sections and each section starts with the introduction of the eminent scientists in whose memory the lectures were delivered. It is gratifying that the lectures have been carefully selected and compiled in this compendium. It is our earnest hope that this endeavour will be useful for readers. This compendium will promote knowledge of scientific information and general awareness about our professional standards.

Finally, I would like to take the opportunity to acknowledge the valuable efforts of all individuals in bringing out this report, especially the HQ staff.

Nov 07, 2013
New Delhi

R K Gupta
Chairman
Diamond Jubilee Celebrations Committee

1909 - 1966

DR HOMI JEHANGIR BHABHA *needs no introduction. He was a well-known atomic scientist, engineer and administrator. It was unfortunate for the community of scientists and engineers that this genius was suddenly snatched away in an air crash in January 1966. His versatility was so great that he made monumental contributions to many areas of science and technology including electronics. The setting up of the vast electronics complex at Hyderabad and the preparation of Electronics Committee Report known as Bhabha Committee Report are significant contributions, which he made to the development of electronics in this country. His involvement in the development of knowledge of Science and Engineering was so intense that most of the organizations connected with these fields, considered his death as their personal loss. The Institution of Electronics and Telecommunication Engineers (IETE) was one of them. It was decided to perpetuate the memory of this great Scientist by institutionalizing a lecture series, which is held every year during Annual Technical Convention of IETE.*

Role of Communications Satellites in National Development

G MADHAVAN NAIR

Former Chairman, ISRO & Secretary to Dept of Space, Govt of India

Recognising the immense potential of communications satellites for establishing connectivity to far-flung and remote areas and for using television broadcasting for mass education, India undertook experimental projects to demonstrate the need for having a domestic communications satellite that paved the way for establishing Indian National Satellite (INSAT) system, Starting with multipurpose communications satellites INSAT-1 series combining telecommunications, TV broadcast and meteorological services procured from abroad, ISRO embarked on design, development of more advanced INSAT-2, 3 and 4 series of satellites indigenously.

The telecommunications, TV broadcast, radio networking and meteorological services were operationalised with INSAT-1 system in 1983. While providing uninterrupted services to the country in the above areas, ISRO undertook several innovative experiments using communications satellites. Staring with using INSAT satellites for training and developmental communications, societal applications such as tele-education and tele-medicine facilities were established. Use of INSAT satellites for disaster management support has also been established. A new concept namely Village Resource Centres (VRC) combining the services of INSAT satellites and Indian Remote Sensing (IRS) Satellites for providing holistic services at village level has also been operationalised.

INTRODUCTION

Late Dr Vikram Sarabahai, the founding father of Indian Space Program had envisioned that space technology is a powerful tool, which can play a vital role in the development of the country and can be used for the benefit of common man.

The potential of space technology for mass education, especially in terms of omnipotence, visual power and outreach was recognised in the early 1970s. ISRO undertook in 1975-76, the Satellite Instructional Television Experiment (SITE) to telecast educational TV programs on health, hygiene, agriculture, adult education etc., to cover 2500 villages in six states using the US satellite ATS-6. It was the largest sociological experiment ever carried out in the world.

The Satellite Telecommunications Experiment Project (STEP) conducted using the Franco-German satellite Symphonie during 1977-79 was another major demonstration of long distance satellite telecommunication application of space.

The objectives of STEP was to provide a system test of geosynchronous satellite for domestic telecommunications and to enhance the country's capability in the design, development and operation of various ground systems required and to acquire competence in the operation of systems for satellite telecommunications.

The demonstration of space applications in SITE and STEP for developmental communications, TV broadcast and for domestic long distance telecommunication and the experience gained through design, development and operation of APPLE satellite in 1981 paved the way for establishment of INSAT system.

INSAT-1 Satellites

The first generation INSAT-1 series of satellites was a unique design combining telecommunications, television broadcasting and meteorological services in a single platform. The involvement of various users like the Department of Telecommunications, Ministry of Information and Broadcasting and India Meteorological Department enabled realization of INSAT system towards identified national needs. INSAT-1 series of satellites were procured from Ford Aerospace Communication Corporation (FACC).

Each of the satellites in INSAT-1 series weighed about 1200 Kg with about 11.5 sq.m of solar array of five panels, involving multi axial deployment in orbit to provide 900 W at the end of seven years of life.

Each INSAT satellite was designed to provide 12 national coverage C band transponder of 36 MHz bandwidth each, 2 high power S band national coverage transponders for TV broadcast and five low level carriers for radio program distribution, disaster warning and dissemination of standard time and frequency signals and VHRR instrument for meteorological imaging in the visible and infrared channels.

2.1 Second Generation INSAT Satellites

Second generation three axis stabilized INSAT-2 series of satellites, weighing over 1900 kg and having Much higher capacity compared to the first generation INSAT's, were developed indigenously by ISRO. These satellites carried 12 C-band and 6 extended C-band transponders, two high power S-band transponders, a data relay transponder and an improved VHRR with a resolution of 2 km in the visible and 8 km in the infrared bands.

INSAT-2E, launched in 1999, incorporated many new technologies in spacecraft design including ASIC based TTC and AOCS systems and shaped beam and dual grid antennas to increase payload capacity. The meteorological payload of INSAT-2E included VHRR with 2 Km resolution in visible band and a water vapour channel having 8 km resolution and a Charge Coupled Device (CCD) camera operating in the visible, near infrared and short wave infrared bands with 1 km resolution. The satellite has been operating since its launch with eleven 36 MHz equivalent C-band transponder capacity.

2.2 Third and Fourth Generation INSAT Satellites

Rapid expansion of VSAT services and growing demand from communication and broadcasting services necessitated the development of third generation INSAT's which began with the launching of INSAT-3B which carried 12 extended C-band and 3Ku band transponders in March 2000.

Since then INSAT-3A, 3C and 3E each weighing in excess of 2,700 kg have been launched to provide extensive communication capability in C, extended C and Ku bands and also enhancing the sensitivity of VHRR As the communication payloads grew in capacity and capabilities, it was decided to separate communication and meteorological spacecrafts, to avoid constraints put by one payload on the other.

Accordingly a dedicated meteorological, satellite, originally named as Metsat, weighing 1 ton and carrying VHRR payload with water vapour channels and a data collection transponder was launched on September 12, 2002.

GSAT SERIES OF COMMUNICATION SATELLITES

Indigenously developed communication satellites launched by the Indian Geo-synchronous Satellites Launch Vehicle (GSLV) form the GSAT series of satellite. GSLV MK-1, in its very first developmental test flight on April 18, 2001, succeeded in placing an experimental communication satellite, GSAT-1 weighing 1540 Kg, into a Geosynchronous Transfer Orbit (GTO). Subsequently, other satellites in this series, GSAT-2 and GSAT-3 (also called as Edusat) were launched.

GSAT-2 carries four C-band transponders, two Ku-band transponders and a Mobile Satellite Service (MMS) payload.

EDUSAT is India's first exclusive satellite for serving the educational sector. It is specially configured for audio-visual medium, employing digital interactive classroom and multimedia delivery. EDUSAT was built around a standardized spacecraft bus called 1-2K. It has certain new technological elements - a multiple spot beam antenna with 1.2m reflector to direct precisely the Ku-band sport beams towards their intended region of India, a dual core bent heat pipe for thermal control, high efficiency multi-junction solar cells and an improved thruster configuration for optimized propellant used for orbit and orientation maintenance.

3.1. Telecommunications and Broadcasting

Currently about 90 earth stations are operational on INSAT under government owned Bharat Sanchar Nigam Limited (BSNL) network providing 3840 IDR channels. More than 60,000 Very Small Aperture Terminals (VSAT) are operating with 90 hubs in the government and private sectors.

Doordarshan, another government owned TV service-provider, is providing about 60 channels for national, regional, Digital Satellite News Gathering (DSNG) and VSAT services through 11 C band transponders in the INSAT system and 2C band transponders in PAS10. In Ku-band DTH service they transmit 50 TV and 20 Radio Channels through INSAT, NSS-6 and PAS10 satellites.

AIR is operating 40 Radio Networking (RN) channels is S-band, 53 RN Channels in C-band and 12 number of DSNG using INSAT S and C band transponders. Doordarshan and All India Radio (AIR) use satellite medium to transmit the signals to their 1406 and 231 terrestrial transmitters, respectively for local rebroadcast. They cover 70% of Indian landmass and 95% of population.

In addition the Direct to Home (DTH) satellite broadcast covers almost 100% landmass except islands. More than 8 million households in India are now receiving the DTH satellite TV and radio transmissions from national and private broadcasters.

3.2. Special Applications

Meteorology

Indian Meteorological Department (IMD) is regularly provided with VHRR imagery through Kalpana-1 satellite. About 22 pictures are taken in a day. Meteorological Data Distribution (MDD) service is up-linked from the earth stations at Secunderabad on round the clock basis. The Data Relay Transponders (DRT) of Kalpana-1 and INSAT 3A are being used by the IMD, Central water Commission, Narmada Control Authority, Snow & Avalanche Study Establishment, Andhra Pradesh Government and VRCs for hydro meteorological data collection, water management, flood forecasting, snow assessment, etc. for almost two decades now. Over 300 Automatic Weather Stations are using the Kalpana DRT for data collection from remote/unattended platforms.

3.3 Disaster Management Support and Search and Rescue

ISRO has been a part of the international satellite-based search and rescue system COSPAS-SARSAT since the early 1990s. This system uses six Low Earth Orbit(LEO) and four Geostationary Equatorial Orbit (GEO) satellites of which one GEO satellite is provided by India. ISRO, therefore, has a special status, among 40 member countries, as a geostationary space segment provider, in this system.

Two Local User Terminals (LUT) located at Bangalore and Lucknow are connected to the international search and rescue network and support 121.5 MHz, 243 MHz and 406 MHz beacons. These LUT's are a part of the international maritime organization's Global Maritime Distress and Safety System (GMDSS) as also the International Civil Aviation Organization (ICAO).

India Meteorological Department also uses satellite medium to transmit cyclone warnings in the local language of the coastal area that may get affected due to impending cyclone. These Cyclone Warning Dissemination signals are transmitted from Area Cyclone Warning Centres of IMD at Chennai, Mumbai and Kolkata earth stations.

SOCIETAL APPLICATIONS PROGRAM

India was amongst the first few countries to explore the use of satellite communication for carrying Education and Development oriented information and services to the rural masses. The applications started with Satellite TV Broadcasting to school and rural communities in the mid seventies. With the growth of telephone networks, the broadcasting networks were adopted for one-way video two way audio (return audio on phone) networks for Training. The further development in VSAT technologies, let to applications like telemedicine, tele-education and VRC's.

4.1 Satellite Based Development TV and Training

More than 6000 receiving centres so far have been set up across the country under TDCC programme and more than 10 lakh participants/functionaries of more than 60 departments of various state governments have been trained in these centres.

4.2 Tele-Education

In order to bring the modern developments of the satellite based multimedia communications to the education sector in the country, Edusat a satellite dedicated for education-was launched. The launch of this satellite has led to a revolution in the utilization of satcom networks for education. ISRO is supporting the setting up of VSAT networks for education in all the states and union territories of India by providing one hub with teaching end and few interactive terminals for remote classrooms. Under Edusat utilization program, two types of satellite based (Edusat satellite) VSAT network, interactive terminals (SIT's) and receive-only networks using Receive-Only-Terminals (ROT's) are being setup in various states across the country for promoting universal education.

4.3 Tele-Medicine

Telemedicine is one of the important applications of space technology for societal development. The tele-medicine facility connects the hospital & Community Health Centres located at remote locations with super-specialty hospitals for providing expert consultation to the needy and under served population. Tele-medicine system consists of customized medical software integrated with computer hardware along with medical diagnostic instruments. The program was initiated by ISRO in 2001 as a pilot exercise in five locations but is now being rapidly expanded to cover entire country. The telemedicine networks have been able to provide connectivity to the remotest locations in the country like the Andaman and Nicobar Islands, the Lakshadweep islands, the Northeastern Hilly regions, and the snow covered mountainous regions of Jammu and Kashmir.

Mobile telemedicine vans have also been deployed by ISRO for taking the telemedicine facilities to the remote villages where the permanent patient end is not setup.

In addition to this, tele-medicine network is also used for providing Continued Medical Education (CME). Several Specialty Hospitals and Medical Colleges are providing CME programs to keep the doctors and health workers informed of the new practices, treatments plans, advances, unique case studies, etc.

4.4 Village Resource Centres

Satellite based communication and remote sensing technologies have demonstrated their capabilities to provide services related to education, healthcare, weather, land and water resources management, mitigation and impact of natural disasters, etc. To provide these space-based services directly to the rural areas, ISRO has initiated a program to set up Village Resource Centres (VRC's) in association with NGO's and trusts and state and central agencies concerned. VRC's are envisaged as single window delivery mechanism for a variety of space based products and services, such as tele-education; tele-medicine; information on natural resources for planning and development at local level; interactive advisories on agriculture, fisheries, land and water resources management, livestock management, etc; interactive vocational training towards alternative livelihood; e-governance; weather information; etc. VRC's also addressed a variety of social aspects locally, and can act as help lines.

More than 350 VRC's have already been setup across the country and the programme, so far, has been a great success. The expansion of the network is planned in a big way in the coming years.

EMERGING TRENDS IN SATCOM

Globally, today there are more than 6000 transponders in Space. The growth of transponders requirement over next five years is predicted to be only moderate- about 8000. Multi-media, IP-TV, mobile TV and high definition TV are emerging as new application areas. The migration to Ku band for broadband services rather appears to be slow. The spacecraft bus is still hovering around 4T class, through there are few heavier class spacecraft in the range of 5 to 6 Tons.

In the next five years, two major developments are expected in the terrestrial communication area. The number of mobile phones with 3G and multimedia capability will increase considerably and Wi-Fi and Wi-Max systems with broadband multimedia delivery capability will be increasingly used for fixed communications. Large-scale penetration of these two technologies in the Indian scenario will have two major implications on satellite communication services. The first, bandwidth in the 430 MHz, 800 MHz, 1800 MHz,. 2.1 GHz, 2.3 GHz, 2.5 GHz and 3.4 GHz bands will be taken over substantially by these services and the second, the cost per Hertz for these terrestrial services will be much lower than the satellite bandwidth charges for similar capability. This will mean that the SATCOM bandwidth lease charges will have to be substantially reduced to remain competitive. Use of advanced modulation techniques for increasing the throughput (bits/hertz) will become necessary to remain competitive. Use of satellites will be increasingly made for connectivity to remote and inaccessible places where no other medium is economical. The satellite systems are increasingly being used for disaster recovery of telecom networks. Other emerging fields are digital multi-media broadcast, back haul link for WiFi/Wimax network and mobile communications.

The roadmap for the Indian Space Program has been planned considering these emerging trends and to meet the expected demands of satellite-based services within the country.

FUTURE ROADMAP OF SATELLITE COMMUNICATIONS PROGRAM

- Augmentation of INSAT/GSAT space segment to meet the demand of 500 transponders by end of 2012.
- Development of high power Ka-band satellites and ground systems for point-to -point connectivity.
- Development of cost-effective 4T-12KW bus with capacity of more than 50 transponders and flexible enough to accommodate wide range of payloads.
- New communication services including multimedia broadcast, broadband services, high definition TV, satellite-based tele-surgery and innovative communication media for education and training, and mobile communications.
- R&D in satellite communication technologies such as multiple spot beam communication payload, multiple beam frequency reuse, reconfigurable beams, onboard data regeneration, etc...,
- Development of low cost indigenous ground systems including hand held communication system for voice and data communications for strategic users, low cost least maintenance tele-medicine equipments and software, ground systems compatible for MEO SAR payloads.
- Institutionalization of ongoing developmental programmes like tele-education, tele-medicine, Village Resource Centres (VRC's) with the involvement of Central Government Ministries/ Departments, State Governments and NGO's self-sustenance and large scale training.
- Communication systems and support for disaster management.
- Progress towards self-sustenance of INSAT/GSAT systems and enabling private sector role in Indian Satellite Systems.

AUGMENTATION OF INSAT/GSAT SPACE SEGMENT

The INSAT/GSAT system currently has 199 transponders. Keeping in mind the growing demand and the need to maintain on-orbit spares, it is planned to create transponder capacity of about 500 by end of 2012. In order to meet the above demand, the planned satcom mission comprise of a mix of small, medium and large satellites compatible with GSLV Mk II, Mk III and procured launches. The planning takes into account the continuity of services for Search and Rescue as well as Data Collection system for meteorological services.

An advanced meteorological satellite INSAT-3D is scheduled for launch in 2008-2009. Digital multimedia and data broadcast satellites with multiple beams in S-band have also been planned. It is also proposed to realize hand -held terminal capable of receiving broadband services. With the INSAT and GSAT missions planned during next 5 years, the total capacity by end of 2012 is expected to reach 500 transponders as shown in Fig 3 in tune with the estimated demand.

A multimedia satellite, INSAT-4E/GSAT-6, is being built to provide satellite based multimedia service using high power transponders in S-band and regional beams covering India. This will cater to requirements of the multimedia service requirements of both fixed and mobile consumers including societal, education and strategic needs via fixed, portable and mobile video/audio receivers for vehicles. The satellite will have 5 spot beams in the CxS (BSS) band and a return link capability in SxC (MSS) band facilitating provision of interactive services and mobile communications. The satellite is being built around 1-2K Bus. The life of the satellite will be 12 years. To protect, sustain and expand the services for the long term, necessary back up capacity is being planned. Extensive use of the indigenously developed hardware is envisaged for the spacecraft realization including the 5.5 m unfurlable antenna.

CONCLUSION

India was among the first few countries to realize the potential of space technology to solve the real problems of man and society and took initiatives to develop the space technology for the benefit of the nation. Over the last four decades, India has achieved a notable progress in the design, development and operation of space systems, as well as, using them for vital services like telecommunication, television broadcasting, meteorology, disaster warning as well as natural resources survey and management. The space programme has become largely self-reliant with capability to design and build satellites for providing space services and to launch them using indigenously designed and developed launch vehicles. The Indian Space Program is application driven with emphasis on self- reliance.

The overall thrust of the space program during the coming decades will be to sustain and strengthen the already established space based services towards socio-economic development of the country. The program profile will be based on the emerging requirements in the priority areas of national development and security requirements and will take cognizance of the policy framework and global trends.

Author

Email: chairman@isro.gore.in

G Madhavan Nair graduated in Engineering from Kerala University in 1966 and underwent training at Bhabha Atomic Research Centre (BARC), Bombay. He is associated with the Indian space programme since inception, joining Thumba Equatorial Rocket Launching Station (TERLS) in 1967.

Shri Madhavan Nair has made outstanding contribution particularly in the development of launch vehicles, specifically, as Project Director, he led the development of Polar Satellite launch Vehicle (PSLV) which has since become the workhorse for launching mainly Indian remote sensing satellites.

As Director of ISRO's largest R&D Centre, Vikram Sarabhai Space Centre, he also saw India's Geo-synchronous Satellite Launch Vehicle (GSLV) successfully coming to fruition. Further, as Director of the Liquid Propulsion Systems Centre of ISRO, he played a central role in the design and development of the crucial cryogenic engine for GSLV.

Shri Madhavan Nair gave further fillip to space applications for societal development especially in implementing the EDUSAT programme for tele-educations and expanding the telemedicine network across the country. He embarked upon setting up the novel Village resources Centres, that facilitated access to spatial information on important aspects like land use/land cover, soil and ground water prospects and enabled farmers to take appropriate decisions through interaction with experts. VRCs also enabled to provide telemedicine and artisan training programme as well, thus acting as a powerful tool for rural development.

Shri Madhavan Nair has nurtured international co-operation having led the Indian delegation to various flora including the United Nations Committee on Peaceful Uses of Outer Space, International Astronautical Federation and Committee on Space Research. He has been awarded honorary doctorate from several Indian Universities. He has been decorated with many prestigious awards from professional bodies from India and abroad. He has been awarded Padma Bhushan by Government of India.

Science in Nation Building

T RAMASAMI
Secretary, Dept of Science & Technology, Govt of India

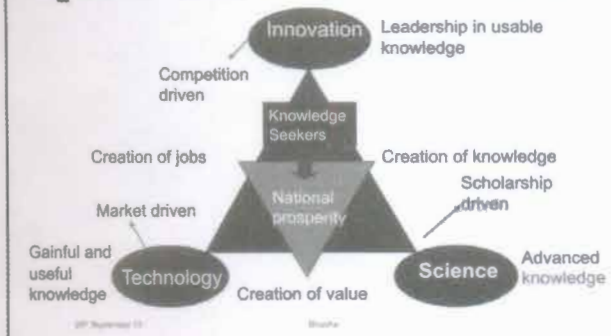
Science in Nation Building

Bhabha as an Inspirator
T Ramasami
Department of Science and Technology, GoI

Nation building Role for Science: An Emerging paradigm

- Scientists invest their creativity for generating new knowledge and gain peer leadership
- Governments invest public funds into Research and Development for generation of public strategic and social good
- Companies invest into Research and Development for gaining first-mover advantages in the market
- Countries invest into Science for building nations. Nation building role for science is new paradigm

Science, Technology and Innovation in global economy



Science as next driver of Value creation

In knowledge economies, creators of knowledge of science could contribute significantly to creation of value and jobs.

Bhabha: A living inspirator

- For people associated with Atomic Energy programme in India, the life of Homi Bhaba himself is an inexhaustible source of inspiration. To me he is beyond the atomic energy as well as his time. He remains an inspirational leader for scientists of many colours and disciplines and above all many generations. Therefore, I consider Bhabha as an inspirator for the use of Science in Nation Building.

Inspiration: Its special features

- Inspiration is an elevated state of mind. When thoughts are elevated, mind is able to receive positive signals and energies from both within. When the mind is inspired, it expresses a rare level of beauty and excellence. It extracts extraordinary values for the human effort and genius. An inspired mind is uninhibited and knows no limitations and constraints. It reaches a stage where the painful realities of mundane and dreary human habits vanish. In some sense, it is a stage of trance. Creativity prevails over everything moving and stationary, when the mind is truly inspired.

Vision setting for Energy: Bhabha in Nation Building

- Bhabha had a vision far ahead of time for peaceful applications of nuclear energy for power requirements. He propounded his three stage nuclear programme based on closed nuclear fuel cycle as early as in 1954. It was aimed at gaining technological self reliance. For him, technology denial was an opportunity for designing and developing technologies based on indigenous capacity in advanced and frontier areas.

Connecting discovery to solutions of national problems

- *"I venture to predict that a method will be found for liberating fusion energy in a controlled manner within the next two decades. When that happens, energy problems of the world will have been truly solved for a while, for the fuel will be plentiful as the heavy hydrogen in the oceans"*

India at the front of nuclear energy related technologies

- Technology denial made India invest into research in atomic energy
- Today Fast breeder reactor being established in Kalpakkam is emerging as the first global experiment. It is a technological marvel
- If India closed the nuclear fuel cycle and made Thorium based reactors deliver energy, she would have solved the energy problem for the herself and the world.

Electronics, Computers and Telecom sectors

- India has emerged as ith a major importer of electronic goods
  - By 2035 import electronic goods could exceed US$ 400 billion and even the oil bill!!
- In information technology, India became a major player
  - Value addition to Indian export of IT products is the next best step
- In telecom sector, India became a major player more than 900 million connections
  - Connectivity revolution needs nest infusion of science

Game changing Technologies

For Electronics, Computers and Telecom sectors: Needs of Modern India

Indian preparation

- Electronics Mission
  - India has launched an electronics mission
- National Mission on High performance Computing
  - Coordinated mission is being launched to make India arrive at the world od super computers
- Next Generation Communication Network
  - Several initiatives made to position India strong in the world of technologies in the sector

Evolving Policy Space

Science, Technology and Innovation Policy 2013

In favor of High Technology led path for India

Contextual Referencing of STI policy of India

Science, Research and Innovation System for High Technology-led for path for India ← Aspiration for Nation STIP 2013

Increasing Gross Expenditure on R&D for increasing outputs ← Ambition for science STP 2003

Articulation of principle SPR 1958

Attaining goals TPS 1983 → Focus on technological self reliance

→ Laying a Foundation for science and Scientific temper

- Science Research Innovation System for High-Technology-led path for India (SRISHTI)

  Is a policy goal

Capturing Aspirations

- Spread of scientific temper and Applications of science
- Making scientific careers attractive for youth
- Connect excellence with relevance
- Trigger mind set changes for value creation from knowledge
- Establish robust national innovation system
- Positioning India among the best five
- Enhance private sector investment into R&D
- Establish new PPP structures for creating value for R&D outputs
- New mechanisms for high risk innovations
- Foster cost effective innovations

Strategic Actions planned in alignment of STI policy 2013

- Balanced emphasis on Excellence and Relevance of Research themes
- Focus on "Discovery Science" for global competitiveness in cutting areas of science and increasing Indian share of papers in top 1% journals and resident Indian research in patents
- Stress on "Solution Science" for affordable solutions for problems of food and nutrition, water and sanitation, energy and environment, affordable health care, climate change adaptation and mitigation

Changing Indian Landscape In search of solutions

For those wanting to work on solution science, India is rich with large number of problems to solve

There is plenty of opportunity and challenges for purposeful innovations

Solution priority of people and states

Strength of India that she will be in 2035

	2010 India	2035 India
People	Demography	High aspirations
Education	High Volume	Volume and Value
Research	Expanding R & D Base	Leadership in some areas
University	Expansion Focus	Expansion and Excellence
Innovation	Affordable	Affordable and competitive
Industry	Economy of Scope	Economies of scale and scope

INSPIRE Scheme: For Shaping scientists for Nation Building

Evidence for attraction of talent to science is emerging.

(Innovation in Science Pursuit for Inspired Research) INSPIRE

28th September '11 Bhabha

INSPIRE (age group targeted)	Coverage achieved	Awards made	Gender parity	Remarks
Award (10-15)	28 states/7 UTs	10.1 lakhs 2,19,403 in 2012-13	47.6% F 52.4%M	All states and UT enrolled
Integship (16-17)	26 states/7 UTs; 770 camps	~1.8 lakh 55896 in 2012-13	42% F 58%M	50 NLs and 3500 mentors participated
Scholarship (17-22)	All India	12,000 up to 2011-12; 14,050 in 2012-13	40% F 60% M	School boards enrolled for reaching out
Fellowship (22-27)	All India	1402 up to 2011-12, 1340 in 2012-13	60%(848) F 40%(558) M	Agriculture research stimulated
Faculty (27-32)	All India	74 up to 2011-12, 196 in 2012-13, total 370 in position	34%(F) 66%(M)	Indian Diaspora welcome. One third of fellows is from overseas

INSPIRE Awards: Some Key Indicators

- National coverage established. As a measure of good Governance, E-Management process is initiated
- Gender parity (47.6% Girls) and proportional representation of communities with 15.2% Sc, 9.6% STs, 47.3% OBCs are emerging
- From among 5.2 lakh students two national level project exhibitions organized in Delhi (August 2011 and October 2012) involving 1752 students. Total of 128 students were awarded state, regional and national level awards.
- From among the national level exhibits, about 230 entries are being evaluated for provisional patenting by TIFAC
- An interaction meeting State, Regional and National level awardees with the Hon'ble President of India was organized

29th September '11 Bhabha

Thank you

Gandhi is not the Past... he is the Future for Science of India as well

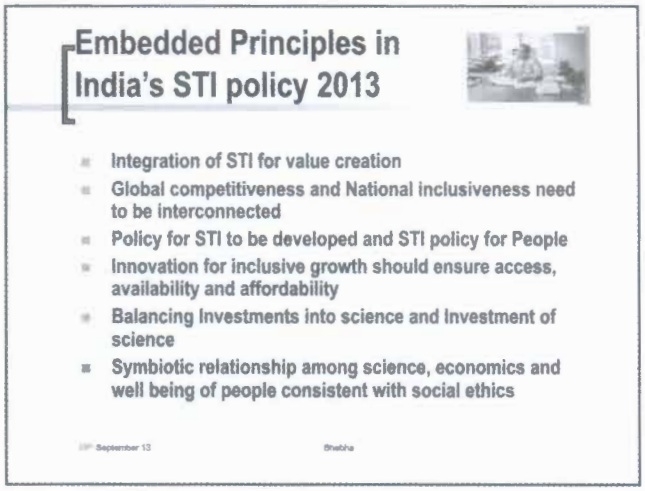
Bhabha remains even today as an immortal leader in Indian science because he spoke the language of the universe and saw more than any on the importance of science in Nation Building

29th September '11 Bhabha

Leadership: An Art of Persuasion

- Bhabha made the nation invest into his convictions and faith. To him, India of the future could not do without the use of nuclear energy.
- When other minds would have felt challenged by inadequacies of ambiance and environment, he took it upon himself to change what should be changed.
- Whether it was the Prime Minister of the Country or the most decorated Nobel Prize winners of the world or even the much despised civil servants, all of them listened to Bhabha, because he made sense to all to them in whichever language he spoke.

29th September '11 Bhabha



Author :

Email: dstsec @nic. in

Dr T Ramasami, currently Secretary to the Government of India, Department of Science and Technology, holds a Master's degree in Leather Technology from the University of Madras, India and PhD in Chemistry from the University of Leeds, UK. He has also worked on energy research in Ames Laboratory Iowa, USA and on electron transport phenomena in the Wayne State University, USA prior to returning to India for undertaking his scientific career. He joined the Central Leather Research Institute, Chennai as a scientist in 1984 and served as its Director for more than 10 years during the period up to May 2006. He is known among the scientific establishments in the country for his leadership to the Central Leather Research Institute.

Dr Ramasami has assumed the role of Secretary S&T in the Government of India since May 2006. He is currently engaged in the development of policies and programs for attraction of talents for study and careers with science, rejuvenation of research in universities, stepping up of international S&T cooperation, development of public-private partnerships in R&D sector and accountability of public funded research, development and demonstration. The Department of Science and Technology is aggressively engaged in the development of new models and mechanisms for enhancing the role of public funded institutions in innovations and research and development.

Dr Ramasami has a large number of publications in highly peer-valued journals and significant number of patents, which are under commercial exploitation. His research experience spans over several fields and areas in both basic and applied sciences. He has made some important contributions in the fields of inorganic chemistry as well as chemical and leather related technologies, which has earned him several professional recognitions in both India and abroad. These include Shanti Swarup Bhatnagar Prize for chemical sciences in 1993, election to all major science academies as a fellow as well the Third World Academy of Sciences and the National civilian award Padma Sri in 2001.

A Next Generation Turboprop: Why an Indian PPP for a Global Venture can now be a Winner

RODDAM NARASIMHA, FRS

DST Year-of-Science Professor, EM Unit, JLNCASR, Bengaluru

HOMI JEHANGIR BHABHA (1909-1966)

BHABHA AS SCIENTIST

Cosmic ray payload being launched from Central College, Bangalore

At his study, Bombay

THE MODERN SCIENCE PROJECT IN INDIA

From right:
Jawaharlal Nehru
Homi Bhabha
JRD Tata
Rustom Choksi

WHAT BHABHA DID 1/3

- Father of Nuclear Energy programme (DAE)
- Initiates Particle Physics (IISc 1939-45)
- Promotes Molecular biology (TIFR 1945-)
- Inspires TIFRAC, acquires CDC 3600 (TIFR 1955/1962)
- Plans for electronics (1963-65)
- Encourages space (Sarabhai, INCOSPAR 1962)
- Establishes modern mathematics (at TIFR)
- And : Astrophysics, Accelerators, Radio astronomy . . .
- Uncanny foresight in identifying significant game-changing developments in world science and technology
- Uncanny judgment in identifying gifted individuals who could take them forward

WHAT BHABHA DID 2/3

- Extraordinary ability to live simultaneously and creatively in the worlds of Science, Engineering, Administration, Politics and Art, integrating all of them in everything he did
- Path maker in India's Big Science project through the careful crafting of the Commission / Department / Organization structure that fitted into but expanded national administrative and political structure.

What the developed countries have and the underdeveloped lack is modern science and technology and an economy based on modern technology

-Address to ICSU, Mumbai 7 Jan 1966

THE GREAT MODERNISER: TRANSFORMS INDIAN SCIENCE AND TECHNOLOGY, LEAP-FROGS INTO POST-WAR HALF OF 20TH C.

WHAT BHABHA DID 3/3

- ..... the modern equivalent of Leonardo da Vinci

  – CV Raman at IASc, 1941

- He was one of our leading Social Engineers.

  – Prime Minister Indira Gandhi at inauguration of Homi Bhabha Auditorium, 9 Nov 1968

- ..... of all the men I have known.... Homi was the only one I would say was a complete man.

  – JRD Tata at release of HJB's *Collected Scientific Papers*, 27 March 1986

ATOMIC ENERGY LEADS TO SPACE

It is tempting to speculate that Vikram [Sarabhai] and Bhabha, the two princes of Indian science, used their youthful days in Bangalore to spin dreams for the future . . . sharing their precocious hopes in the rambling wild landscapes of the IISc or sealing a blood pact under the bright lights of the West End

– Amrita Shah 2007 *Vikram Sarabhai: A Life*

A NEXT-GEN TURBOPROP
Why an Indian PPP for a Global Venture can now be a Winner

Indian Turboprop 2018? Boeing SUGAR 2030?

RODDAM NARASIMHA
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore

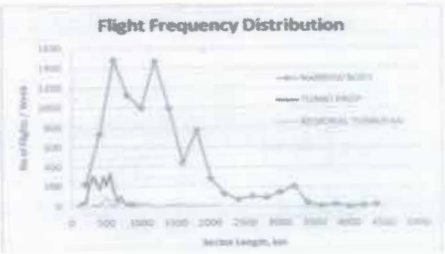
29 September 2012

Homi Bhabha Lecture, 55th Annual Convocation Institution of Electronic and Tele communication Engineers, Bangalore

CONTENTS

- Why Turboprop
- Why Indian PPP
- Why Global Venture
- What New Technologies?
- Why it can be a Winner
- How it could be done

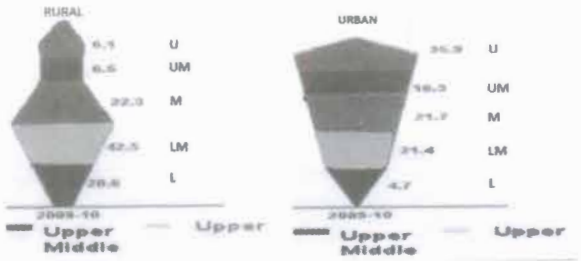
INDIAN JET MANIA IS BAD BUSINESS



Indian airlines using narrow body jets where turboprops are the optimal choice.

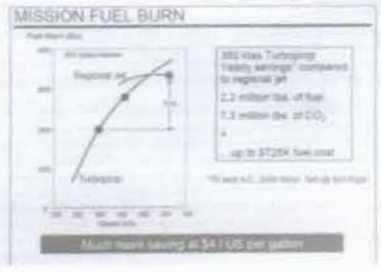
NCAD

THE INDIAN MARKET : RURAL = ½ URBAN



Source: R. Bijapurkar

TURBOPROP SAVES FUEL



On a 400 km route a regional jet burns 70% more fuel than a turboprop

NCAD

TURBOPROP DEMAND MIRRORS OIL PRICE

The turboprop trend is up

NCAD

ASIAN AIRCRAFT MARKET >1/3 GLOBAL

Boeing Forecast:
US$ 4.5T to 2031

India-Pacific is more than 1/3 of projected deliveries

AWST 9/7.2012

LOOK AT CHINA

- The Chinese civil aircraft industry is now preparing to be the 3rd largest in the world, next only to Airbus and Boeing.
- In 2007, the Chinese government announced major new initiatives in civil aviation and aeronautics, now considered by them more important than military aeronautics.
- In 2011, half of global profits in civil aviation made by China.
- China investing US$ 0.25T(~Rs 13 lakh crores) in aeronautics.
- Expects to be 10% of global market in 20yrs.
- COMAC has 13 western suppliers as partners.
- Cooperating with Indonesia in setting up industry in Indonesia.

RN 2012

CURRENT REGIONAL TURBOJETS/FANS 1/2

Aircraft	Produced (#)	Max Capacity (pax)	Status
Embraer ERJ-140	74	44+2	In Production, launched in 1999
Canadair CRJ100/200	> 430	50+2	In Production, first delivery in 1992
Embraer ERJ-145	648	50+2	In Production, first flight in 1995
Canadair CRJ700	310	70+2	In Production, entered service in 2001
Embraer ERJ-170	182	70+2	In Production, launched in 1999
Embraer ERJ-175	145	78+2	In Production, first flight in 2003
Embraer ERJ-190	402	98+2	In Production, launched in 1999
Embraer ERJ-195	88	108+2	In Production, first flight in 2004

CURRENT REGIONAL TURBOJETS/FANS 2/2

Aircraft	Produced (#)	Max Capacity (pax)	Status
Mitsubishi MRJ900	-	92	Flight testing 2013, delivery scheduled 2015
Sukhoi Superjet 100	-	103+2	First delivery April 2011
Comac ARJ21-900	-	105+2	First delivery scheduled 2013 end
Bombardier CS100	-	125+2	First flight test scheduled Dec2012, deliveries 2013
Kawasaki YPX	-	< 150	Based on Kawasaki P-1, currently undergoing flight tests

CURRENT REGIONAL TURBOPROPS

Aircraft	Produced (#)	Max Capacity (pax)	Status
Antonov An-140	1999-xxxx (8)	52+2	Entering Service
Xian MA60	2000-xxxx (23)	60+2	In Service, not certified by FAA
Ilyushin Il-114	1997-xxxx (15)	64+2	In Service
DHC 8-400 Dash 8 (Bombardier Q400)	2000-xxxx (64)	70+2	In Service
ATR-72-500	1986-xxxx (270)	74+2	In Service

TURBOPROPS VS TURBOJECTS/FANS

The turboprop is greener, more rugged

NCAD

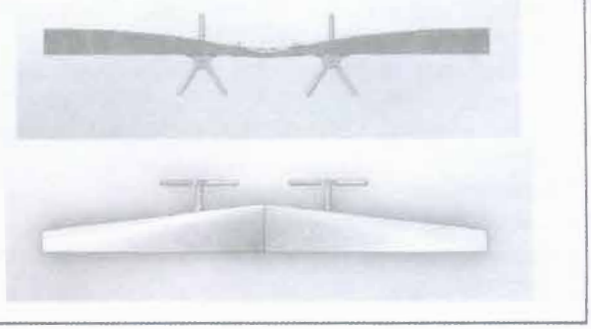
NEXT-GEN TURBOPROPS

- Has to be Cheaper, Greener, Quieter
- At least 20% less fuel consumption
- Low fares, mass markets
- New propeller-wing integrated aerodynamics
- Lighter structure (composites)
- Tractor, engine mounted on wing
- Quieter cabin
- Bigger overhead luggage bins
- 'Economy comfort' seating (new chairs), iPad entertainment, point-to-point journey . . .
- Next+ 2? Environmentally Responsible Aviation, NASA's SUGAR (Super-Ultra Green Air craft Research) projects on aircraft in next 25 years

A NEW AERODYNAMICS

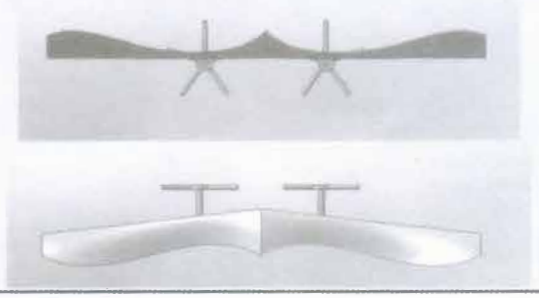
REFERENCE WING

$C_L = 0.38$, wash out twist (twist magnified by 20 times!!!), AR = 12

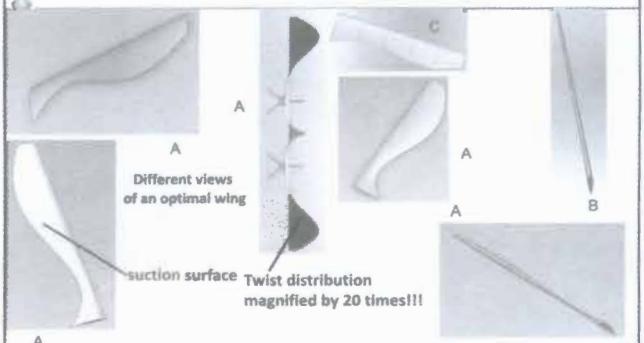


Optimized wing

$nc = 320$, $nf = 48$, $nuc = 4$, $nut = 4$, $-14^o \leq \alpha_i \leq 14^o$, $C_L = 0.38$, twist magnified by 20 times!!!, AR = 12, $c_{uc} = 1.0717s$, $c_t = 0.5359s$, Up-Inboard



3 KINDS OF OPTIMAL WINGS

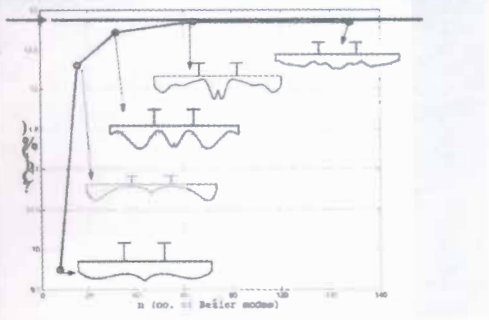


A: Standard optimum
B: Opt. with thickness varying linearly along span
C: Opt. with t.e. of straight segments

Rakshith++ 2012

DRAG BENEFIT FOR DIFFERENT T.E.MODES

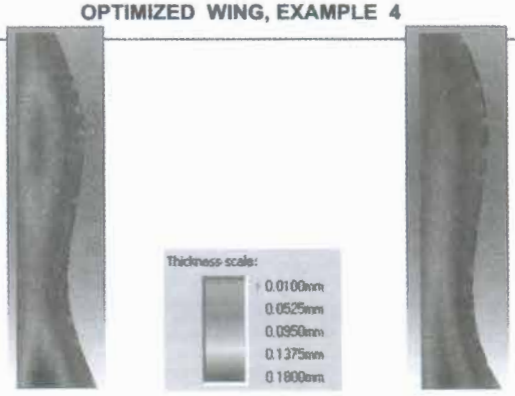
Global optimum



n (no. of Bezier modes)

Rakshith++ 2012

OPTIMIZED WING, EXAMPLE 4



Same t/c from root to tip

Linear spanwise varia of thickness

VALIDATION BY Hi-Fi CFD

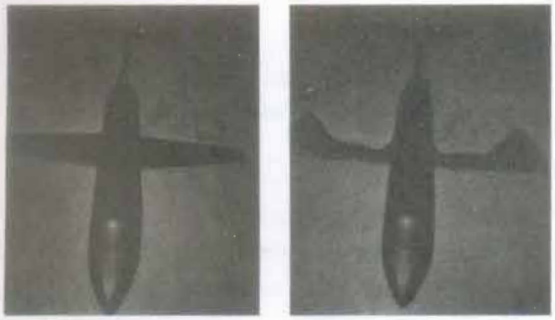
APPROACH	ΔC_{Di}
PROWING (theory)	-9.35%
PROP-EULER (10^7 mesh vol.)	-8.15%
PROP-EULER ($3x10^7$ mesh vol.)	-8%

Rakshith++ 2012

Wind tunnel tests

Thanks to
Dr K Yegnanarayan and his colleagues at C-CADD,CSIR-NAL and
Prof J Dey and his colleagues at AE, IISc
G. Panda et al. 2012 NAL PDCA 1204

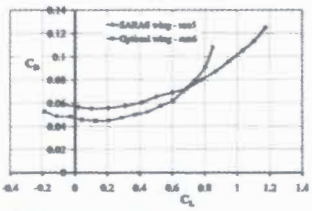
WIND-TUNNEL TEST MODELS



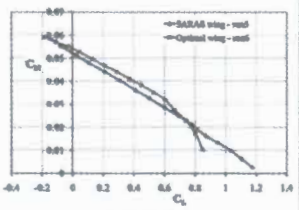
Control - SARAS-c testing

Optimal - SARAS-o

TUNNEL TEST RESULTS



Comparison of drag polar between Runs 5 and 6



Comparison of pitching moment variation with C_L curves between runs 5 and 6

PCT REPORT ON PATENT APPLICATION

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/IN2010/000448

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1, 3 ✓	YES
	Claims NONE	NO
Inventive step (IS)	Claims 1, 3 ✓	YES
	Claims NONE	NO
Industrial applicability (IA)	Claims 1, 3 ✓	YES
	Claims NONE	NO

2. Citations and explanations (Rule 70.7)

The following documents identified in the International Search Report have been considered for the purpose of this report:

D1: US 2009/0152405 A1 (K...

D2: VELDHUIS, L.L.M. et al... International Council of the Ae...

D3: VELDHUIS, L.L.M., "Op... Mechanical Engineers, Part G: Journal of Aerospace Engineering 1989 - 1996, Vol 209, Number 03, pages 215 - 226, 1995

Please note that as indicated in Box I.4 claims 2 and 4 have not been examined as they are considered to go beyond the disclosure of the specification as originally filed.

Please note that as indicated in Box I.4 claims 2 and 4 have not been examined as they are considered to go beyond the disclosure of the specification as originally filed.

IN SUMMARY . . .

MOTIVATION

Turboprops making a come back owing to

- **Climate change concerns** (On a 370 km sector, the ATR 72-500 emits about 50% less CO_2 and consumes 40% less fuel per passenger km than new generation jets - http://www.atr.fr/)
- **Uncertain fuel prices**
- **Connectivity demands** (take off and landing field length
  1. CRJ 700 - 6072ft & 5119ft respectively - http://www.bombardier.com/
  2. ATR 72-500 - 4232ft & 3500ft respectively - http://www.atr.fr/)
- **Crowding in the skies** (Turboprops fly at lower altitudes and do not compete with jets for airspace)
- **Advances in various technologies** (aerodynamics, vibration control, composites, flight control, avionics ...)

WHY TURBOPROP 1/2

1. Regional low-cost aviation is waiting for *right* a/c
2. T/P Inherently energy-efficient, green
3. New aerodynamics can further lower fuel costs
4. Ideal for Many parts of Asia, Europe (inter-city distances of 300-1000km); only economical choice for regions with poor road/rail infrastructure (e.g.NE India, Indonesian islands)

TURBO-PROP FACTS

- ATR selling turboprops in Asia (72 in 2012, 85 in 2014), has 80% of market with 90-seats
- Top markets for regional aircraft:

N. America :	2100 jets	1250 turboprops
Europe	880	1000
Asia	400	1100

- Age of current regional transport aircraft

	No.	Age
Jets	3800	9.7y
Turboprops	4800	20y

WHY TURBOPROP 2/2

5. What is needed:
   - Range = 1000-1500km
   - Marginally higher speeds irrelevant
   - Market estimates
   - Needed: judicious mix of economy, comfort, novelty, green appeal - a current 'sweet spot'
   - Engine manufactures' interest in new power units for turboprops picking up

WHY INDIAN INITIATIVE

- Large number of appropriate inter-city pairs
- Growing air traffic
- Indian market very price-sensitive
- Advantage in manpower costs
- IAF can be launch customer for military transport version

WHY INITIATIVE FROM INDIA

- Huge, growing market for turboprops
- Much aero talent, nurtured by Government for long time, now ready for bigger-risk commercial projects that public sector cannot manage.

WHY PRIVATE + PUBLIC

- Good business opportunity in a growing market for right product
- IAF now prefers to work with private industry
- Planning Commission advocates and encourages public / private partnership
- For commercial success good global contacts / presence necessary
- Public funding of R&D can make fundamental knowledge base more open
- Private sector better at manufacturing, market sensitive pricing, financing, PR, MRO, etc.

WHY GLOBAL

- Commercial success needs large market, new technologies, large finances, global services... Foreign partners essential in all these areas
- Indian industry has no brand name, good foreign brand will be great asset
- Indian companies now have some foreign assets already
- Indo-X projects can be more robust, on policy as well as market; can gain quick access to relevant technologies
- Several global players keen on Indian partnership

THE PROBLEM WITH TURBOPROPS

"It's a conundrum. Recent experience shows that U.S. customers might accept newer-generation turboprops, if they can be convinced to try them. But for that to happen, the models have to be available. This means airlines must order them, which they are reluctant to do because customers... well, you know."

– *Andrew Compart, Aviation Week & Space Tech./February 2011

NEW TECHNOLOGIES 1/2

New engines under development

GE	CPX #38 (based on GE 38) 5600 k W class
P&WC	NGRT (for Next Gen Regional Turboprop) PW-150A enhanced? 3700-5200 kW, up from 2000 kW on PW 127
RR	AE 2100
Russia	TV7-117 SM?; in use on IL-114-300 [Development stopped? *AWST* 26/9.11]
What speed:	ATR 72: 511 km/h max Q400: 646 km/h MA700: ~600-650 km/h A320: Mach 0.82

NEW TECHNOLOGIES 2/2

Composite structures
- Lighter
- More appropriate for novel wing plan forms
- India's considerable experience after LCA

Fly-by-wire, active gust control
- More comfortable ride

Cabin noise
- Active noise control

Modern seating
- Sculpted chairs

Flight entertainment
- How about iPads ?

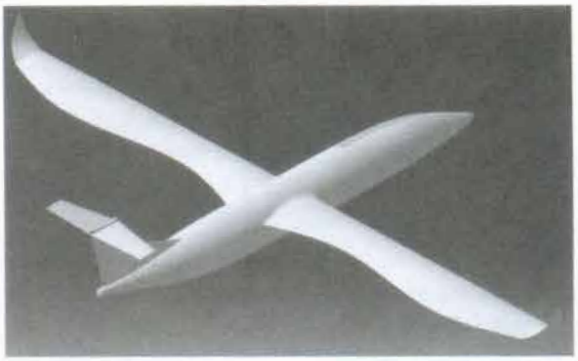
CURRENT TRENDS

- Till recently, engine manufacturers have been 'vendors' to airframe companies, and the latter 'customers' to the former.
- View changing now, because of benefits of integrated design.
- New turboprops want to achieve
  - At least 20% less fuel consumption
  - 40% less climb time
  - Lower drag by combining aerodynamics and engine design

CURRENT TRENDS

- Open rotors too costly for the savings in fuel/time on short haul routes.
- Active vibration control?
- P&W (C) designing new 5000-7000 shp engines for larger turboprops (~ 100 pax) going to market by 2014. 'If a larger turboprop is available tomorrow, the airlines would go for it'. (-Dassault)
- 'The turboprop market is in the midst of a resurgence' (AWST 23, May 2011).
- Market: ATR estimates for next 20 yrs
  1000 with > 90 pax
  1600 with 61-90 pax
  40% of all regional aircraft

A NEXT-GEN INDIAN TURBOPROP ?



RN 2012

CURRENT AND FUTURISTIC TURBOPROP PROJECTS

- ATR (France) – 42-300 (1981), 42-500 (1995), 42-600 (2010), 72-200 (1989), 72-500 (1997), **72-600 (2012)**
- Bombardier (Canada) – Q100(1984), Q300(1989), Q400(1999), **Q400 nextgen (2011)**
- Xian (China) – MA 60&40 (2002), MA600(2008), **MA700 (2013)**
- Airbus – **A400M (2009)**
- South Korea;
  Antonov, Ukraine: **Emerging**
- Boeing - **SUGAR (2030)**
- GE - **20 passenger aircraft (2030)**

UAV RUSTOM-II

Medium Altitude Long Endurance UAV (ADE)

J.Aesp.Sc. & Tech. 2012

SMALL TURBOPROP AIRCRAFT

Aircraft	Produced (#)	Max. Capacity (pax)	Status
Cessna 425 Corsair	1980-1986 (236)	4+2	Probably available
Piper PA-31T Cheyenne II	1973 (526)	5+1	Probably available
Beechcraft KingAir C90GTi (Raytheon 90KingAir)	xxxx (1925)	6+2	In service
Mitsubishi MU-2B	xxxx (800)	7+2	In service
Fairchild Merlin	1965 (87)	8+2	-
Gulfstream 690A Turboprop Commander	1970's (541)	8+2	In service
Cessna 441 Conquest II	1977-1986 (370)	9+2	Probably available
GAF N22B Nomad	1975-1985 (172)	12+2	In civil & military service

NEXT STEPS

- Try new wings on small / old prop etc.?
- Make preliminary designs
- Invite global partnership bids
- Craft risk- and profit-sharing arrangement
- Make it a national flagship project
- Revamp National Civil Aviation regulatory structure
- Set up a government / private industry / RD&E consortium (cf. Taiwan)

Thank you !

Author :

Email: roddam@jncasr.ac.in; roddam@caos.iisc.ernet.in

Dr Roddam Narasimha is an Indian aerospace scientist and fluid dynamicist. Presently is an Honorary Professor in the Engineering Mechanics Unit at the Jawaharlal Nehru Centre for Advanced Scientific Research. Prof Narasimha has been educated at Bangalore and at the California Institute of Technology (PhD 1961). Held various positions at the Indian Institute of Science 1962-98, including Chairman, Department of Aerospace Engineering, Chairman, Centre for Atmospheric and Oceanic Sciences. He was the Director, National Aerospace Laboratories 1984-93. Has been Clark B Millikan Professor at Caltech several times, Jawaharlal Nehru Professor at Cambridge, INSA Golden Jubilee Professor and ISRO K R Ramanathan Distinguished Professor at Bangalore. Fellow of the Royal Society, Foreign Associate of both the US National Academy of Engineering and the Academy of Sciences, and fellow of all the national academies of science and engineering in India. Member of the Space Commission, Consultative Group of Eminent Senior Scientists, Government of India, and of the Bureau of the International Union of Theoretical and Applied Mechanics. Padma Bhushan. His research areas include:

- Transition, flow control, relaminarization, hydrodynamic stability
- Fluid dynamics of clouds, atmospheric convection, temperature distribution near ground
- aerospace technology, S&T policy studies

1919 - 1971

DR VIKRAM AMBALAL SARABHAI *was a well - known scientist, educationist and a perfect gentleman. It was unfortunate for our country and the community of scientists that this genius was suddenly snatched away in December 1971 at an young age of 52.*

Dr Sarabhai initiated and established Physical Research Laboratory (PRL), at Ahmedabad, where he was Professor and the Director. He also established the Indian Space Research Organization with Centres at Thumba (near Thiruvananthapuram), Ahmedabad, Shriharikota (north of Madras) and Arvi (near Bombay). Dr Sarabhai was awarded Shanti Swarup Bhatnagar Award for Physics in 1962. In 1966 he was conferred Padma Bhushan by Government of India and in the same year he was appointed Chairman of the Atomic Energy Commission. The Government conferred on him the award of Padma Vibhushan posthumously in 1972.

Dr Sarabhai's involvement with Science and Technology was so intense that most of the organizations connected with him and those who were with him considered his death as their personal loss. The Council of The Institution of Electronics and Telecommunication Engineers decided to institute a lecture series to be held every year during Mid Term Symposium to perpetuate the memory of this great scientist.

Mass Scale Examination System

RAJAT MOONA

Director General, C-DAC, Pune

Pre- Examination Activities

- ❑ Large Examinations also require the manual applications to be converted to data.
  - Data entry
  - OMR
  - Web forms
- ❑ Online registration – Application forms online.
  - A big help for the planning - may not be too helpful for the applicant though.
  - GATE 2010 experience of load forecasting.
- ❑ Admit card / roll list preparation, dispatch.
- ❑ Support to candidates enquiry.
- ❑ Cost reduction is however a myth.

Conduct of Examination

- ❑ Multiple different ways
  - Conventional examination systems.
    - o Printed paper ? A huge overhead for a large examination.
  - Online Examination
    - o Often driven by ICT experts
  - Offline but Computer Assisted Examination
- ❑ For ICT technology driven examinations, support for grading is the most important.
  - Objective grading or simple answer based grading.

Purpose of an Examination

- ❑ To select the most appropriately suited for a position / job / education / privilege.
- ❑ To assess the capability.
- ❑ To rank within a group.
  - Only a secondary purpose. To allot multiple jobs / seats / resources based on demand, supply and planning.
- ❑ Requirement for a course examination vs. entrance examination vs. assessment testing.
  - Different goals and different procedures.

Alternatives to Exams

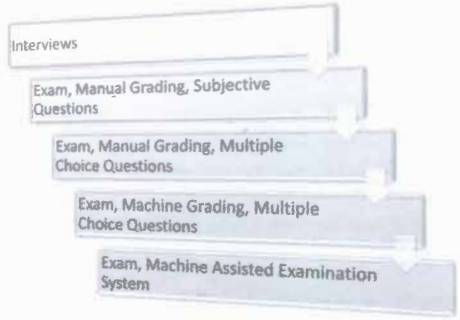
- ❑ A purpose of selection of the most suited can be met.
  - By references from known sources (admissions in universities for higher education)

    Trust on the known source evaluation.
  - By the interviews (Is the person good enough as assessed by the interviewers) Subjectivity.
  - Perfomance in schools, universities (Continuous evaluation) Uniformity across different background / examining bodies?
- ❑ For an entrance examination, filtering and ranking are the most important objectives.

Interview vs. Examination

Objective		Methods	
Filtering	Typical Examination System	Examination	Interview
Ranking	Impractical System	Interview	Interview

Growth of Entrance Examinations



Machine Assisted Examination System (MAES)

- Claim : Primarily to solve the administrative and logistic issues related to conduct of examination .
  - Printing of paper, movement of paper, collection of paper, reconciliation, grading result all major logistic issue in a classic large examination system.
- Every other claim advantage is a side effect.
- Printing : A major security threat on paper.
- Movement Logistics : What if the paper does not reach at right time?
- Reconciliation : Time needed for reconciliation is important.

MAES

- Common advantage is on the security of the paper.
  - Paper can be set by the paper setters, encrypted at that time and decrypted only during the exam day. End –to – end security.
- No printing and hence a simple logistic solution.

Current Practices

- Online Examination
  - Q Paper can be moved online through Email or Internet. Encrypted document and hence secure to transmit.
  - Can be carried even on a storage media by the examination representatives.
- Questions and Answers are pulled from or pushed to a server.
- Network in the loop is a major unreliability factor.
  - Speed, availability etc. are all major issues.
- Online Examination is not a reality but MAES is

MAES

- Online Examination.
  - Using the internet but brings in a unreliability factor.
  - What purpose is solved by an online examination? Why do we need it?
- Offline Examination.
  - But using the machines.

MAES : Current Practices

- Machines are provided by the examination conducting body.
  - In the country more than 20000 machines availability is a problem.
  - Most such places are also not conducive to the examination system but are designed for a collaborative mode of working.
- Exam becomes an extended activity (month long, 3 shift each day)
- Question banks are provided.
  - Toughness of the questions is specified by paper setters.(Oxymoron by itself)
  - Not the same paper is provided to all candidates. Hence can only be a filtering and not ranking examination.
  - Speed test can be setup. But most admissions are not based on the speed but for the capability.
- Question bank approach is not suited for the examination which test for capability rather than memory.

A model for Offline MAES

- Let the candidates bring their own computers / laptops / smart phone or tablets (e.g. Aakash).
  - Capability to view web pages is all that is needed.
- The representatives bring
  - a "web server" or exam server.
  - a Lan boot strap server (combined functionality In a single machine – may be a high - end laptop)
  - encrypted exam paper that is decrypted before the start
- At the end,
  - representative can take all answers on the server and leave digitally signed solutions on candidate's machine.

Issues and solutions

- What if the page is not display properly? Can candidate claim that paper was "not printed" properly.
  - Solution : Use a simple standardized language for page.
- What if the students bring pre – recorded books / papers.
  - Solutions : Use standardized boot environment.
  - Or use full screen and no display switch
  - Strenghten the invigilation operation.

MAES Model

- This model seems to work for the ranking kind of exam.
- Because of machine involvement, audit trails for each candidate's activity are available.
- Candidate's behavior based paper presentation is not good for a ranking exam. For the machines, however, this is the easiest thing to do.
- Exam can be multiple choice single answer, word or short sentence based or even subjective questions.

Post Exam Activities

- Reconciliation of absentees, centre changes etc.
- Accounting for all answer copies.
- Grading in a fair (may be anonymous) manner.
- Result preparations, cut-off determination, dispatch etc.
- Web – based displays.

National Online Examination System

- CDAC solution to examination system.
- Provides facilities for
  - Pre examination activities.
  - Paper setting activities.
  - Conduct of online examination.
  - Result preparation and display.
- NOES has been in use in parts for many examination systems.

Thank You

- Questions . . . . . .
- Acknowledgements :
  - Profs. Umanand (IISC), Sudarshan (IITB), Arun Kumar(IITD), SV Rao (IITG), Sudhir Barai (IIT KGP), V Jagadeesh Kumar (IITM), Manoj Arora (IITR).
  - National Online Exam System(NOES) group at CDAC Noida.
  - Various Companies including Meritrac, TCS, Prometric.
  - Various students who worked both as technology providers and users.

Author :

Email: moona@cdac.in

Prof Rajat Moona received his BTech degree in Electrical Engineering from IIT Kanpur in 1985 and a PhD degree in Computer Science and Automation from IISc Bangalore in 1990. He worked for about one year as Scientific Officer in IISc Bangalore and joined as a faculty member of IIT Kanpur in 1991 where he is a full professor in the department of CSE. In recognition of his research, Prof. Rajat Moona was offered the prestigious Poonam and Prabhu Goel Chair Professorship by IIT Kanpur in 2008.

During his stay at IIT Kanpur, he had been a recipient of Indo-US Science and Technology Fellowship, a scheme jointly supported by the Governments of India and USA, and had been a visiting scientist to MIT USA in 1994-95 on this fellowship. He had also been a senior Engineering Manager in Mentor Graphics India during 2002-04 where he led a team to develop a tool for embedded system design that is now a product from Mentor Graphics.

He has taught a large number of courses at IIT Kanpur, both at undergraduate and postgraduate level. He has also supervised about 80 postgraduate theses. He along with his students and other colleagues, has authored 7 patents, about 30 research papers and 2 books.

The research area of Rajat Moona spans over embedded computing, computer security, VLSI design and Operating Systems. He has been involved in defining standards for the Operating Systems for Smart Cards for Indian Government which are in use in applications such as Driving License, Vehicle Registration Systems, Indian National ID, Electronic Passports and several other ID related applications.

He along with his students and National Informatics Centre has defined the Key Management System and Layout of the data on the Driving License, National Id Card and Electronic Passports. He has also been instrumental in defining the strategy for smart card certification mechanisms for the Government of India. He along with other faculty members and students have also defined and developed a secure encrypting file system with extremely powerful trust model for use in the enterprise storage technologies. He is involved in defining the RFID applications in areas such as electronic toll collection.

Global Navigation Satellite System (GNSS)

S PAL

Former Prof Satish Dhawan Professor, Senior Adviser, Satellite Navigation (ISRO), Distinguished Scientist
Associate Director, Prog Director Satellite Navigation & Chairman GAGAN-ISRO Satellite Centre-Bangalore

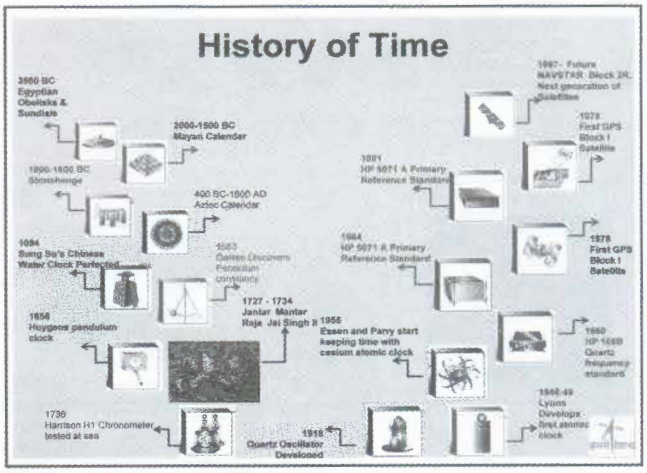
HISTORY OF NAVIGATION

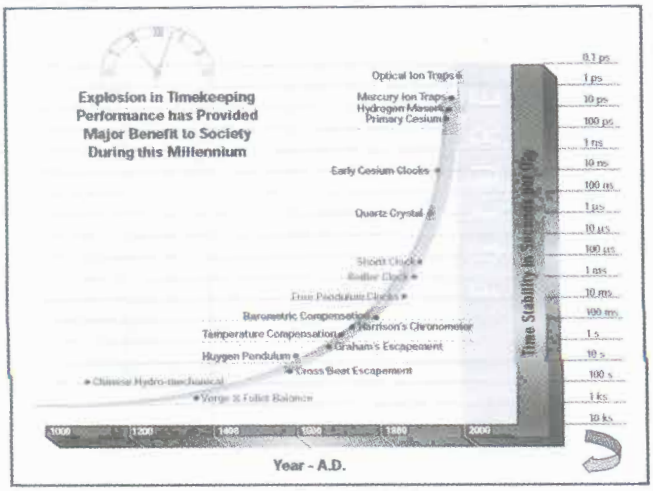
- Phoenicians , Vikings and Greek were undertaking sea voyages and had navigation skills even 3000 years back. Phoenicians claimed to have circumnavigated Africa from Red sea, sailing via the Cape of Good Hope.
- Burning fire on mountain tops were used as light houses. The legendary Light House of Alexandria was an example.
- 'Navigation' word has perhaps its origin in 'Naoka'- 'Nav' boat + 'Gati'- velocity , in Sanskrit.
- Not much is written in the modern history about Navigation activities in Asia-Pacific region. Chinese, Arabs etc., had under taken lot of sea voyages.
- In Mohanjadaro ruins (Indian sub continent) one clay tablet was found which depicted a boat.
- Sindhu or Indus valley civilization ruins (parts of Pakistan, Gujarat , Harayana) do show that perhaps a successful business existed with Romans, Babylonians and Sumerian civilizations.
- Out of 18 Tamil Sidhas, Sidha Bhoganathar went to China via sea route (even he is supposed to have designed an aeroplane) and lived in China as Lao-tzu, spread Taosim. He is attributed to have great navigational skills.

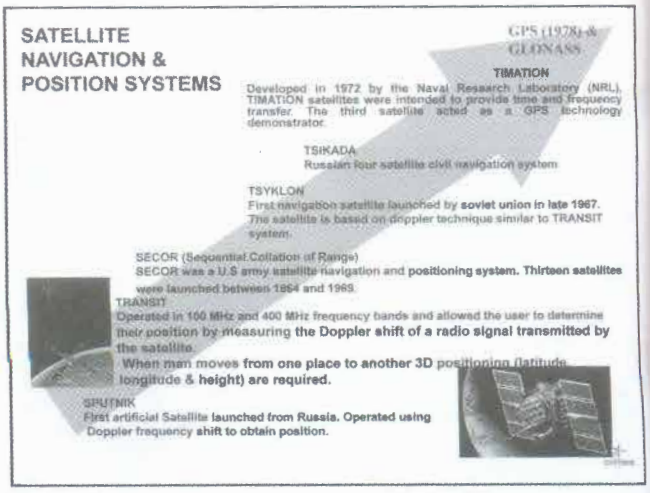
HISTORY OF NAVIGATION

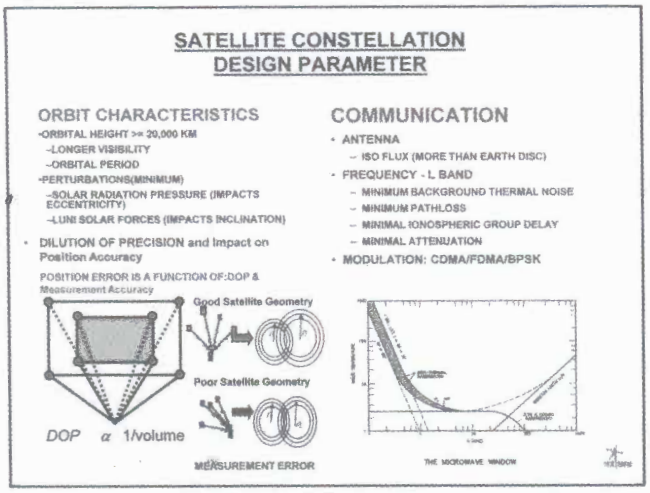
The great sanskrit scholar Kalidas (4th century A.D) was the first one to imagine above land navigation. In his famous Sanskrit composition `Meghdoot' , Kalidas's Yaksha instructs `Megha' ,how to navigate from Ramagiri to Alkapuri. He used complete Bio-Sphere as Navigational Control Points.

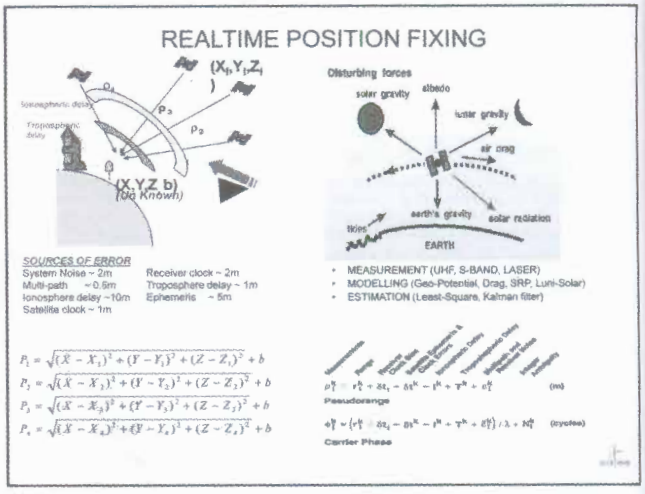
Archeological site at Lothal (Gujarat ,India) has got remains of a port which indicated more than 4500 years back India had advanced sea transport system. The dock is almost of the same size as that of Visakhapatnam, modern port.

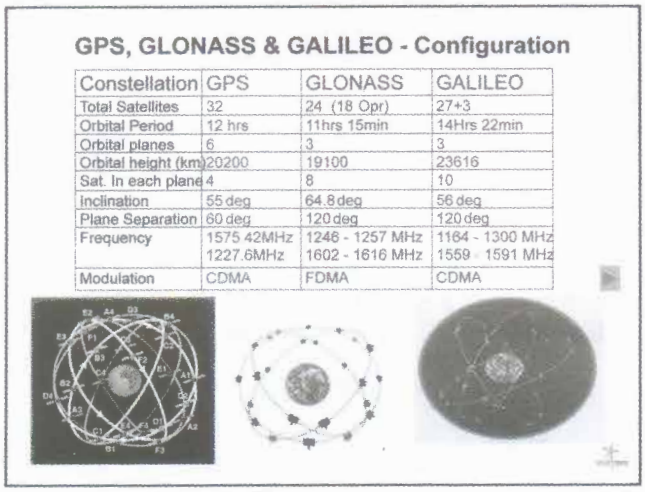












Constellation	GPS	GLONASS	GALILEO
Total Satellites	32	24 (18 Opr)	27+3
Orbital Period	12 hrs	11hrs 15min	14Hrs 22min
Orbital planes	6	3	3
Orbital height (km)	20200	19100	23616
Sat. In each plane	4	8	10
Inclination	55 deg	64.8 deg	56 deg
Plane Separation	60 deg	120 deg	120 deg
Frequency	1575.42MHz 1227.6MHz	1246 - 1257 MHz 1602 - 1616 MHz	1164 - 1300 MHz 1559 - 1591 MHz
Modulation	CDMA	FDMA	CDMA

GLOBAL POSITIONING SYSTEM

- **GPS is first one way (passive) ranging satellite system**
- **The principal objective of the DOD is to offer US military accurate estimates of Position, Velocity and Time (PVT) for a high dynamics platform (P ≈ 10m, velocity error 0.1 m/s and time error 100 ns all in rms)**
- **Signal should have a measure of resistance to jamming and interference. That is why transmission of signals on the same carrier is being done using CDMA.**
- **Provision to deny the use to US adversaries and at the same time enhancing the accuracy over a geographical location on a limited time. (This was done in the Iraq war keeping high accuracy over a period of 2Hrs).**

Planned modernization of the GPS signals

Current frequency Plan	Planned Frequency (additional)	Capabilities
Carrier frequencies	Additional civilian frequency	6 dB higher power relative to L1
L1 : 1575.42 MHz	L5 : 1176.45 MHz	20 MHz broadcast bandwidth
L2 : 1227.60 MHz L2 C	(safety-of-life service frequency protection (ARNS-band))	Improved signal cross correlation
Code frequencies (pseudorandom) P-code: 10.23 MHZ (on L1/L2)	M_E code (L1/L2)	M-code designed to enhance system security to improve anti-jamming
Code frequencies (gold code) C/A-code:1.023MHz(onL1)	C/A code on L2(1127.60MHz)	Dual freq. ionosphere correction (improved) UERE and better accuracy)
Navigation message	Ephemeris, SV clock parameters ionospheric parameters, SV health	On L1, L2 and L5

GLONASS
(GLObal'naya NAvigatsionnaya Sputnikovaya Sistema)

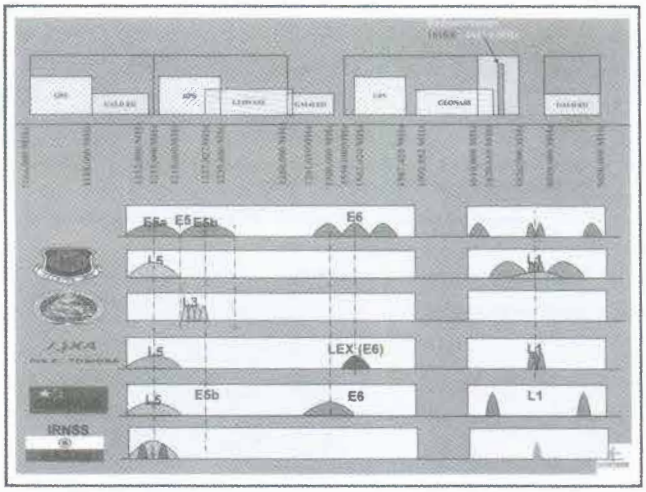
- Parallel constellation to GPS
- Constellation was fully operational only in 1995 – 98 and failed satellites were not replaced later on.
- As of Jan 2009, 16 operational satellites available.
- GLONASS is credited for providing precise universal time coordinated transfer with better position accuracies
- India will be helping in completion of the full constellation by launching M series and manufacturing K series

Note: Use of GLONASS in addition to GPS provides increased satellite signal observations, spatial distribution of visible satellites, reduced horizontal and vertical DOP and decreased occupational times.

GALILEO Services (Planned)

- Galileo envisages the provision of large variety of services based on needs and market analysis.
  - satellite only, locally assisted, EGNOS Combined services
- ***Galileo satellite only services:***
  - **Open services**, Safety of life, Commercial, Public regulated, Search & Rescue
  - **Open service** Position and Timing Performance of :
    - H: 15 meters, V: 35 meters (95% Single frequency)
    - H: 4 meters, V: 8 meters (95% Dual frequency)
    - Integrity: No, Timing Accuracy: 30 ns (Three frequencies)
- ***Safety of Life:***
  - Availability: 99.8%, Position accuracy: 4-6 m (95% Dual Frequency)
  - Integrity: Yes. Certification/Liability: Yes
- ***Combined Services:***
  - Availability : 99.8% (Global), Position Accuracy : 95% (Dual frequency)
  - Integrity Value Added Services
- ***Public Regulated Services:***
  - Availability : 99%, Position Accuracy: H-6.5m, V-12m(95% Dual frequency), Timing Accuracy : 100 ns, Integrity: Yes
- ***Search and Rescue Services:***
  - Capacity:150 beacons
- ***Galileo Locally Assisted Services:***
  - Local Precision & High Precision Navigation Service
  - Local Assisted Navigation & Augmented Availability (Pseudolite) Services

Note: Total Project cost is ≈2.3 billion Euros and market as projected is ≈10 billion Euros/Year and Growth rate is 20% and will reach 300 billion Euros in 2020 with 3 billion receivers in market.



Comparison of SATNAV Systems

System	GPS	GLONASS	GALILEO	GAGAN / IRNSS
No. of satellites	24 (30)	18 now, 24 reqd	30 , GIOVE-A.	2 / 7
Altitude	20,200 Km	19,100 Km	23,616 Km	36,000 Km
Frequency of operation	L-band	L-band	L-band	L1,L5 / L5 & S-band
Absolute position accuracy	10 meters	10 meters	8 meters	< 8 meters with GAGAN & < 20 meters with IRNSS
Multiple access	CDMA	FDMA/CDMA	CDMA	CDMA
Spacecraft life	7.5 years	5 years	>7 years	10 years
Controlled by	Dept. of Defence, US Airforce	Min. of Defence	Not yet known	India
Coordinate system	WGS-84, ECEF	PZ-90, ECEF	ITREF	WGS-84

INTRODUCTION OF L5 SERVICE

Introduction of L5 in GPS Modernisation Plan and Other Upcoming GNSS Constellation

- Semi codeless technique & L 2 C : A method of tracking P(Y) on L1 & L2 without P(Y) Code knowledge, but correlate the L1 & L2 measurements. Present days civilian dual frequency receivers are based on this technique.
- As per U.S after Dec 31, 2020 there is no guarantee that semi codeless receivers will work.
- Solution is to upgrade receivers with L 2 C & L5

(Acknowledgement: Eric Gakstatter-Webinar)

Special Features - L5 (1176.45 MHz)

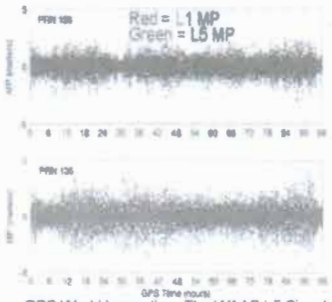
- Broad cast strength is 4 X more powerful than L 2 C
- Larger frequency separation, than L1 (1575.42) & L2 (1227.6), for better ionospheric corrections.
- Longer code and error-correcting techniques for more robust tracking in adverse environments.
- Supported by Galileo, Compass, IRNSS, WAAS, EGNOS, MSAS, & GAGAN.
- Located in the highly-protected aeronautical band. Designed for safety of life applications. No interference as in case of L1 from Light Squared Network & Services.
- Superior tracking on L5 in tougher conditions.

(Acknowledgement: Eric Gakstatter-Webinar)

- **S-BAS accuracy using L1/L5 will be ≈10 cms (RT) as compared to ≈1 to 2 m using L1. EGNOS, WAAS, GAGAN & MSAS support L5. EGNOS support Galileo.**
- **RTK accuracy will improve (more satellites better accuracy)**
- **Single frequency L5 receivers will give better accuracy then L1, due to stronger signal stronger & better code structure.**
- **L5 – (11-SV) will be available by 2014/2015. A-24 satellite constellation will be available by 2019.**
- **GLONASS has announced – L5 support.**
- **Galileo will support L5.**

(Acknowledgement: Eric Gakstatter-Webinar)

Improvement of L5 over L1 for Code Tracking

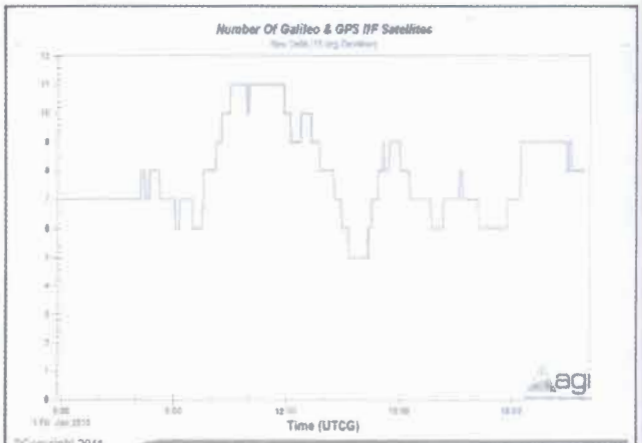


GPS World Innovation: The WAAS L5 Signal
Richard B. Langley, Hyunho Rho

MARKET INSIGHTS WEBINAR GPS World Geospatial

GPS and GALILEO Constellations

©Copyright 2011 MARKET INSIGHTS WEBINAR GPS World Geospatial



©Copyright 2011 MARKET INSIGHTS WEBINAR GPS World Geospatial

L5 Service

ISSUES

- All schedules are projected but not guaranteed. Budgets are likely to get hiked. Legacy GPS is doing well so why?
- Galileo has slipped on schedule many times.....?
- COMPASS is a wild cat.

LIMITATIONS OF GPS AND GLONASS

- GPS stand alone, cannot satisfy the integrity, accuracy & availability requirements for all phases of flight, particularly for the more stringent precision approaches.
- Integrity is not guaranteed, since all satellites may not be satisfactorily working all times.
- Time to alarm could be from minutes to hours and there is no indication of quality of service.
- Accuracy is not sufficient even with S/A off, the vertical accuracy for 95% of the time is >10m
- For GPS & GLONASS stand alone systems availability & continuity are not assured.
- All these calls for a special system addressing all the above, which could be done by augmenting the GNSS systems.

REQUIREMENT OF ENHANCEMENT OF ACCURACY, AVAILABILITY AND INTEGRITY

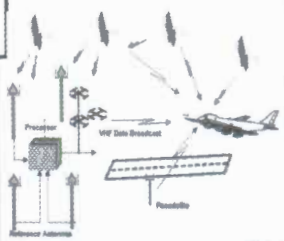
- For the safety-critical applications it is essential that a user be assured that the system is operating within design tolerances and the position estimates derived from it can be trusted to be within specifications – **This is the so called integrity requirement.**
- Timely warning of a system anomaly (which may be hazardous is called "time to alarm".
  - 30Sec En-route
  - 6 Sec APV 1.5

AUGMENTATION OF GPS / GLONASS

LIMITATIONS OF GPS:

- SIGNAL NOT AVAILABLE INSIDE TUNNEL & WATER
- NO ASSURANCE OF AVAILABILITY AND INTEGRITY OF DATA
  - CRITICAL FOR AVIATION APPLICATIONS
  - ACCURACY REQUIREMENTS STRINGENT

- SPACE BASED AUGMENTATION (SBAS)
  - WAAS, EGNOS, MSAS & GAGAN
- GROUND BASED AUGMENTATION (GBAS)
  - LAAS, PSUEDOLITE, DGPS
- AIRCRAFT BASED AUGMENTATION (ABAS)
  - RAIM (RECEIVER AUTONOMOUS INTEGRITY MONITORING TECHNIQUE)

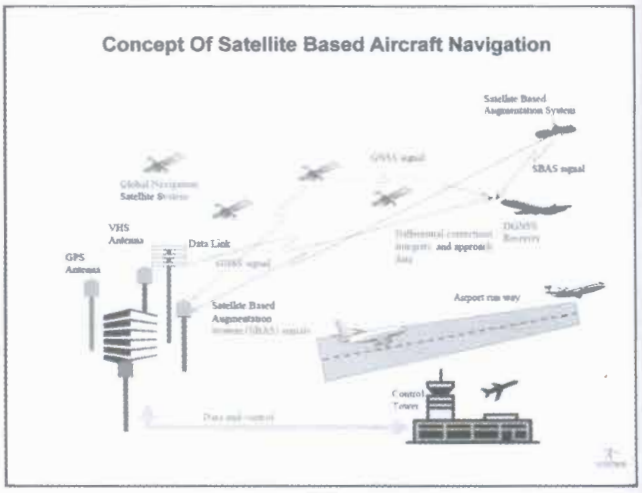


GPS Wide Area Augmentation Systems

INDIAN SCENARIO IN GNSS

- Satellite Positioning System (SPS) in IRS & Scientific satellites & GAGAN
- Participation in GALILEO & GLONASS
- Having our own regional constellation (IRNSS)
- Ionospheric & Tropospheric – Studies and modeling

India may become biggest user of GNSS for GIS, mobile, survey, mining, fishing industry, aviation, road, rail transport, etc.



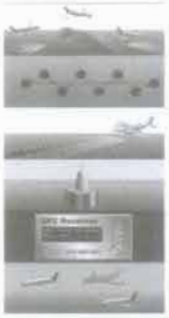
AVIATION REQUIREMENTS

- Accuracy: < 7.6 m 95% Horizontal and Vertical
- Integrity:
  - probability of informing the user a wrong (misleading) information should not exceed one in about 47 years
  - 6 second time-to-alarm
- Continuity: < 10^{-5} Chance of Aborting a Procedure Once It Is Initiated
- Availability: System to be available 99% of Time to 100% over the region of interest

SBAS ERROR BUDGET

GPS ephemeris	0.4m
GPS clock	0.2m
Ionosphere	0.5m
Troposphere	0.2m
Multipath	0.1m
Receiver specific	0.2m
UERE	*0.74m*
ACCURACY	*1.1m*

BENEFITS OF SBAS



Primary Means of Navigation - Take-Off, En Route, Approach and Landing

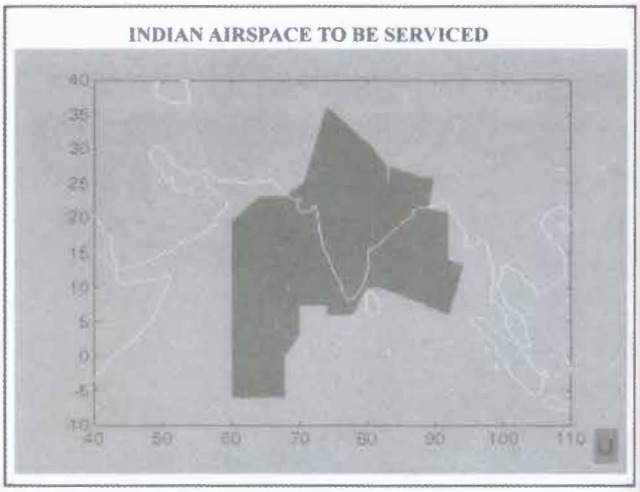
More Direct Routes - Not Restricted By Location of Ground-Based Equipment

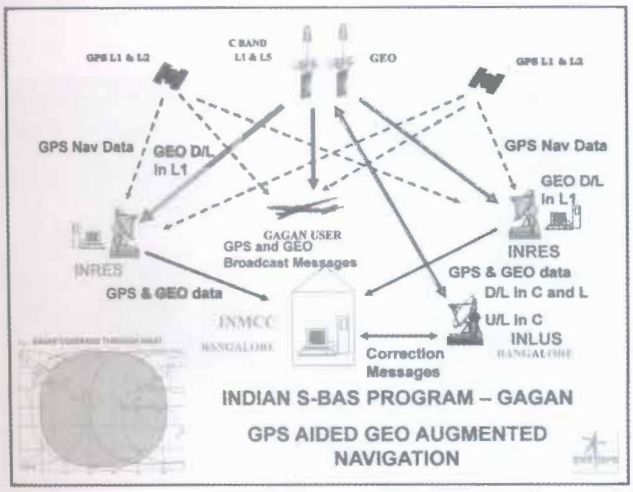
Precision Approach Capability - At Any Qualified Airport

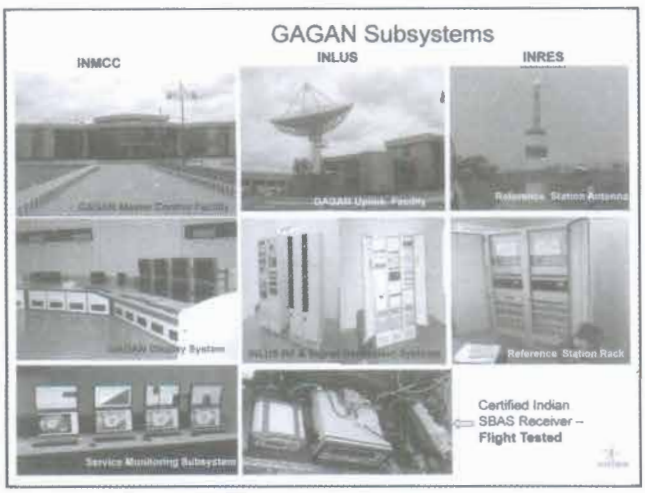
Decommission of Older, Expensive Ground-Based Navigation Equipment

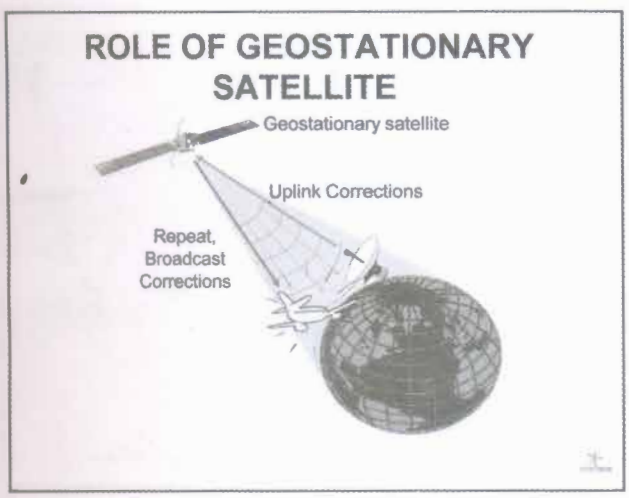
Reduced/Simplified Equipment On Board Aircraft

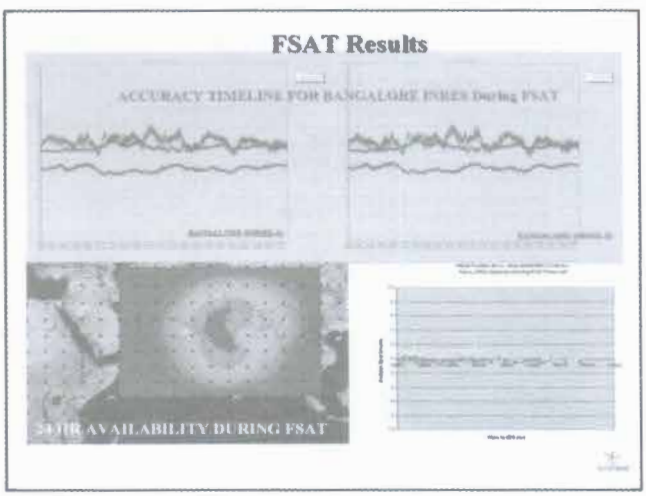
Increased Capacity - Reduced Separation Due to Improved Accuracy

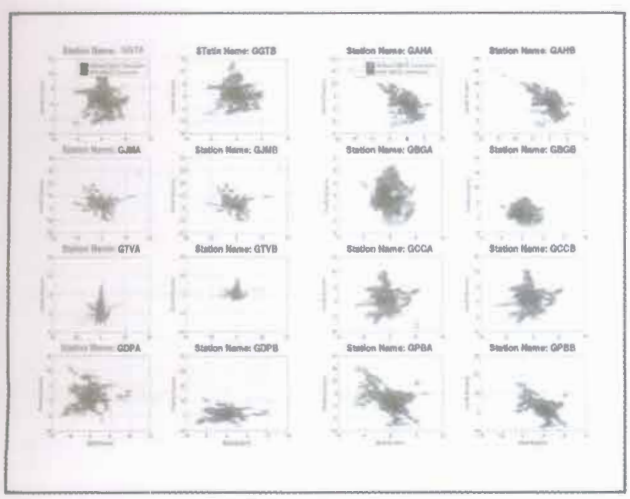












Performance Requirements

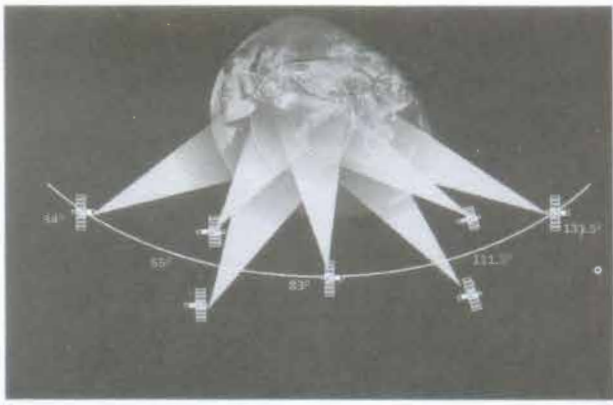
Flight Phase	Accuracy	TTA	Integrity	HAL	VAL
En-route	3.7 Km (H)	5 min	$1\text{-}10^{-7}$/h	4 NM	N/A
En-route Terminal	0.74 Km (H)	15 s	$1\text{-}10^{-7}$/h	1 NM	N/A
NPA/LNAV (RNP 0.3)	220 m (H)	10 s	$1\text{-}10^{-7}$/h	556m	N/A
RNP 0.1	74 m (H)	10 s	$1\text{-}10^{-7}$/h	185 m	N/A
APV 1.5	16 m (H) 20 m (V)	10 s	$1\text{-}2x10^{-7}$/app	40 m	50 m
APV 1.0 (LPV)	16.0 m (H) 4.0 m (V)	6.0 s	$1\text{-}2x10^{-7}$/app	40.0m	50 m
APV 2	16.0 m (H) 8.0 m (V)	6.0 s	$1\text{-}2x10^{-7}$/app	40.0 m	20 m
CAT 1	16.0 m (H) 6-4 m (V)	6.0 s	$1\text{-}2x10^{-7}$/app	40.0 m	10 - 10 m

Performance Objective

- The objective of GAGAN-FOP is to realize a certified and operational SBAS for all phases of flight path over the Indian FIR to provide air navigation services of
  - RNP 0.1 en route navigation within Indian FIR
  - APV-I/I.5 precision approach over the landmass of Indian FIR
- GAGAN SIS to meet the required Accuracy, Integrity, Continuity, Availability and Time to Alarm parameters of ICAO GNSS SARPs
- Common coverage of GAGAN GEO satellites (located at 48 , 55 and 82 degrees) is beyond the Indian FIR (GSAT-4, GSAT-8 & GSAT-10)

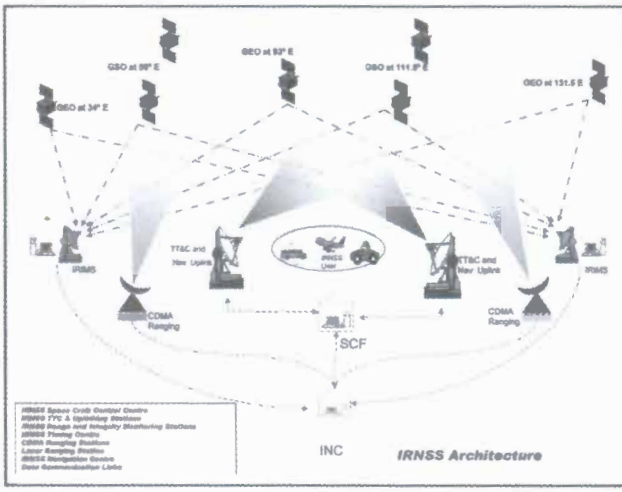
Certified SBAS to be realized by 2013

IRNSS Constellation

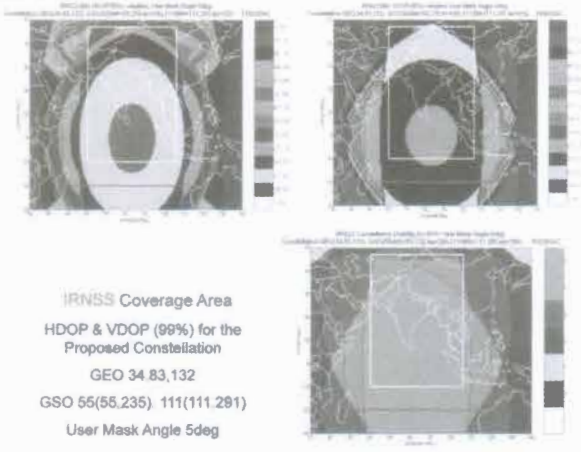


IRNSS Architecture

- Space Segment
  - Seven satellite configuration, 3 SVs in Geo-Stationary orbit (34°, 83° and 131.5° East), 4 SVs are in GEO Synchronous orbit placed at inclination of 29 ° (with Longitude crossing at 55° and 111.5° East)
  - The configuration takes care of continuity of service with a failure of one satellite.
  - The satellites are of 1 ton class with navigation payload of 102 Kgs and power consumption of 676 Watts .
  - There will be two downlinks (L and S bands) providing dual frequency operation with EIRP of 31.5 dBW at EOC.
  - The payload will have 3 Rubidium clocks.
- Ground Segment
  - Master Control Center
  - IRNSS Ranging & Integrity Monitoring stations (IRIM)
  - IRNSS Telemetry and Command stations
  - Navigation Control Centre
  - IRNSS Network Timing Centre
- User Segment



IRNSS Architecture



IRNSS Coverage Area

HDOP & VDOP (99%) for the Proposed Constellation

GEO 34,83,132

GSO 55(55.235), 111(111.281)

User Mask Angle 5deg

IRNWT

- The IRNSS timing facility generates the free running time scale is designated Free-(n), where 'n' is either A or B depending on whether it is the online or backup system.
- The steered time scale is designated Steered-(n) or System time. The physical realization of the steered time scale is IRNWT, which is a leap second free time scale. This will be synchronized & steered to TAI from international time lab maintained with in accuracy of ± 25 ns at any instant of time over a year. This will be can also be called as TAI after synchronization.
- IRNWT is normally delivered by the primary system, and it is delivered by the redundant system in case the primary fails.

GNSS APPLICATIONS

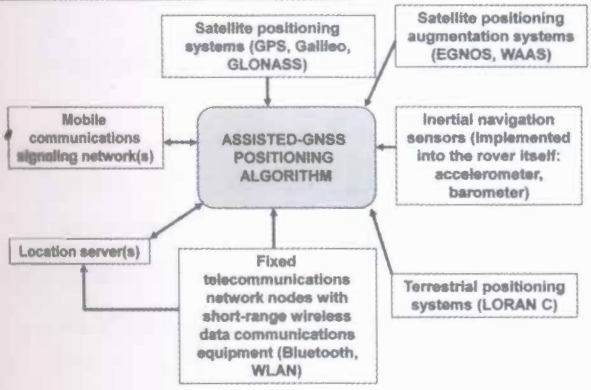
- NAVIGATION
  - SPACECRAFT
  - AIRCRAFT
  - SHIP
  - VEHICLE
- GEOGRAPHIC DATA COLLECTION
  - MAPPING
  - SURVEYING
  - ENGINEERING
- SCIENTIFIC RESEARCH
  - ATMOSPHERIC STUDIES
- GEODYNAMICS
  - CRUSTAL MOVEMENTS
  - CRUSTAL DEFORMATIONS
- MILITARY
- NATURAL RESOURCE AND LAND MANAGEMENT
  - GIS INGEST
  - FOREST MENSURATION
  - TOWN PLANNING
  - FLEET MOVEMENT
  - ROUTING/ALIGNMENT
- MONITORING THE HEALTH OF TALL BUILDINGS/TOWERS, LONG BRIDGES
- Power grid synchronization
- AGRICULTURE
  - PRECISION FARMING
- EMERGENCY RESPONSE
  - SEARCH AND RESCUE
- BUSINESS SOLUTIONS
  - LOCATION BASED SERVICES
    - MOBILE
    - TOURISM
    - RETAILING/Banking

... MANY MORE

CURRENT GNSS APPLICATIONS

- Personal Navigation(Mobile, PDA, Vehicle mounted sensors etc.)
- Automotive Applications(Departure to destination with out much detouring)
- Weak Signal navigation
- Marine applications
- Space and missile applications
- Geodesy and survey
- Town planning, bridges and tall building health monitoring
- Agriculture, Forestland ,Natural resources exploration.
- Epidemic demarcation and control
- Specific Applications related to PN(V)T

Assisted GNSS Applications



AREAS OF RESEARCH & DEVELOPMENT IN POSITIONING AND TIMING SYSTEM (GNSS)

SCIENCE

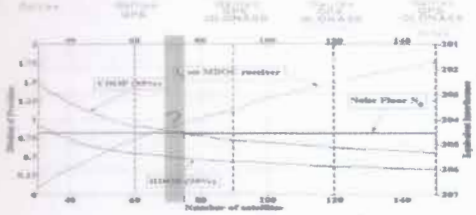
- IONO-TROPO MODELLING IN THE EQUATORIAL REGION IN L-BAND
- RADIO OCCULTATION STUDIES FOR NEAR EARTH ATMOSPHERIC TEMPERATURE PROFILE
- REAL-TIME WEATHER FORECASTING

TECHNOLOGY

- PRECISION ORBITS
- TIME SYNCHRONISATION
- DEVELOPMENT OF NAVIGATION SOFTWARE
- ATOMIC CLOCK – RUBIDIUM, CESIUM, HYDROGEN MASERS
- ISOFLUX ANTENNAS FOR SPACECRAFT
- DUAL RECEIVERS (GPS+GLONAAS, GPS+GALILEO)
- ACCURATE ESTIMATE OF PHASE DELAYS ONBOARD SATELLITE

Issues related with GNSS

- **Interoperability** refers to the ability of open global and regional satellite navigation and timing services to be used together to provide better capabilities at the user level than would be achieved by relying solely on one service or signal
- **Compatibility** refers to the ability of space-based positioning, navigation, and timing services to be used separately or together without interfering with each individual service or signal.



Courtesy: Inside GNSS

Issues related with GNSS

- Intentional and Unintentional Interferences
- Multipath, Indoor and Urban Environment
- Over crowding of Frequency Spectra
- Need for higher anti-jamming margins
- Protection of RNSS and Radio Astronomy bands
- Continuity of existing and planned constellations
- Ionospheric and Solar weather impact on GNSS signals
- Standardization of Civilian Signals and Receivers
- Universal Time and Reference Frames (Each Constellation as of today has adopted different time and geodetic reference frames)

CONCLUSION

After all, we need measurements of space and time for almost all our activities and GNSS provides these.

For the emerging civil aviation scenario (less than 5 years), all airlines should equip their aircraft with SBAS (GAGAN) receivers and integration with FMS. Since GAGAN will be a reality in next 2 years. GAGAN will help in operation into small airports for aircraft as well as heli-services.

All these will get further augmented by IRNSS, which in future does have potential to expand, will provide better navigational facility to specified users, surveyors, transporters and various other users with 100% availability and better accuracies. The PNT accuracies can be enhanced if receivers use other constellations.

Hence, GNSS will influence our life more than any other technological advent.

Present Status of GNSS in India

- Gagan System is operational for uncertified services.
- Gagan will be operational (certified) by March 2014 using GSAT-8 (127 PRN) & GSAT-10(128 PRN) with GSAT-15 standby
- First IRNSS- s/c was launched in July 2013. The system is likely to be operational by 2015.

Author :

Email : pal_surendra@hotmail.com

Dr S Pal, President IETE is an alumnus of Birla Institute of Technology & Science (BITS), Pilani and Indian Institute of Science, Bangalore, India. He is a Space Communication Technologist of repute and is a Distinguished Fellow of IETE, Fellow IEEE, Fellow National Academy of Engineering, Fellow of The National Academy of Sciences, Fellow IET, UK; and many other national and International Professional Societies.

Formerly he was a Prof Satish Dhawan Professor & Senior Advisor, Satellite Navigation Programme, and Distinguished Scientist, Indian Space Research Organization.

Dr Pal pioneered the Microwave & Antenna and RF communication activities at the ISRO Satellite Centre at the inception stage. He is also responsible for pioneering satellite based navigation activities in India.

His fields of interest are: RF Communications, Space Technology, Microwaves, Electromagnetics, Antennas, Radars, Digital Communication and Satellite Navigation. His expertise in his field has been utilized as consultant & Advisor by many national and international organizations like: INMARSAT , ICO (UK), International Telecommunication Union (ITU), Nanyang Technolgical University, Singapore; UN Office for Outer Space, Defence Research Development Organization; Dept of Information Technology. He is on the UN panel of experts on Global Navigation Satellite Systems (GNSS), Visiting Professor of INAE & Distinguished Lecturer of IEEE (USA).

Dr Pal is recipient of more than one and a half dozen national and international awards & holds Indian, European & International patents for various inventions.

1858 - 1937

ACHARYA SIR JAGADISH CHANDRA BOSE *was a Physicist who was well known for his path breaking invention of millimetric electromagnetic waves. He became professor of Physics at Presidency College, Kolkata when this post was given only to Englishmen. He had an unique personality, always on the lookout for new ideas.*

He set up a Laboratory for his research work with the Instruments designed and assembled with his own money in a small room of Calcutta University. He had successfully generated and transmitted wireless at very short wavelength almost at the same time as Marconi did. Marconi was able to announce his research work and show how wireless Telegraphy worked, earlier than Sir J C Bose. However, Royal Society of England, recognized his work in 1896 through his research article on " Electro-magnetic Waves" and Professor Bose was honoured with the degree of Doctor of Science. Calibre of Dr Jagadish Chandra Bose as a scientist was recognized by famous scientists of his time like Marconi, Neil Bohr, Rutherford, Righi etc.

After 1900 his attention was primarily devoted towards intensive study of the behavior of plant tissues under different type stimuli, which led him to devise many remarkably delicate measuring and recording instruments having one to ten million magnification, almost 100 times more sensitive than the contemporary instruments.

In 1995 exactly after hundred years of Sir JC BOSE's demonstration of generation and transmission of electromagnetic waves, the IETE paid a fitting tribute to the illustrious and pioneering scientist of India with the initiation of a new lecture series in his memory. This lecture is held every year on 30th November on the birth anniversary of Sir J C Bose at the venues alternating between Delhi and Kolkata each successive year.

Biotechnology Research for Self - Reliance

MANJU SHARMA

Department of Biotechnology, Ministry of Science and Technology, New Delhi

Sir J C Bose - intellect, simplicity, poetry and compassion personified in his magnificent personality are reflected in the excerpts from his diary.

(i) "Beloved Lord, hear the cry of thy erring child. He has long wandered far and found no peace. Breathe in his dead soul and let it revive with thy love.

- Compassion, 30th November 1882

(ii) "I have been long thinking whether the vast solar energy that is wasted in the tropical regions, can in any way be utilized. Of course Trees consume the solar energy. But is there no other way of directly utilizing the radiant energy of the Sun?"

- Science, 5th March, 1885

Sir J C Bose, a doyen of Indian Science, dedicated his whole life to research as one of the pioneers in the field of electromagnetic theory. The main areas in which he later worked include physical research, plant physiological investigations and the last 20 years of his research was devoted to comparative studies on the responses of plant and animal organisms. He nearly opened up the fields of microwave physics and communication, one of the great achievements in Indian science. He developed the microwave receiver and he was referred to as the first to employ a semiconductor 'Galena' as a self-recovering detector of electronics rays. India is proud of this invention. Today he is internationally famous as the father of modern biology. Isn't he an exceptional genius making landmarks in two non-correlated fields - physics and biology?

Sir J C Bose was just not a scientist par excellence; he was a poet, a professor and a saint. He set up the Bose Institute in Kolkata and he ensured that the surroundings of the Institute reflect the artistic personality and spirituality of the founder; he said:

"I dedicated today this Institute as not merely a laboratory but a temple."

He further said that "The lectures given here will not be mere repetitions of second-hand knowledge". He also wanted the facilities of the Institute to be used by other scientists in the country. In his beautiful philosophical words, he remarked:

"Although science is neither of the East nor of the West but rather international in its universality, yet India is specially fitted to make great contributions. The burning Indian imagination, which can extort new order out of a mass of apparently contradictory facts, is held in check by the habit of concentration. This restraint confers the power to hold the mind to the pursuit of truth with the infinite patience."

Sir J C Bose become a Fellow of the Royal Society in 1920, and in 1927, he was the President of the Indian Science Congress. The great human being he was is reflected as *"It is invention which is of importance for the mankind, not the inventor."*

The third area in which Sir Bose put in major efforts was to emphasize on self-reliance in science and technology. Even the instruments which he used for his research were developed by him and he was very proud of it. It is the inspiration I drew from the life history of this great scientist that I decided to speak today before this august gathering, the relevance of self-reliance in biotechnology.

> *"Attaining new heights in biotechnology research, shaping biotechnology into a premier precision tool of the future for creation of wealth and ensuring social justice -specially for the welfare of the poor".*
>
> -From the vision Document released by the Hon'ble Prime Minister of India, September 7, 2001.

BIOTECHNOLOGY

The World has witnessed major technological revolutions which have changed the very fabric of the socio-economic scenario. The first revolution was in biological sciences; and the second in super computing and large-scale simulation. The scientists feel that the third revolution would be a social one with merger of biology and computer science; it may also involve the areas of physics, mathematics and engineering. Biotechnology in true sense represents a synergy of various disciplines; what Prof J C Bose considered important for scientific progress. The spectacular success of biotechnology in the 20th century is almost entirely based on discoveries and innovations in basic research; there has been great awareness to expand the investment in bioscience and knowledge base globally.

The biotechnological tools have helped researchers to dissect the innermost secrets of the cell and develop new ways for an early and correct diagnosis of diseases, prophylactic measures such as vaccines to impart immunity and therapeutic measures for treatment of diseases. Simultaneously, development in the field of transgenic plants with enhanced productivity, disease resistance and stress tolerance offer means to feed the ever increasing population on this planet. These discoveries have had a major impact on environment such as microbial bioremediation, phytoremediation, etc towards an environmentally sustainable development. All this has been made possible by biochemists and molecular biologists, who explore the tiny realm inside the cells, study the cause of diseases and search ways to improve life on earth.

If deadly diseases such as AIDS and cancer are to be cured, if the planet's pollution is to be cleaned up, if the food requirements of increasing population are to be met from limited arable land, new crop architecture is to be introduced to benefit the farmers. If the designer babies are to be produced, it will be the biochemists and molecular biologists together who will generate this knowledge and have more scientific breakthroughs.

Living organisms have the great ability to change and adapt for providing better understanding of the dynamics of life, from the secrets of cell to cell communication to the chemical changes in the brain which gives us the signal to change and adapt.

At the molecular level, there is need to understand the information in the DNA, to discover how portions of genetic material are turned "on and off" and to learn how the structure of protein determines its function. At mean level, scientists are discovering to study the interaction of different chemicals to form cells and that of cells to build different organisms. It is mind boggling to imagine how subtle differences in the instructions issued by the DNA are able to create vast array of life forms on this earth.

About 1.5 billion people in the world earn less than a dollar per day. In India, for population of more than a billion with limited arable land of 142.5 million hectare, the threat of large number of malnourished people, serious epidemics like malaria, tuberculosis, cholera and HIV AIDS are looming large on our horizon. The environmental burden of pollution and the rapid erosion of biodiversity of the country, lastly, a large number of unemployed people, biotechnology research and development would be a major tool to contribute towards self-reliance, to achieve our objective of sustainable development in harmony with environment for the entire population.

Biotechnology has made significant strides in the last century and this millennium world over is recognized as the era of biotechnology and information technology. A large number of products have already been approved for marketing and many more are being developed. These products include dozens of therapeutics including human insulin for diabetes, growth factors used in bone marrow transplants, products for treating heart attacks, scores of diagnostic kits for AIDS, Hepatitis and other infective agents, enzymes used in food production etc. The first life saving drug Humulin was produced by recombinant DNA technology and this followed a plethora of drugs including Betaseron for treating multiple sclerosis, pulmozyme for cystic fibrosis, activate, a clot dissolving tissue plasminogen activator used for treating heart diseases. Not only now it is possible to produce these biopharmaceuticals in a form identical to that of normally occurring in the human body but also to design meaningful improvement in activity, stability or bio-availability. Such products are also free from contamination.

I am sure; we all recognize today that for humankind to fulfill its minimum basic requirements, one area of science which offers enormous potential is biotechnology

I quote from the Address of the Hon'ble Minister (S&T), Prof Murli Manohar Joshi which he gave on the occasion of the 8th General Conference and 13th General Meeting of the Third World Academy of Sciences.

"I propose for your consideration that 'Technology with a Human Face' could be that common agenda. Providing creative and innovative solutions in health services, population management, mitigating the damage to vast sections and cyclones, technologies for higher productivity in agriculture and desired levels of nutrition, technologies for conservation of land, water and resources and their integrated management for sustainable development and consumption leading to their ecologically balanced management could be some crucial elements of such an agenda."

AGRICULTURE

Biotechnology is helping to resolve that quandary by making it possible to grow more, healthier and nutritional food under unfavorable conditions of biotic and abiotic stress. Malnutrition has been one of the main concerns of the developing World as it results in nearly 12 million deaths every year of the third world children under five. Growing enough staple crops such as corn, rice, wheat, and potatoes without further extending the area of land will require sustained increase in yields per acre. Biotechnological innovations have a key role in fighting against malnutrition Worldwide.

Deficiencies of vitamin-A and iron, for instance are very serious health issues in many regions of the developing World, causing childhood blindness and maternal anemia in millions of people whose dietary staple food is rice. Biotechnology has been used to produce a new variety of rice "The Golden Rice"-that contains Vitamin A precursor carotene and iron. This modified rice is expected to provide nutritional benefits to people suffering from vitamin-A deficiency related diseases. Adequate vitamin A intake can also reduce the mortality associated with infectious diseases like diarrhea and childhood measles by enhancing the activity of human immune system. Genetically modified rice, which boosts yields by nearly 35%, has been developed.

Pioneer-Hi Bred (Nature Biotechnology, May 2000) devised a pin-point technique that could revolutionize the effectiveness of genetically improved plants. Just by changing a single base, herbicide resistance persist in successive generations of the modified plants.

Farmers have been battling for centuries using methods from conventional plant-breeding techniques, chemicals like pesticides and herbicides. But because of environmental and health concerns, the development and use of new chemical treatment regimes has declined. Advanced biology can endow plants with genes that help them to resist pests. For instance, cotton, potato and corn containing the Bt gene from a soil bacterium producing delta-toxin proteins that are selectively toxic to certain kinds of insects are harmless to other insects, humans and animals. Bt cotton has been launched for field trials in India with promising results.

In addition to pest resistance and herbicide tolerance, other traits are being added to crop plants that will allow them to withstand drought, freezing temperatures and salt toxicity. ICRISAT, Hyderabad has introduced short-duration chick pea varieties, maturing in 85-100 days. Two chick per varieties Swetha and Kranthi not only could escape drought but also produced a yield as much as 1.7 tons per hectare. Another major problem we face in our crops is early pod shattering all over. Now the gene responsible for this trait has been identified. If this is inactivated, it prevents the seed shattering. This finding was reported in Nature. This is very significant as inactivation of these very genes in mustard, canola and other related commercially important crops would prevent dispersal of seeds which normally results in significant losses.

Recently a protein, the first of its kind, that switches in plant natural defenses against diseases and insects has been approved in US in April 2000 giving farmers an alternative to chemical pesticides. The protein, named Messenger-produced from genetically engineered bacteria has been shown to increase yields in tomatoes and peppers by us to 22% besides, making plants more tolerant to drought. This Messenger protein is the first natural product that can turn on the immune systems of crops.

The merging of medical and agricultural biotechnology has opened up new vistas to develop plant varieties with characteristics to improve health. Research work is underway that will deliver medicines and vaccines through common foods which could be used to immunize individuals against a wide variety of enteric and other infectious diseases.

Food production is the largest world-wide industry using bioengineering principles along with biology.

Application of recombinant DNA to food industry is enormous. Functional quality of foods has also been improved by producing fruits and vegetables with improved flavor and texture. The effort to improve the functional quality of foods through biotechnology occurred in 1989, Flavr Savr tomato engineered to provide increased shelf life. Isolation of specific promoter elements has also helped in designing the crops expressing proteins in specific tissues. Now we can have blue roses and pink dahlias. These have a wider application in creating designed ornamentals for export purposes. Not only this, now we can prevent our fruits and vegetables from frost damage by genetic transformation. We need low cost nutritious food for children. Many technologies are available for this.

HEALTH RELATED ASPECTS - A MOLECULAR MEDICINE REGIME

Cloning or the exact duplication of specific genes has been an essential tool in biotechnology for more than 20 years. Cloning of human cells, organs and other tissues can produce replacement skin, cartilage and bone tissue for burn and accident victims. This could prove useful for developing internal organs for human transplantation.

The cloning of Dolly and Polly demonstrated that nuclear transfer technology could be used effectively. The breakthrough in developing stem cells holds the potential to control cancer, regenerate spinal cord and brain tissue, and successfully treat many diseases associated with aging.

Vaccines are one of the greatest developments of modern medicine. They have helped in eradicating diseases like small pox, pushed polio to the brink of extinction and spared countless people from numerous diseases like typhus, tetanus, measles, hepatitis A, hepatitis B, rotavirus and other dangerous infections.

In the words of Nobel Laureate Prof Rolf M Zinkernagel (1996 Nobel Prize)

"Social medicine and access to basic necessities in life are as important as providing immunization cover to population."

But still for many other diseases like, malaria, AIDS, herpes, hepatitis C, we have yet to find a successful vaccine. This gap exists due to the fact that standard immunization methods work poorly or pose unacceptable risks when targeted against a particular illness. Certainly alternate strategies are to be explored. One of the most promising ways is to develop vaccines out of the genetic material either the DNA or RNA. DNA based vaccines will preserve all the positive aspects of the existing vaccines while avoiding the risks. They are easy to design and to generate in large quantities using recombinant DNA technology and as stable as others (even more so) when stored. Since they-can be engineered to carry genes from different strains of a pathogen, they can potentially provide immunity against several other strains at once. DNA/RNA based vaccines are delivered directly into the cells and then these vaccines instruct the cell to synthesize the encoded antigenic proteins.

Indian scientists are making a concerted effort to develop vaccines for malaria, tuberculosis, rabies, JEV and HIV AIDS with good success and potential leads. We have already put the leprosy vaccine as an immunomodulator in the market and Rota viral diarrhea vaccine is under field trials. In fact, we are also in an advanced stage of developing an anthrax vaccine. A number of diagnostic kits have been transferred to industry for use by the people of the country.

BIODIVERSITY & ENVIRONMENT

Biotechnology has paved the way for conservation and sustainable use of biodiversity, our precious heritage, its conservation, evaluation and the study of genetic structure of species. Applications of modern biotechnology for bioremediation of contaminated land and water have made an impact. Bioremediation employs biological agents to render hazardous wastes into non-hazardous wastes. Even plants have been used for phytoremediation successfully.

Biotechnology as a tool has helped in recovery of degraded ecosystem. Some of the methods based on plant biotechnology include reforestation involving micro propagation and use of mycorrhiza. Micro propagation has resulted in increasing plant cover and thus preventing erosion and giving a climatic stability. Phytoplankton microscopic plants which freely float through the oceans and inhabit three-quarters of Earth's surface, hold a fundamental warming influence on the planet by capturing and absorbing the Sun's radiation. Thus, have a vital role in climate change. This concept has emerged as a result of studies carried out in the University of California, San Diego.

Our own scientists at TERI, New Delhi along with the support from DBT have developed technologies that can degrade crude oil and oil sludge. This can be packed in polybags and easily transported to the sites of refinery or accidental crude spill areas. Such are the innovations of biotechnology.

BIOENERGY

Biotechnology also has a wider implication in increasing the bioenergy resources by increasing the acceptability of biomass, biogas, fuel alcohol as feasible commercially available energy options for the future. Even the generation of biofuel cells by making use of catalytic properties of organisms and enzymes are used for energy conversion. Biofuel cells convert chemical energy into electrical energy. These biocells would be used as specific sensing devices for energy conservation.

BIOINFORMATICS

Advent of computers have added a new dimension to biological research. With the rapidly evolving superfast computers, improved accuracy in legend screening, improved combinatorial chemistry designs, virtual explosion in the availability of three dimensional structural information and genome sequence database, the computational techniques will continue to take a centre stage in many different aspects of drug design and development process. Computer aided structure based drug design played a significant role in the recent successful development of drugs for the treatment of AIDS (HIV protease inhibitors) and of inflammation (COX-2 inhibitors).

Of late, biological materials in the form of biochips are going to have a tremendous impact on computer development per se the biochips would replace the conventional silicon chips used in the computer. The development of bimolecular computers promise to be ten to thousand times smaller than the best super computers with much faster switching times and extremely low power dissipation.

Researchers at Advanced Centre for biochemical Engineering, London have succeeded in obtaining a tiny semiconductor structure from yeast Schizosaccharomyces pombe. The yeast produces structures as quantum semiconductors.

Computational tools for mining the genomic data, identifying the potential new drug targets, elucidating and /or predicting the three dimensional structure of targets from the primary structure are at the core of the present day bio-informatics technology. Computational approaches will continue to be essential part of the ongoing and future drug design and development process. Thus, future advances in biotechnology offer the promise of an impressive array of new and useful products and technologies for consumers, including farmers and rural population.

TO SUM UP

Recent issue of 30th October of the Newsweek on the title page says "The Biotech Boom". In the words of Karen Lowry Miller:

"Long dominated by the U S, the field now bristles with new entrepreneurial players. The next Genentech may come from Rio, Munich or Delhi".

India has enormous potential to harness the fruits of biotechnology. How Biotechnology has helped or is helping or would do so in future, I give some examples:

(i) Over 2000 million people Worldwide have been helped by more than 80 biotechnology drug products and vaccines.

(ii) There are many biotechnology tailored drug products and vaccines currently under human clinical Trials and many more in early development.

(iii) Scores of medical diagnostic kits that keep the blood supply safe from AIDS virus and detect other conditions early enough to be successfully treated. Home pregnancy tests are also biotechnology diagnostic products.

(iv) Consumers are already enjoying food such as vine-ripened, long lasting tomatoes, better tasting Carrots and peppers. A number of biopesticides and other agricultural biotech products are in use.

(v) Innovations have led to expansion of numerous Biotech companies.

(vi) Market capitalization, the amount of money invested by Govt. and private sector has also shown tremendous increase.

(vii) Biotechnology as industry has given opportunities and created avenues for people.

(viii) Biotechnology is one of the most research intensive industries in the World.

World has witnessed spectacular advances in the field of biotechnology after that breaking discovery of the double helix structure by Watson and Crick in 1953. On 26th June, the first "working draft" on Human Genome, the blue print of life was announced. Arabidopsis genome is complete; work on Rice Genome is nearing completion and so on. Genomics is a priority. Three billion ladders of the human genome priority. Three billion ladders of the human genome provide enormous raw data for biotechnologists, medical and computer expert's world over to move in their countless discovery regime. Hunger, poverty, ill health, unemployment and environmental calamities-as they would come in the way of progress of humankind, our dependence would increase manifold on this frontier area of science i.e. biotechnology. The challenge before us is to mount a massive effort on basic innovations in biology and build entirely new partnerships with industries both private and public sectors, financial institutions, etc. The biotech industries-about 1300 in US; about 700 in Europe with massive investment, have already paved the way to a big bioindustrial revolution based on biotechnological innovations in the 20th Century. Presently, world over in US and Europe, 42 biotech products are in the market; about 230 in pipeline. In India, 11 biotech products have been introduced by drug industry. (Biotech Monitor, SGCOWEN March 2002), and many are in advanced stages of development.

The investment in these sectors is increasing manifold every year. My plea to the industry is that they must take the risk, make investment and try to speed up the revolution. Scientists alone would not be able to take the challenge. It will have to be a partnership and a team. Beside US, UK, other countries are speeding up. Japan is trying to catch up very fast in the post genome era. It is now for us to accept the major technological challenge and put in our best efforts to ensure a healthy, wealthy, prosperous and sustainable 21st Century for our people.

For indigenous self-reliance, it is essential that our scientific community works on Indian problems of agriculture, health and environment. The initiative of the Department in this direction is giving useful results. Our partnerships, with engineering community being strengthened now would be truly responsible for Biotechnology Incubator, Biotechnology Parks and industrial ventures.

Biotechnology is knowledge intensive, skill based field and is being nurtured all round for harnessing its full potential for the welfare of humankind.

Let me conclude:

Albert Einstein, the man of the Millennium, said:

"Concern for man and his fate must always form the chief interest of all technical endeavors ... In order that the creations of our minds shall be blessing and not a curse to mankind. Never forget this in the midst of your diagrams and equations"

When we are steadily marching towards the path of innovations and discoveries, let us remember:

Prajnanam Brahm - "Knowledge is God"

Author :

Email: manju@dbt.nic.in

Dr Manju Sharma is the former secretary of the Department of Biotechnology of India and current president and executive director of the Indian Institute of Advanced Research. She is a renowned leader in promoting bioscience and technology in India and around the world. She has many research publications, a monograph on medicinal plants, several technical and policy reports, nationally and internationally, to her credit.

Beginning in 1974, she held various positions in the Indian government, including in the Department of Science and Technology, the Planning Commission, the Office of Scientific Adviser to the Prime Minister, and the Department of Biotechnology. She has played an important role in promoting science and technology in general and biosciences in particular.

Over her career, Dr Sharma has initiated and promoted many successful programs in diverse areas, including biomass production and conversion, biofertilizers, status reports on photosynthesis research, plant tissue culture for varied applications, biosphere reserves, report on the "Silent Valley" in Kerala and its conservation, transgenic research in crops, germplasm conservation, medicinal and aromatic plants, food biotechnology, diagnostics, new vaccines, and human genetics.

Dr Sharma received a master's degree in science from Lucknow University with a gold medal and performed post-doctoral research at Purdue.

Since retiring, she founded a new institute called the Indian Institute of Advanced Research, located in Gandhinagar Gurajat.

Her contributions to the field have been honored with numerous awards, among them the Padma Bhushan, National Senior Woman Bioscientist Award, NASI Platinum Jubilee Gold Medal, and the Norman E. Borlaug Award. In 2004, she received a lifetime achievement award from BIOSPECTRUM.

Past, Present and Future Application of Radio Waves - Hertz to Terahertz

O P N CALLA
Distinguished Fellow and Past President IETE, FIEEE Director ICRS
International Center for Radio Science, Jodhpur

"The law of nature is that discoveries take place in the universe when the time is ripe for that event."

Introduction

In 1895, one of the remarkable and noteworthy year, the world, witnessed the birth of millimeter waves by Sir, J.C Bose one of the most prominent Indian Scientist. This year was marked by progress at that time when people had no clue what so ever regarding many features and applications his invention will provide in future. The fruit of all which was initiated by Sir J.C. Bose, the present generation is reaping the harvest!

In 1895 radio waves were generated transmitted and detected. They were generated at 60 GHz and were detected at a distance of 23 meters. Before this invention the communication was taking place through various means. There had been number of means using pigeon, post, drums, signs, light signals, reflecting mirror and sending man carrying the messages. Then came MORSE CODE transmission using wires and later voice messages through the cables. The communication down the lane was done through all these means until Sir J.C. Bose's invention of millimeter waves and demonstration of the generation, transmission and detection. This ushered a new era of wireless communication. Thus the invisible communicator revolutionized our lives. The whole humanity bows to their parents who gave us Sir J.C. BOSE for inventing the invisible waves which have provided new dimension in various applications that were not thought of even by Sir J.C. Bose himself.

Sir J.C. Bose demonstrated the communicating capability which was further explored by Sir Marconi who established communication from Europe to Australia. We divide era of application of Radio waves in PAST that is from 1895 to S. K. Mitra era where during the period of S. K. Mitra radiowaves were used for ionospheric research and also similar use was made by Dr. K.R. Ramanathan at PRL and Dr. A.P. Mitra , Dr. B.M. Reddy at NPL. Prof. O.P.N. Calla worked on Instrumentation for Rocket Borne application at ISRO and is still continues to work in the field of Application of Microwaves using ground based airborne and Space borne system. Prof. R.V.S. Sita Ram at SAMEER contributed in ground based hardware. Dr. Vikram Sarabhai created MASEG (Microwave Antenna System Group) and Prof. O.P.N. Calla was Head of ED of MASEG. Later Prof. M.G.K. Mennon renamed the Electronic Division of Microwave Antenna System Engineering Group as Microwave division-MID of ISRO. All over the world the use of radiowaves for communication purpose was growing by Leaps and bounds. The frequency ranges from LF to Microwaves/ Millimeter waves were being used for Radar application. This era which is part of present as the LOS Communication was getting crowded and the scientific community was given a new surprise by Mr. Arthur Clark by giving the concept having Satellite at 36000 Km up in the space for providing Global Communication by having three satellites 120° apart in order to cover whole earth. This concept totally revolutionized the method of communication using Radio waves. Dr. Vikram Sarabhai was the one who brought this to India through SITE experiment carried out in 1975-1976.

During this time, first ever Satellite base propagation studies at frequencies above 10 GHz to study the effects of rain was done by Microwave Division of ISRO whose Project Incharge was Prof. O.P.N. Calla. The MID of ISRO which was a part of SAC at Ahmedabad used microwaves and various application were initiated that included Medical and Remote Sensing. Also Prof. M.G.K. Menon created SAMEER where Prof. R.V.S. Sita Ram focused on Industrial application of Radio waves and Medical application. Before this Dr. Homi J. Bhabha brought Dr. G. Swarup to start the Radio Astronomy in India, Ooty Telescope was established by TIFR Group. Thus application of radio wave is deeply rooted us almost

every sphere like Industrial, Medical, Communication, Remote Sensing, Atmosphere and Scientific including Astronomy. The uniqueness of Radio waves in each application makes it stand on its own at the same time they provide complementary and supplementary role to the wavelength which are much shorter like infrared and optical wavelengths.

2. *Acharya Sir Jagadish Chandra Bose was a Polymath :*

A physicist, biologist, botanist, archaeologist, and writer of science fiction. He pioneered the investigation of radio and microwave optics, made very significant contributions to plant science, and laid the foundations of experimental science in the Indian subcontinent. He is considered as the father of radio waves, and also the father of Bengali science fiction. He was the first from the Indian subcontinent to get a US patent, in 1904. On 30th November 1858 in Mymensingh (now in Bangladesh), Bhagaban Chandra Bose and Bamasundari Debi were the proud parents of a legend who is known as " Jagadish Chandra" to this world. His wife Abala Bose was an Educationist & Torch Bearer for Women Education in India and a constant inspiration for him and supported him in his difficult times at Presidency college.

Figure1. Father ***Bhagaban Chandra Bose*** *and Mother* ***Bamasundari Debi*** *and wife* ***Abala Bose***

2.1 Chronology

According to D. M. Bose, the research activities of J. C. Bose, extending from 1894 to 1937, the year he died, can be divided into three periods.

From (i) 1894 to 1899

During the first period, extending from 1894 to 1899, he produced the shortest of the then possible electromagnetic waves (the microwaves),and extensively studied their quasi-optical properties. His researches with coherers not only led to the anticipation of semi-conductors but the effect of microwaves on the coherers led to the next important phase of his research.

(ii) From 1899 to 1904

During the second period, extending from 1899 to 1904, began with his study of the fatigue effect in metallic coherers, used for detection of electric waves, from which he went over to the study of various other inorganic systems which exhibit stress under different kinds of physical stimulation. The similarities in responses of inorganic and organic systems led to his famous and controversial generalization about the responses in the living and the non-living.

(iii) From 1904 to 1937

The third period that logically followed from the second phase led to his studies of Plant Electrophysiology and led to monumental investigations, which like most of his researches, were ahead of his time. These researches lasted till the end of his life.

2.2 Microwaves

A book by Oliver Lodge on Hertzian waves "Heinrich Hertz and His Successors" impressed sir J.C Bose and intuitively felt that this was an area that need attention. Bose made a spectacular discovery, of producing radiation at wavelength of the order of 5 mm (called millimeter waves or microwaves, 1/130 that of Hertz's waves). Bose was the first to demonstrate Microwaves and undertook research on what may be termed as "Microwave Optics".

2.3 Who Invented the Radio?

A question that is frequently asked in India is: "Who invented the radio? Or, should not J. C. Bose have received the Nobel Prize for inventing the Radio, at least jointly?" This has been discussed by Das Gupta*. Das Gupta questions the commonly held belief that Bose anticipated Marconi by two years, and provides evidence to the contrary. Kochar# also shows that it was Bose's intransigence towards patenting that came in the way of his being recognized as one of the inventors of wireless telegraphy. The 1909 Nobel Prize for Physics was awarded to Guglielmo Marconi (1874-1937) and C. F. Braun (1850-1918) for wireless telegraphy.

* S. Dasgupta, Jagadis Chandra Bose and the Indian Response to Western Science (Oxford University Press, 1999).

K. Rajesh, J. C. Bose: The inventor who wouldn't patent, Science Reporter (NISCOM, 2000).

2.4 Wired and Wireless Communication

Electrical telegraph system shown in Figure 2 was developed by the American artist Samuel F. B. Morse, the American physicist Joseph Henry, and Alfred Vail. This system sent pulses of electric current along wires which controlled an electromagnet that was located at the receiving end of the telegraph system.

Figure 2 : ***Electrical telegraph***

2.5 Wireless Communication

Acharya Sir J.C. Bose gave the first demonstration of wireless communication in 1895. He demonstrated in Calcutta Town Hall, in the presence of the Lt. Governor of Bengal, where he transmitted electromagnetic waves from the lecture hall through intervening walls - covering a total distance of 25 meters tripping a relay which threw a heavy iron ball, fired off a pistol and blew a small mine. Sir J.C. Bose's inventions are shown in figure 3 where the Radio waves produced at 60 GHz were transmitted through two prisms and detected by a detector and a conical horn with wired polarizer.

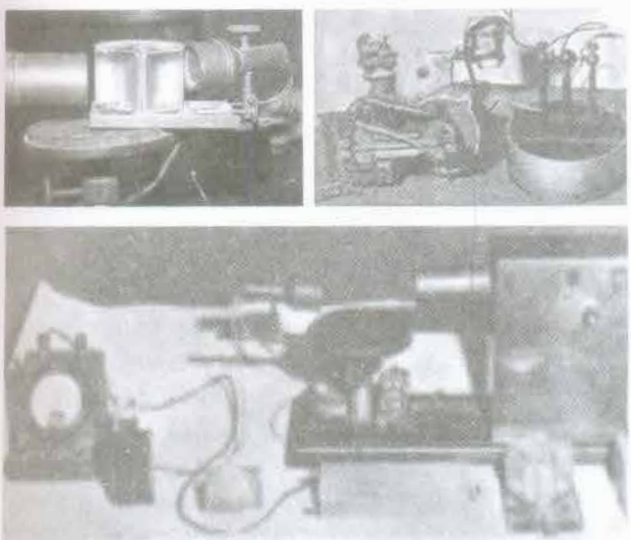


Figure 3 showing complete setup ***sir J.C. Bose's*** *famous experiment for producing radio waves at 60 GHz.*

Figure 4 showing photographs of (a) The twisted-jute polarizer used by Bose, (b) One of Bose's polarizers was a cut-off metal plate grating, consisting of a book (Bradshaw's Railway Timetable) with sheets of tinfoil interleaved in the pages. (c) One of Bose's free-space radiation receivers, recently described as a "space-irradiated multi-contact semiconductor (using the natural oxide of the springs)." The springs are kept in place in their tray by a sheet of glass, seen to be partly broken in this photograph.

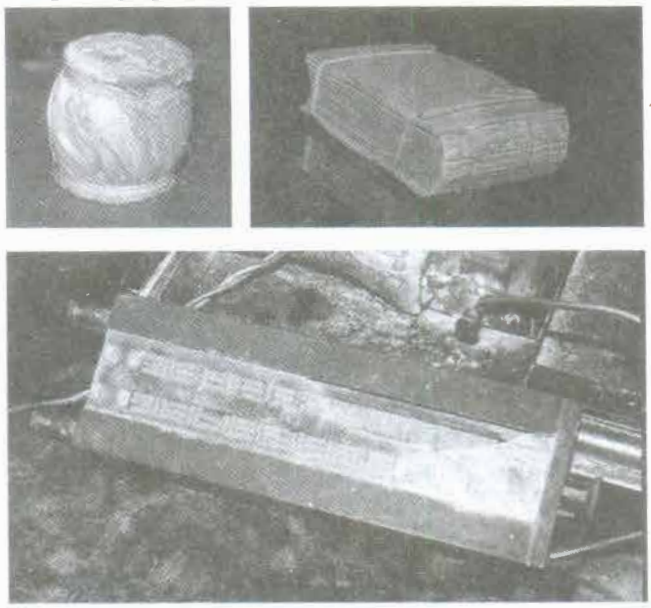


Figure 4 : shows the photograph of the devices developed by Sir J.C. Bose; they include twisted jute polarizer in figure 4 (a) and a metal plate polarizer in Figure4 (b). Figure 4 (c) shows the free space radiation receiver.

2.6 Sir J.C. Bose and Plants - Biophysics

Sir J.C. Bose did research in plants and Biophysics. He presented a very important paper at the International Congress of Physics held in Paris in 1900, titled "On the Similarity of Responses in Inorganic and Living Matter". To prove his point he had devised instruments such as the Crescograph shown in figure 5 a measuring for the rate of growth of a plant and the death recorder to record the exact moment of death of a plant. Figure 6(a) and (b) shows some measurements taken by him on plants.

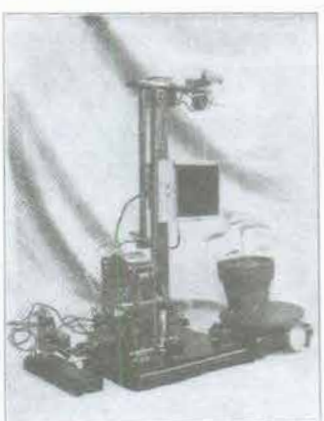


Figure 5 : ***Crescograph***

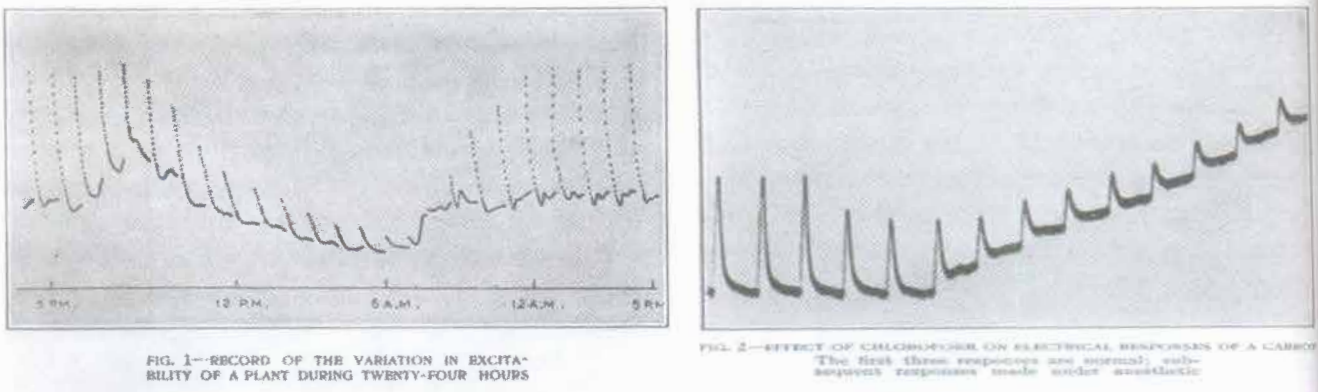


FIG. 1—RECORD OF THE VARIATION IN EXCITABILITY OF A PLANT DURING TWENTY-FOUR HOURS

FIG. 2—EFFECT OF CHLOROFORM ON ELECTRICAL RESPONSES OF A CARROT. The first three responses are normal; subsequent responses made under anesthetic.

Figure 6 : (a) (b) Crescograph: Bose's invention, with some measurements taken by him on plants.

Bose demonstrated that plant response to stimuli parallel that of animals. This discovery led to later experimentation on "The nervous systems of plants". In one example, his laboratory research showed that "pleasant" music enhances plant growth while harsh sounds retard their growth. There was a famous saying by Sir J.C Bose **"These trees have a life like ours. They eat and grow, face poverty, sorrows and suffering. This poverty may induce them to steal and rob, they also help each other develop friendships, sacrifice their lives for their children."**In other research, Bose tested plants for changes in electrical conduction in response to a variety of stimuli including: wounds, chemical agents, microwaves, temperature changes, and seasonal effects. Many scientists have worked upon and verified his studies through researches and peer review articles.

2.7 Acharya MEETS Swami Ji: Aversion to Patenting

Sir J.C. Bose averted from patenting because he detested commercialization and believed to serve Humanity. But Swami Vivekananda insisted to patent his research and experiments. Swami ji was aware of his reluctance towards patenting so with the help of one his disciples Mrs. Sara Chapman Bull, he filed a patent for Bose's research on 30th September 1901. The patent was granted on 29th March 1904 as US Patent 755840 for "Detector for electrical disturbances". This step of Swami Vivekananda lead to recognition of our country and made Sir J.C. Bose the first Indian to get an U.S. Patent who never visited U.S. as shown in figure 7. His intransigence and ignorance to patenting should be considered as his patriotism towards his country and boost the Indian youth to work selflessly to work for the nation.

Figure 7 : Sir J.C. Bose and Swami Vivekananda

2.8 The Poet & The Scientist: Gurudev Rabindranath Tagore

Sir J.C. Bose had equipment fabricated to turn oxygen into ozone (by electric sparks) which Helped Tagore's second daughter for breathing. Tagore had very high regards for Abala Bose who reciprocated his feelings. It was only to Tagore that he would, at moments of deep despair, pour out his heart. Rabindranath Tagore (the lifelong friend of Bose 7th May 1861- 7th August, 1941) went to Bose's house to meet him and having not found him there, left a bunch of Magnolia flowers for Bose and wrote a poem addressing Bose.

"Across the oceans, on the western shore,
Reigns the temple of the Goddess
Of wealth of science.
There you have journeyed, my friend,
And returned richly crowned.
You anointed the motherland,
Modest at heart, poor and shy.
The great and the gloried

Or those far off lands
Assembled and acclaimed
Your work in unison,
The words resounding their message,
Far and wide, the seas beyond.
Her eyes welled up in tears.
Mother sends you the blessings
Of her jumbled heart,
Through a poet of whom
The world of science has never heard.
Only in the inner self of yours,
Will these words echo
As gentle murmurs of
Mother's whispered tone." #

The Poem wrote by Rabindranath Tagore

2.9 Sir J.C. Bose's supporters

1. Sister Nivedita (1867-1911)

Sister Nivedita

Sister Nivedita was a disciple of Swami Vivekananda and a close friend of the Bose couple. She along with Sara Chapman Bull motivated Sir Bose to write the patent application in the required format. Nivedita assisted Bose for hours on end and edited thousands of pages of his manuscript for the books that were published by Longman and asked for nothing in return. She joined hands with Abala Bose in her efforts to promote women's education.

2. Sara Chapman Bull (1850-1911)

Mrs. Sara Bull (or Ole Bull), an American and wife of a musician was responsible for Patenting Bose's document. Bose used to address Mrs. Bull as "Ma" (Bengali for Mother) and could not refuse her request.

Sara Chapman Bull

2.10 Some Honors to Sir J.C. BOSE

On 30th November 1958 Indian post office issued a stamp of 15 paisa on Sir J.C. Bose as shown in figure 8.

Figure 8 : showing stamp brought out by Govt. of India

Other famous honors:

- ❑ Companion of the Order of the Indian Empire (CIE) (1903)
- ❑ Companion of the Order of the Star of India (CSI) (1911)
- ❑ Knight Bachelor (1917)
- ❑ Fellow of the Royal Society (1920)
- ❑ Member of the Vienna Academy of Sciences, 1928
- ❑ President of the 14th session of the Indian Science Congress in 1927.
- ❑ Member of Finnish Society of Sciences and Letters in 1929.
- ❑ Member of the League of Nations' Committee for Intellectual Cooperation
- ❑ Founding fellow of the National Institute of Sciences of India (now renamed as the Indian National Science Academy)
- ❑ The Indian Botanic Garden was renamed as the Acharya Jagadish Chandra Bose Indian Botanic Garden on 25 June 2009 in honor of Jagadish Chandra Bose.

2.11 After Sir J.C. Bose

Prof. Sisir Kumar Mitra (October 24, 1890 - August 13, 1963) obtained the first experimental evidence of E-region of the ionosphere, K. R. Ramanathan (28 February 1893 - 31 December 1984) Indian physicist and meteorologist, carried out research into unsolved problems of the earth's atmosphere, the ionosphere, cosmic rays and Research on the low-latitude ionosphere. Dr. A.P. Mitra (21 February, 1927 - 3 September, 2007), Radio & Space Physics was his area of specialization. He performed major work in the field of earth's near-

space environment, through his group based at NPL. He worked on cosmic radio noise for studying the upper atmosphere which led to a series of discoveries in ionosphere, solar physics and cosmic rays.

3. Electromagnetic Spectrum

The electromagnetic (EM) spectrum is just a name that scientists give to a bunch of typical radiation when they want to talk about them as a group. Radiation is energy that travels and spreads out as it goes visible light that comes from a lamp in your house and radio waves that come from a radio station are two types of electromagnetic radiation. Other examples of EM radiation are microwaves, infrared and ultraviolet light, X-rays and gamma-rays. Hotter the energetic objects and the events create higher energy radiation than cool objects. Only extremely hot objects or particles moving at very high velocities can create high-energy radiation like X-rays and gamma-rays. The spectrum is shown in figure 9 and the figure 10 shows the percentage of transmission through Atmosphere for electromagnetic waves.

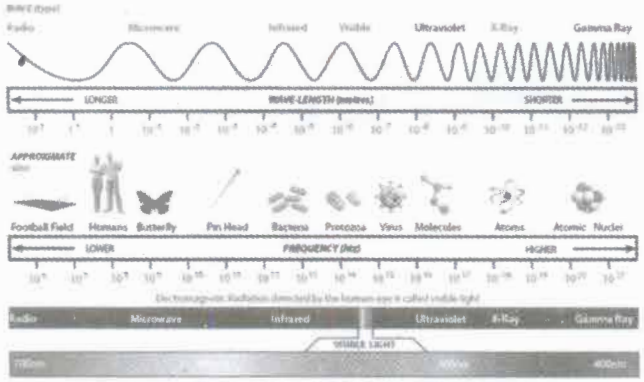


Figure 9 : Shows Electromagnetic Spectrum

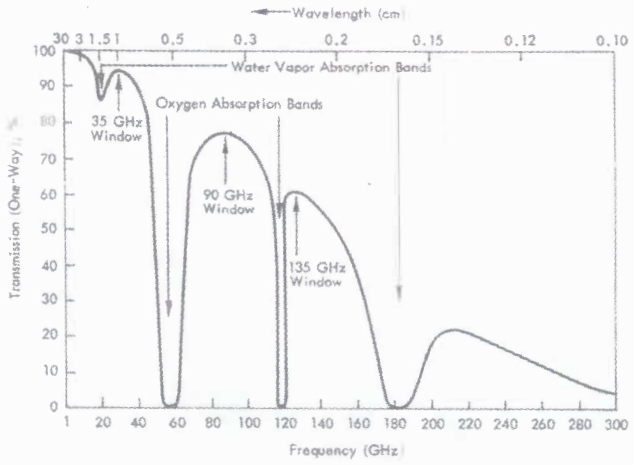


Figure 10 : showing Percentage transmission through the earth's atmosphere, along the vertical direction, under clear sky conditions

3.1 Radio Waves

Radio waves are part of electromagnetic spectrum, also called "electric rays" or "electric waves", have the longest wavelengths in the electromagnetic spectrum. Radio waves have wavelengths as short as a few millimeters and as long as hundreds of kilometers. Radio waves oscillate at frequencies between a few hertz and a few terahertzes (THz or 1012 hertz). "Far infrared" radiation borders radio waves on the electromagnetic spectrum; far IR is slightly higher energy and shorter wavelength radiation than radio. Various frequencies of radio waves are used for television, FM,AM radio broadcasts, military communications, mobile phones, and numerous other communication applications as illustrate in figure 11.

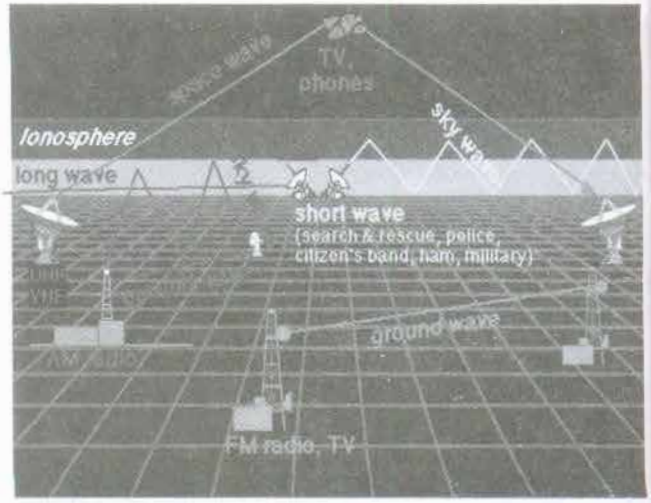


Figure 11 : Showing Types of electromagnetic waves with applications

3.2 Maxwell Equation

In 1865 James Clerk Maxwell noticed wavelike properties of light and similarities in electrical and magnetic observations. He then proposed equations that described light waves and radio waves as waves of electromagnetism that travel in space.

3.3 Radio Wave Propagation

The propagation of Electromagnetic waves takes place by sky waves and ground waves. Radio wave propagation is the method by which radio waves are transmitted, or propagated from one point on the Earth to another, or into various parts of the atmosphere. The electromagnetic radiation, like light waves, radio waves are affected by the phenomena of reflection, refraction,

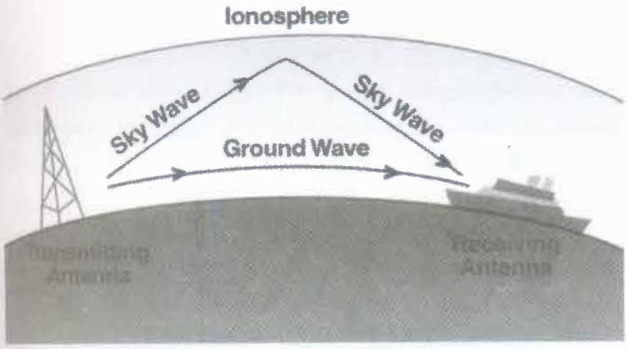


Figure 11 : shows types of radio propagations

diffraction, absorption, polarization and scattering. Figure 11 shows the different methods of Radio wave propagation.

3.4 Applications of Radio Waves:

Radio waves have different applications. These are as follows:

1. Communication
2. Remote Sensing
3. Medical
4. Industrial
5. Scientific
6. Astronomy
7. Planetary Exploration

3.4.1 Applications in Communication

The communication using Radiowaves is done by different methods like which is shown in figure 12.

- Line of Site
- Troposcatter Communication
- Duct Communication
- Satellite communication

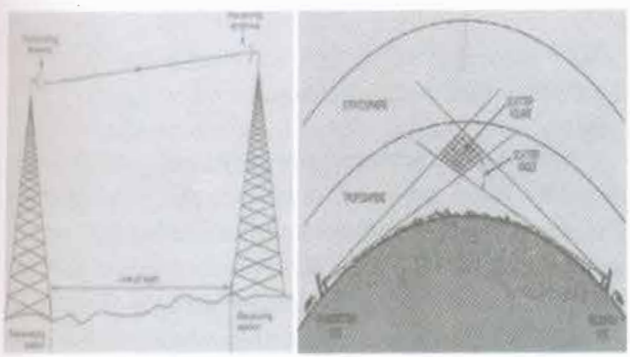


Figure 12 : Applications in communication (a) line of Site (b) Troposcatter

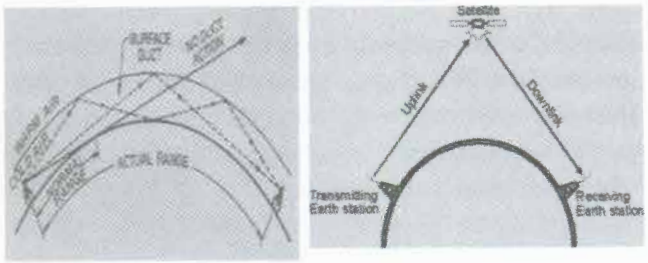


Figure 12 : Applications in communication (c) Duct and (d) Satellite Communication

3.4.1.1 Satellite Communication in India:

Arthur C. Clarke was first to propose a satellite communication system in 1945. Clarke has given the idea that geostationary satellites would be ideal as telecommunications relay. The establishment of the Indian Committee on Space Research (INCOSPARS) took place under the chairmanship of Dr. Vikram Sarabhai. This was established by Dr. Homi Jehangir Bhabha as part of Department of Atomic energy, widely regarded as the father of India's nuclear science program. The first rocket launching station in India was initiated by Dr. Vikram Sarabhai. This center was established at Thumba near Thiruvananthapuram on the coast of the Arabian Sea, primarily because of its proximity to the equator. Dr. Vikram Sarabhai is considered as Father of Space program in India.

Figure 13 : Showing ATS- 6 during testing

3.4.1.2 Satellite Instructional Television Experiment (SITE)

The Satellite Instructional Television Experiment or SITE was an experimental satellite communication's project launched in India in 1975, designed jointly by NASA and the Indian Space Research Organization (ISRO). The project made available informational television programmes to rural India. The satellite

ATS - 6 is shown in figure 13. This has been used for SITE. The main objectives of the experiment were to educate the poor people of India on various issues which included the educational program related to Animal Husbandry, Agriculture etc. via satellite broadcasting, and also to help India gain technical experience in the field of satellite communications.

3.5 Propagation Studies in India

ATS-6 was launched May 30, 1974 and decommissioned July 1979. Prof. O.P.N. Calla was Principal Investigator for 13/18 GHz Millimeter Wave Propagation Studies using American ATS-6 Satellite to study the effects of rain rates on propagation above 10 GHz during 1975 to 76,these were first Satellite based Propagation Studies in India. ATS 6 had two millimeter-wave experiments. The NASA experiment used a C-band uplink and 20 and 30 GHz downlinks, whereas the Communication's Satellite (Comsat) Corporation experiment used 13 and 18 GHz uplinks and a C-band downlink.

3.5.1 Propagation Studies at 13/18 GHz using ATS-6 Satellite

ISRO supported Propagation studies used a transmitter operating at 13/18 GHz which was located at different locations in India. The signals were received at C-Band Earth station at MADRID SPAIN. Later UNDP supported propagation experiment which was conducted with ground based Radiometer and line of site links at 13 GHz located at various locations as shown in figure 14. The table shows the locations selected for studies.

Figure 14 : Showing Propagation Studies at 13/18 GHz using ATS-6 Satellite

3.6 Satellites for Communication in India:

Different types of communication satellites which were used by India namely INSAT-1A/1B/1C/1D/2DT/ 2A/2B/2C/2D/2E/3B, GSAT1, INSAT3C/3A, GSAT 2, INSTA 3E/4A/4B/4CR and the series of GSAT5/5P/8 and 12.

3.7 MOBILE PHONES & Electronic Gadgets

A mobile phone is a device which can make and receive telephone calls over a radio link whilst moving around a wide geographic area. It does so by connecting to a cellular network provided by a mobile network operator. Following diagram given in figure 15 explains the evolution of mobile network from 1G to 3G. Figure 16 shows the latest electronics gadgets.

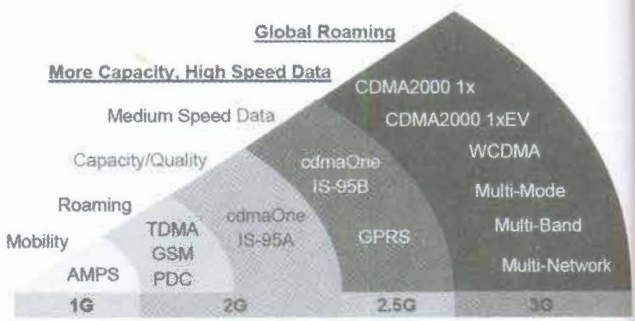


Figure 15 : Evolution of mobile network from 1G to 3G

Figure 16 : Shows the latest electronics gadgets

3.8 Future Mobiles and Gadgets

Everyday the Internet is evolving and getting better, specially when it comes to provide the info. Also the gadgets are becoming more intelligent using the internet and technology. The most significant in this context can be Search of Geographical And Planetary Objects, as explained by the artistic illusion in which the Phone or Tablet computer can explore planets and provide information instantly.

3.9 Applications of Radiowaves for RADAR

3.9.1 Tracking RADAR

Typical tracking radars have a pencil beam to receive echoes from a single target and track the target in angle, range, and/or Doppler. Figure 17 displays this pictorially. For tracking Rockets in early years the Radar Range was to be extended using Transponder which were placed onboard Rocket in India for first time transponders were developed for extending range of Radar for Tracking. Development of dual polarized feed for Troposcatter and satellite communication antenna feeds was done by Microwave Division of ISRO which was headed by Prof. O.P.N. Calla. This Ushered the Era of Microwave System.

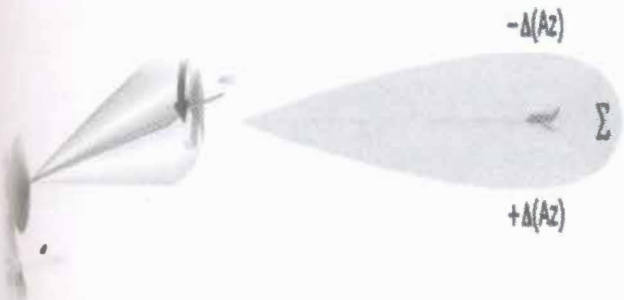


Figure 17 : Showing conical scanning concept and mono-pulse RADAR concept

3.9.2 Present Indian scenario of Development of RADAR

1. **Indian Doppler Radar (INDRA-I):** INDRA is 2D mobile surveillance radar for low level target detection.

2. **Rajendra Radar:** Rajendra, multifunction phased array radar, is the primary sensor at battery level for Akash SAM system - an air defence system for the Indian Army as part of Integrated Guided Missile Development Program (IGMDP).

3. **Dimensional Central Acquisition Radar (3D-CAR):** to tactical forces for all types of operations with matching mobility. This is a medium range surveillance radar for Akash at Group level, with high mobility and excellent high and low level coverage.

4. Microwave Remote Sensing

Obtaining information about an object through analysis of data acquired by a sensor that is not in direct contact with the object. These remote sensors are operated in Microwave Frequencies. It has evolved into an important tool for monitoring the atmospheres and surfaces of planetary objects. It has diverse applications and is very efficient technique to help the growth of economy and solve some of its problems.

4.1 Unique Capabilities of Microwave Remote Sensing

Microwaves possess some unique capabilities such as

- ❑ Capability to penetrate clouds.
- ❑ Independent of sun as source and so microwave sensors can be used in day as well as in night.
- ❑ Sensitive to the moisture content.

Microwave Remote Sensing is UNIQUE and has Stand Alone applications because Microwave sensors give complementary information in some applications and supplementary information in others, to the optical and infrared sensing sensors. The Combination of microwaves, visible and infrared radiation allows a study of the geometric, bulk-dielectric and molecular resonance properties of a surface.

4.2 Sensors for Microwave Remote Sensing

Microwave Remote Sensing uses two types of sensors as shown in flow chart 18. Passive Sensors and Active Sensors. The passive Sensors measure Brightness Temperature/Emissivity/and the active sensors measure scattering Coefficient. The Brightness Temperature/ Emissivity and Scattering coefficient are function of Dielectric Constant of the Target Material. Dielectric Constant is a very important electrical parameter of a natural material. The natural materials include soil, water and snow.

Passive Sensors include Radiometers (Total Power Radiometer in figure 19 and Dicke Radiometer in figure 20) and Active sensors include Scatterometer in figure 21, Real Aperture Radar in figure 22, Side Looking Airborne Radar (SLAR) in figure 23 and Synthetic Aperture Radar.

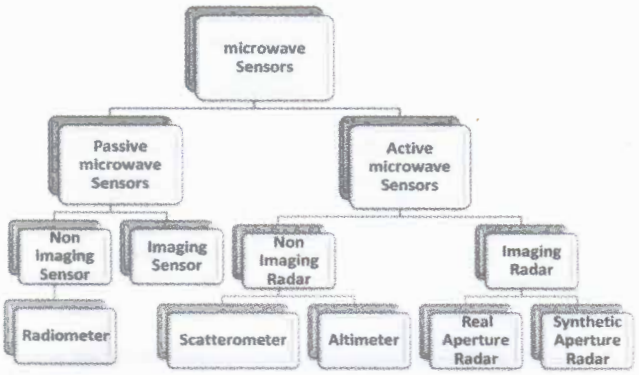


Figure 18 : Microwave sensors

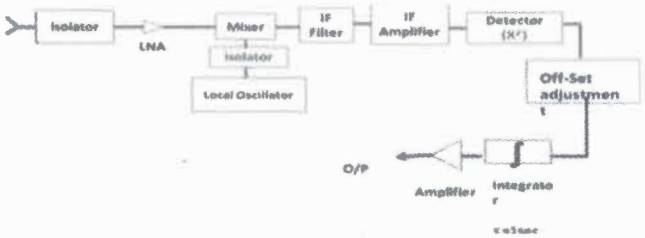


Figure 19 : TPR

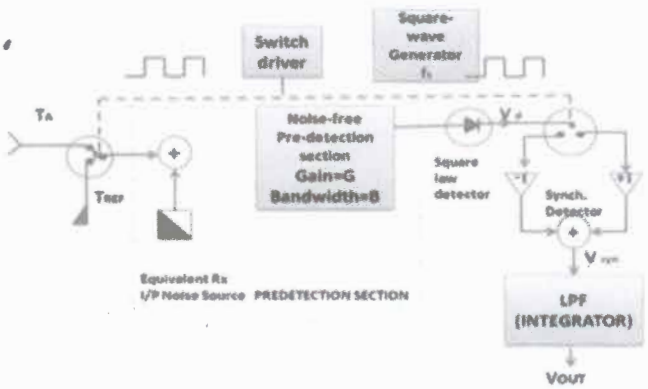


Figure 20 : Dicke radiometer

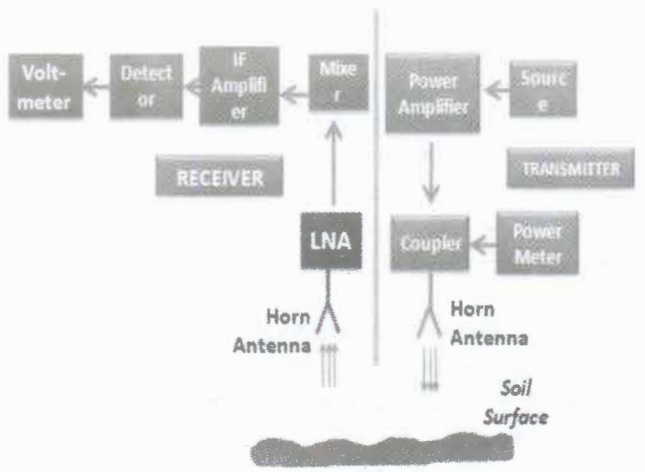


Figure 21 Scatterometer

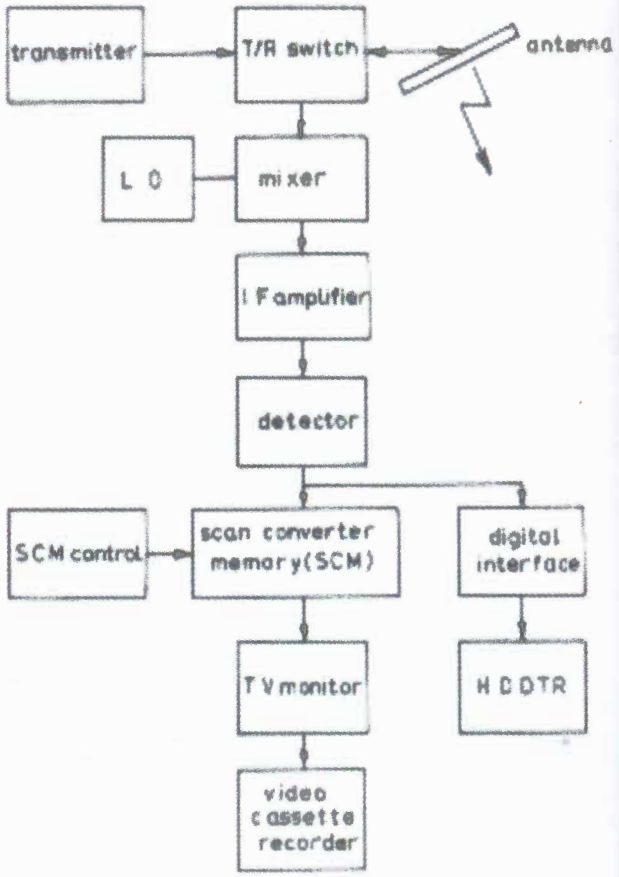


Figure 22 : Real Aperture Radar

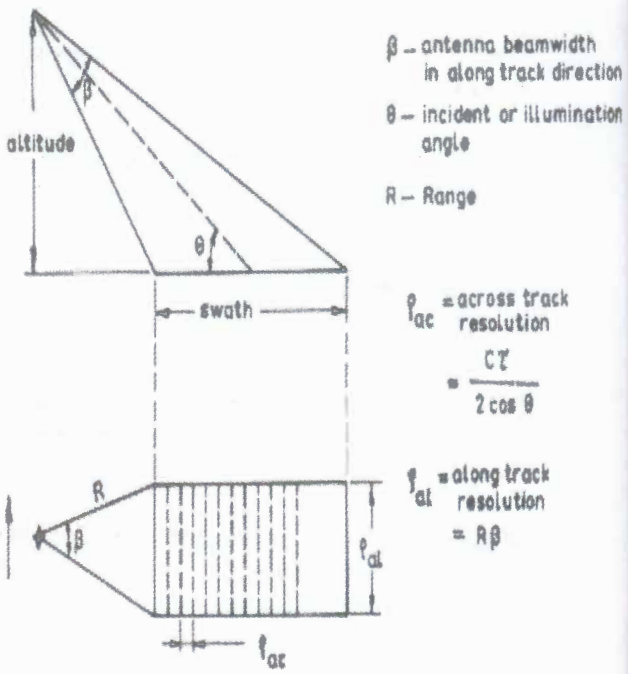


Figure 23 SLAR

4.3 *Areas of Application for Microwave Remote Sensing Applications*

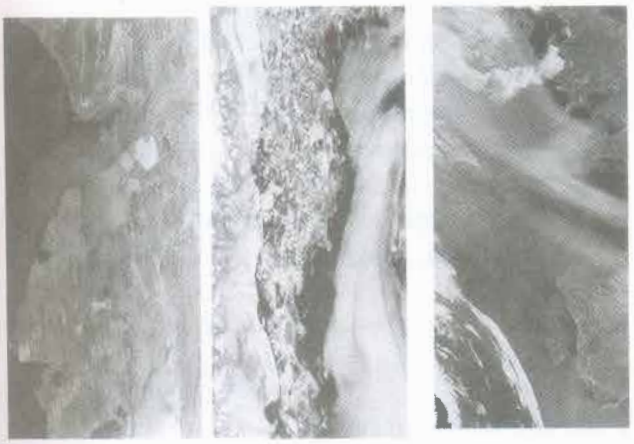


Figure 24 : Showing Application of Microwave Remote Sensing

4.3.1 Land Application

The spatial and temporal variation of soil moisture is of great importance for crop yield models, dry land farming, status of crop health, irrigation scheduling, etc. Microwave Remote Sensing is unique for soil moisture because of its penetration capability and because of the sensitivity of microwave energy to moisture. The microwave remote sensing can be used for study of the different target properties on earth. This technique has been successfully used for study of natural material like soil, water and snow on the earth. Different land based applications that can be studied are

- Soil moisture estimation
- Crop identification
- Flood mapping
- Snow studies
- Geology
- Forestry
- Urban land-use
- Hydrocarbons

The passive radiometer data of MSMR onboard Oceansat has been used for delineating different soils at six sites in figure 25. Study of Delineation of Rice Fields Using MSMR Data of IRS-P4 Satellite at 6.6 GHz for Rice fields from different parts of India were chosen and compared with the Desert Area in figure 26. Floods were reported in West Bengal during fourth week of June, 2011 due to intense depression over Bay of Bengal causing heavy torrential rains in figure 27. A number of studies have been taken up for inventory, monitoring and retreat of Himalayan glaciers in figure 28.

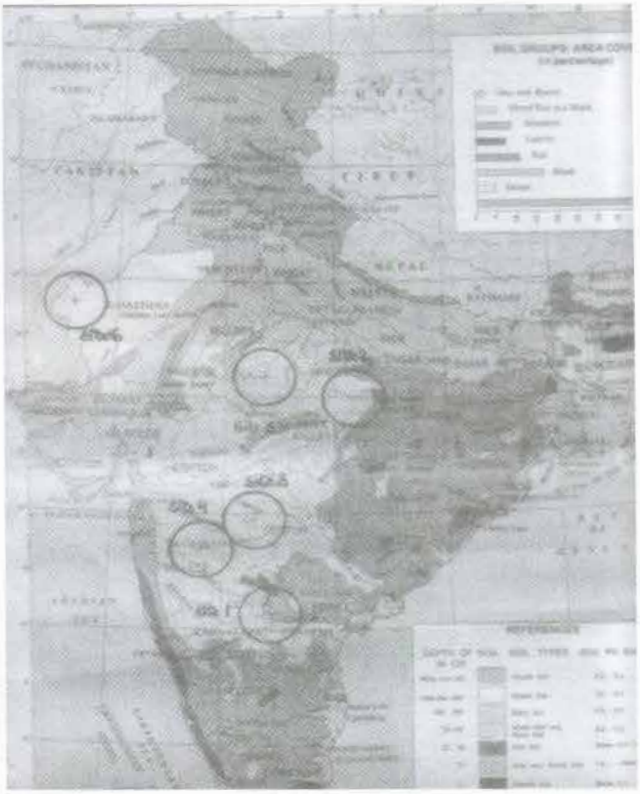


Figure 25 : Circles showing the selected test site

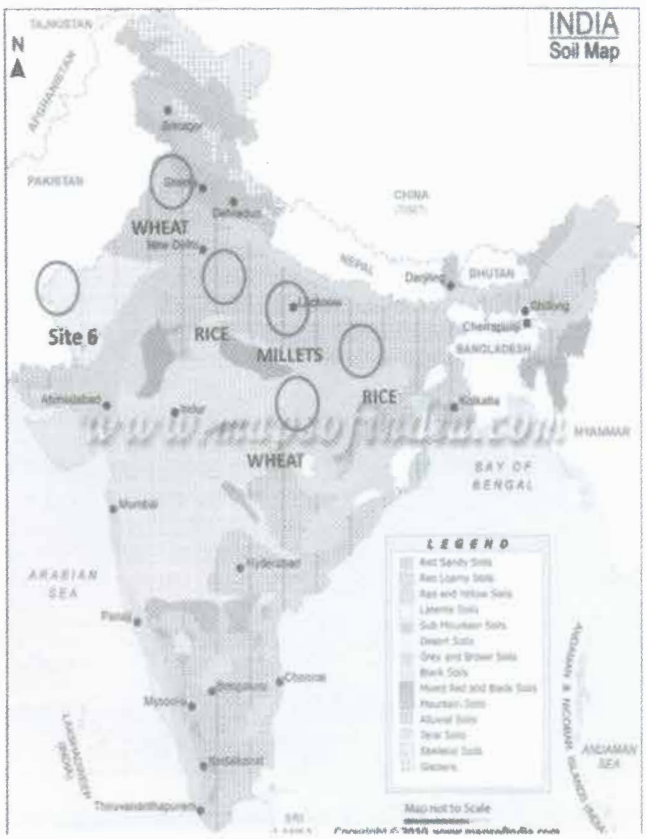


Figure 26 Showing Rice fields and Desert areas

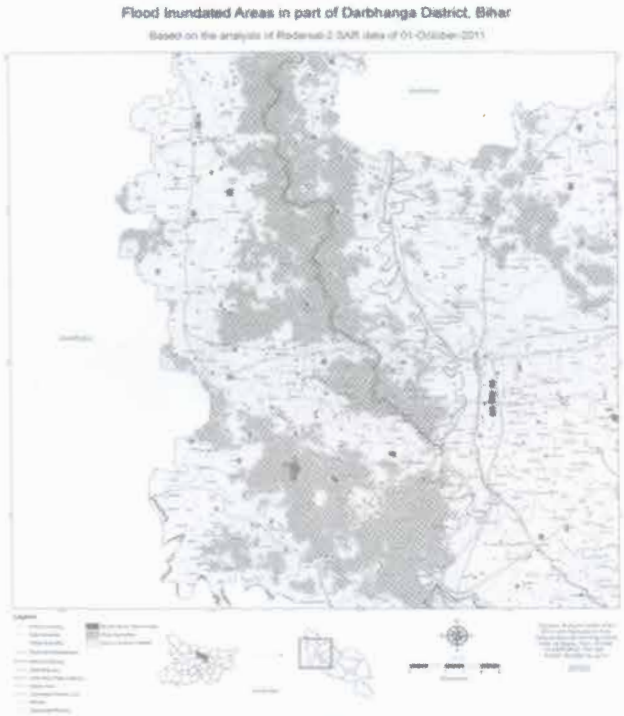


Figure 27 : Showing maps depicting Data from Radarsat Darbhanga, Bihar for date 1st October 2011

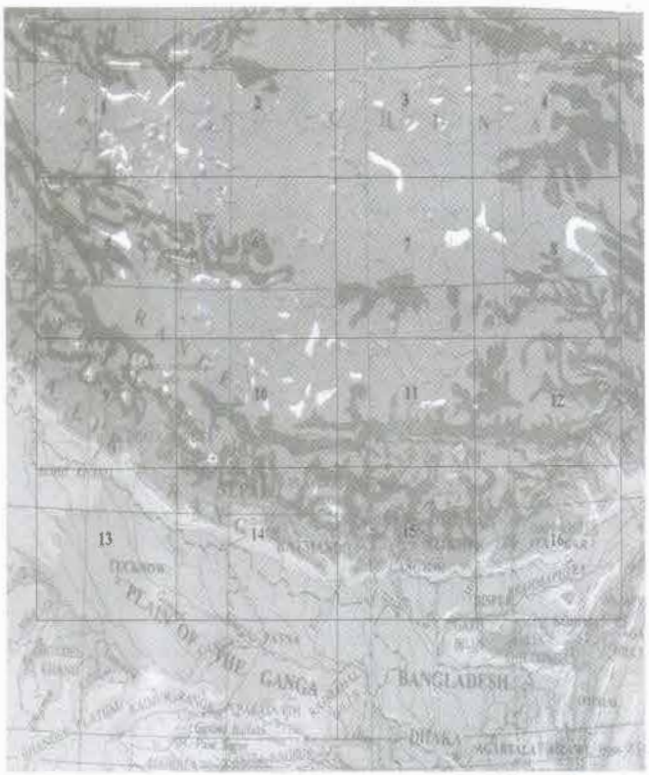


Figure 28 : Figure 34 shows the site selected for analysis. Location is divided into 16 evenly spaced grid cells for classification and comparison purpose

4.3.2 Oceanographic Applications

Due to the focus on the utilization of Exclusive Economic Zone (EEZ) in the future, applications like sea-state, ocean circulation, and shallow-water topography are of high priority. Apart from this, applications like oil pollution monitoring, retrieval of geophysical parameters of the ocean and the study of the ocean geoids are also important. The latter two are considered to be an input for meteorological prediction

Parameters that could be studied using microwave remote sensing are

- Sea-state measurement
- Topography in shallow sea
- Wind speed over sea surface
- Significant wave height
- Sea surface temperature
- Geophysical parameter retrievals
- Measurement of sea surface salinity
- Ocean circulation
- Oil pollution
- Ocean geoids studies

The outline of the oil spill can be clearly seen in this image shown in figure 29 as the darker water in the north surrounded by the yellow rectangle. The oil slick appears dark because the oil itself is dampening the surface capillary waves which results in overall reduced backscatter. The use of radar to map oil spills is a well-tested and used technique. A big plus to radar is its ability to see through clouds; this is important for work done in tropical regions. Radar is also strongly scattered by vegetation. This system has a polar orbit, so it sees more of the earth than the earlier SIR-C mission.

Figure 29 : Shows Radar image showing oil spill

4.3.3 Atmospheric Applications

This application area is accorded a high priority under atmospheric application. Other applications of interest include profiling the moisture and temperature in the atmosphere which is essential for delineating meso-scale climatic systems. The application for studying the minor constituents in the atmosphere is considered important for stratospheric research. These applications have a potential for using microwave data.

The Parameters that will be studied will be useful for

- Indian monsoon studies
- Monsoon temperature profile
- Atmospheric minor constituents

4.3.4 Medical Application

- Microwave Radiometry for early detection of subsurface cancerous growths or tumors.
- Microwave Diathermy or hyperthermia
- Monitoring of Frozen Organs
- Re-warming Infants after hypothermia
- Detection and Monitoring of Inflammation.
- Treatment of Cancer by Microwave Heating.

4.3.5 Industrial Applications

- Manufacture of Synthetics and Pressed Synthetics
- Wood Processing Industries.
- Backing Foundry Cores
- Food Processing.
- Medical Sterlization of Bandages, absorbent, Cotton, Instruments
- Textile Industries
- Curing and Breaking of Concrete
- Sealing of Plastics

4.4 Indian Microwave Remote Sensing Satellites:

The Indian microwave remote sensing program was initiated with launch of Satellite Microwave Radiometer (SAMIR) payload onboard **BHASKARA I** (19.1,19.6 and 22.235 GHz) Satellite in 1979 followed by **BHASKARA II** (31.4,19.35 and 22.235 GHz) in 1981 in figure 30 (a) (b). The onboard TV camera sent imageries which were used in the field of Hydrology and Forestry. SAMIR sent scientific data which were used for oceanographic studies as see in figure 30(c). Microwave Remote Sensing was initiated through SAMIR onboard BHASKARA I & II in India. Prof. O.P.N. Calla was Principle Scientist and responsible for initiating Microwave Remote Sensing in INDIA.

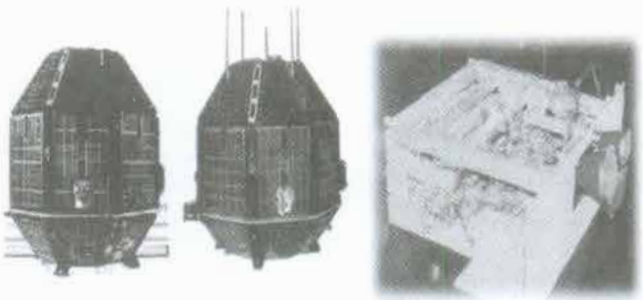


Figure 30 : (a) Bhaskara-I (b) Bhaskara-II (c) SAMIR Payload

OCEANSAT-1 is the first satellite primarily built for Ocean applications (6.6, 10.65 18 and 21 GHz) placed in a Polar Sun Synchronous orbit of 720 km, launched by PSLV-C2 from SHAR Centre, Sriharikota on May 26, 1999. This satellite carried Ocean Colour Monitor (OCM) and a Multi - frequency Scanning Microwave Radiometer (MSMR) for oceanographic studies as shown in figure 31.

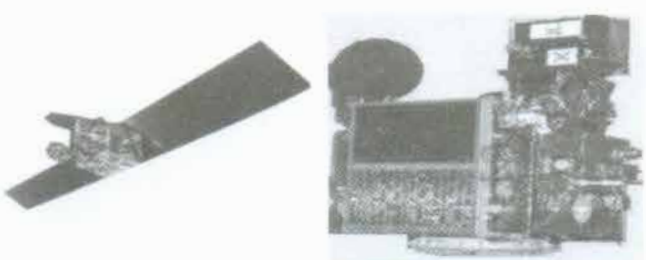


Figure 31 : Ocensat-1 with MSMR Payload

4.5 Microwave Remote Sensing Satellites launched by India

India has launched several satellite such as Bhaskara-I, Bhaskara-II, IRS-P4/OCEANSAT, RISAT-2, Megha-Tropiques and Oceansat-2 (IRS-P4).

4.6 Radio Astronomy

Basically it is Radio Astronomy which studies radiation with wavelengths greater than approximately one millimeter. A wide variety of objects are observable at radio wavelengths, including supernovae, interstellar gas, pulsars, and active galactic nuclei.

4.6.1 Arecibo Observatory

The **Arecibo Observatory** is a radio telescope near the city of Arecibo in Puerto Rico. It is operated by SRI International under cooperative agreement with the National Science Foundation as shown in figure 32.

Figure 32 : Arecibo Observatory (Largest Telescope)

4.5.2 Ooty Radio Telescope

The **Ooty Radio Telescope** is located in Muthorai near Ootacamund (Ooty), south India as shown in figure 33. It is part of the National centre of Radio Astrophysics (NCRA) of the well known Tata Institute of Fundamental Research (TIFR) which is funded by the Government of India through the Department of atomic energy. The ORT has produced results on radio galaxies, quasars, supernovae and pulsars.

Figure 33 : Ooty radio telescope

4.5.3 Giant Metre-wave Radio Telescope

World's largest Radio Telescope: Giant Metre wave Radio Telescope (GMRT), located near Junnar region consists of 30 fully steerable gigantic parabolic dishes of 45m diameter each spread over distances of upto 25 km in a Y shape array as shown in figure 34. Work on GMRT was started ~ 1989 under the leadership of Prof. Govind Swarup and by 1995, all the 30 antennas were operational.

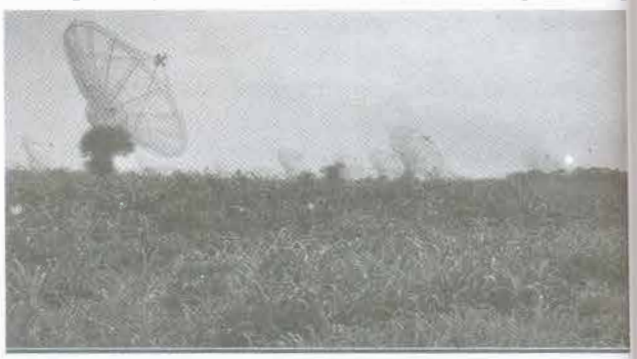


Figure 34 : Giant Metre-wave Radio Telescope

4.6 Planetary Exploration using Microwave Remote Sensing

The planets have been explored using Microwave Remote sensing. The planets like Mars and Venus as well as Satellites like Titan and Moon have also been explored using Microwave sensors.

4.6.1 Mars Exploration

The Mars have been explored by different countries using Microwave Sensors. In the broad context of planetary science, Mars represents an important transition

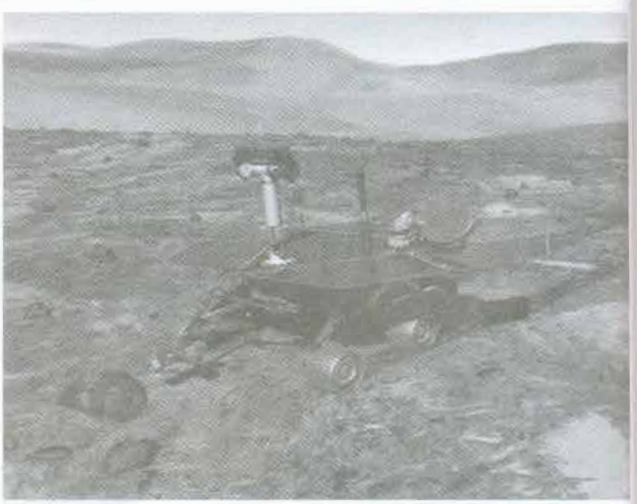


Figure 35 : Computer-generated image of Spirit Mars Exploration Rover which touched down in Gusev Crater in 2004.

between the outer volatile-rich, more oxidized regions of the accretion zone of the terrestrial bodies (asteroid belt) and the inner, more refractory and less oxidized regions from which the Earth, Venus and Mercury accreted. ESA Mars Express-MARSIS Radar-Its major goals are to characterise the subsurface layers of sediments and possibly detect underground water or ice, to conduct large-scale altimetry mapping and provide data on the planet's ionosphere as shown in figure 35

4.6.2 Exploration of Venus

Magellan

Magellan is an American Venus probe as shown in figure 36. The primary objectives of the Magellan mission were to map the surface of Venus with synthetic aperture radar (SAR) and to determine the topographic relief of the planet.

Figure 36 : Magellan Mission

4.6.3 Exploration of Titan

Titan is the moon of Saturn also known as Saturn VI. Titan was discovered on March 25, 1655, by the Dutch astronomer Christiaan Huygens. The Cassini probe, of Cassini-Huygens Spacecraft, took the highest-resolution images ever of the moon's surface, at only 1,200 km, discerning patches of light and dark that would be invisible to the human eye from the Earth can be seen in figure 37.

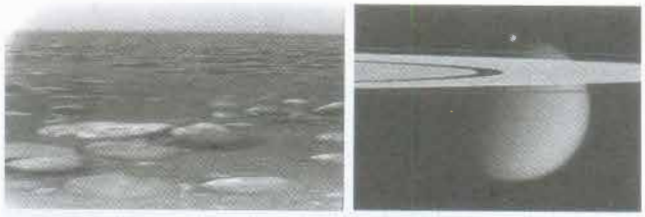


Figure 37 : (a) & (b) Huygens in situ image from Titan's surface & Cassini image of Epimetheus and Titan, with the rings of Saturn in the foreground

4.6.4 Planetary Exploration in INDIA

Chandrayaan-1 was the first spacecraft launched by ISRO, India on 22 October 2008 for exploration of moon with lunar orbiter and impactor. Many high resolution images (optical and Microwave) shows the possible locations of presence of water ice. The Chandrayaan-1 mission is aimed at high-resolution remote sensing of the moon in visible, near infrared (NIR), low energy X-rays and high-energy X-ray regions as shown in figure 38.

Figure 38 : Chandrayaan-1

4.6.5 Study of Terrestrial Analog of Lunar Soil-

At ICRS the electrical properties of Terrestrial Analog of Lunar Soil have been measured at microwave frequencies shown in figure 39.

Figure 39 : JSC-1A lunar regolith simulant used for measurement of complex dielectric constant

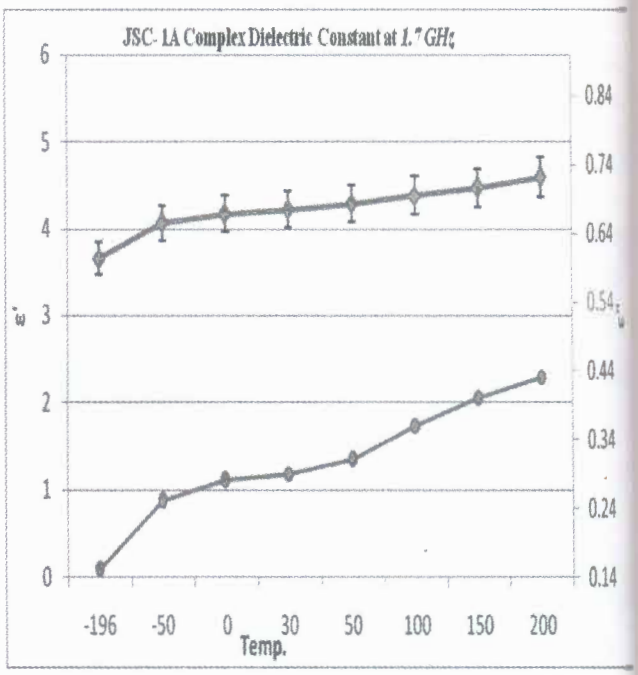


Figure 40 shows Graph Shows dielectric constant of terrestrial analogues of lunar soil ?' & loss factor ?" increases with increasing temperature from -196 C to +200 C at 1.7GHz frequency

S no.	Temp (°C)	ε'	ε"	tanε=ε"/ ε'
1	-196	3.66	0.15	.041
2	-50	4.07	0.25	.061
3	0	4.17	0.28	.067
4	30	4.22	0.29	.069
5	50	4.29	0.31	.072
6	100	4.38	0.36	.082
7	150	4.47	0.4	.089
8	200	4.59	0.43	.094

Table 1 : Shows Values of dielectric constant of terrestrial analogues of lunar soil with temperatures at 1.7GHz & having density 1.8 gm/cm3

		Waveguide cell method						Resonant cavity method		Min-Max
	Freq. (GHz)	1.7GHz	2.5GHz	1.7GHz	2.5GHz	6.6GHz	31.6GHz	2.4GHz	6.6GHz	
	Density (gm/cm³)	1.26	1.26	1.8	1.8	2.18	1.5	2.96	1.6	
S no.	Temp (°C)	ε'	ε'	ε'	ε'	ε'	ε'	ε'	ε'	
1	-196	3.38	3.40	3.66	3.75	3.35	3.50	2.61	3.26	2.61-3.75
2	-50	3.73	3.53	4.07	4.01	3.51	3.55	3.14	3.53	3.14-4.07
3	0	3.80	3.71	4.17	4.1	3.6	3.58	3.39	3.60	3.39-4.17
4	30	3.85	3.78	4.22	4.13	3.68	3.61	3.52	3.72	3.52-4.22
5	50	3.91	3.88	4.29	4.18	3.74	3.67	3.88	3.83	3.67-4.29
6	100	4.18	3.99	4.38	4.26	3.81	3.71	4.74	3.88	3.71-4.74
7	150	4.38	4.08	4.47	4.38	3.96	3.80	4.98	3.97	3.96-4.98
8	200	4.46	4.28	4.59	4.52	4.14	4.00	5.11	4.01	4-5.11

Table 2 : For Dielectric constant of lunar simulant (JSC-1A) depicts the comparison on the basis of various methods to measure Dielectric constant.

S.No.	Sample	JSC-1A	JSC-1A	Apollo 17/70051,20 (Howard E. Bussey et al., 1978)
1.	Dielectric constant(ε')	4.22	4.13	3.78
	Density	1.8	1.8	1.853
2.	Dielectric constant (ε') at normalize bulk density (1gm/cm³)	2.34	2.29	2.04
3.	Frequency	1.7GHz	2.5GHz	2GHz

Table 3 : for Comparison of dielectric constant of JSC-1A at 1.7GHz and 2.5GHz with Apollo sample

S.No.	Sample	JSC-1A	Apollo 14/14163,164 (H.L. Bassett et al., 1972)
1.	Dielectric constant(ε')	3.68	3.59
	Density	2.18	1.71
2.	Dielectric constant (ε') at normalize bulk density (1gm/cm³)	1.69	2.1
3.	Frequency	6.6GHz	9.375GHz

Table 4 : for Comparison of dielectric constant of JSC-1A at 6.6GHz with Apollo sample

S .No .	Sample	JSC-1A	Apollo 14/141 63,164	Apollo 17/70051,20 (Howard E. Bussey et al., 1978)
1.	Dielectric constant(ε')	3.61	3.18	3.71
	Density	1.5	1.493	1.853
2.	Dielectric constant (ε') at normalize bulk density (1gm/cm³)	2.4	2.13	2.002
3.	Frequency	31.6GHz	24GHz	18GHz

Table 5 : for Comparison of dielectric constant of JSC-1A at 31.6GHz with Apollo sample

5. Futuristic ISRO programs in Microwave Remote Sensing

Radar Imaging Satellite (RISAT) undergoing testing and is in queue for launch by the PSLV (5.35 GHz). It is a microwave remote sensing satellite carrying a Synthetic Aperture Radar (SAR). An Artistic expression is depicted in figure 41.

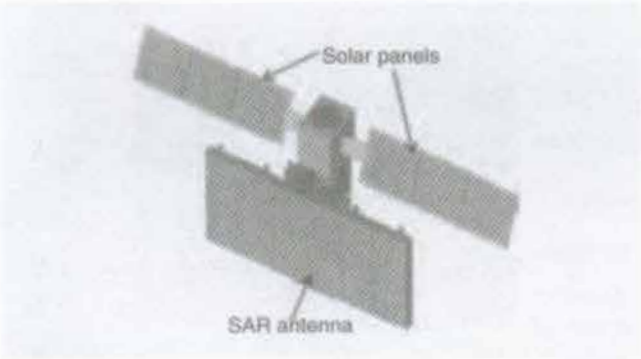


Figure 41 : Conceptual image of RISAT 1

SARAL- The Satellite for ARGOS and ALTIKA (SARAL) is a joint ISRO - CNES mission, and launched 2013 it operate at Ka band, by PSLV-C20 Signal frequencies in the Ka-band will enable better observation of ice, rain, coastal zones, land masses (forests, etc.), and wave heights. A conceptual image of SARAL is shown in figure 42.

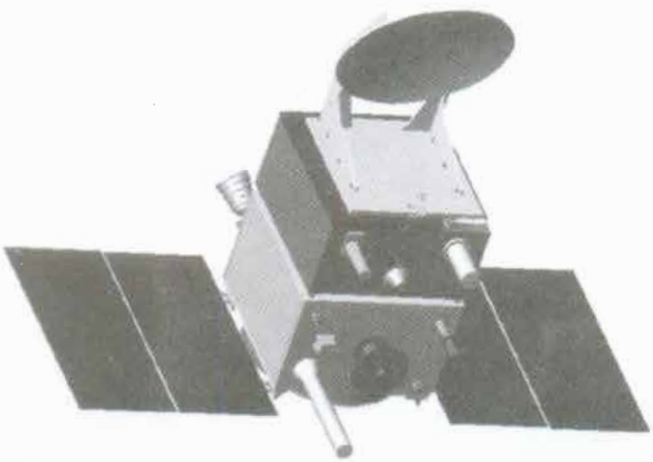


Figure 42 : SARAL

5.1 Future Missions

Basically five types of future missions are being envisaged (These are based upon the current thought process within the scientific community and are NOT yet sanctioned projects by the Govt.

Follow on mission to Moon:

- Considered time frame-2014-15 (Chandrayaan-2)
- Asteroid / Comet flyby mission: Possible time frame-2015
- Mission to Mars: Timeframe-2019
- Missions to other planets (Venus, Mercury…Vision beyond 2020)

5.1.2 Chandrayaan 2

Mission includes Orbiter and Lander, Remote Sensing instruments; Lander includes robotics, rovers and penetrators. Preferred landing sites, specific scientific problems and instruments need to be finalized. Far side of the moon, particularly South Pole Aitkin (SPA) basin is a prime candidate. Considered time frame: 2014- 2015.

5.1.3 Space-based solar power

Space-based solar power (SBSP) is the concept of collecting solar power in space for use on Earth. A conceptual idea is shown through figure 43 below which shows giant, possibly inflatable structures of photovoltaic arrays and antennas that catch the suns rays and create a focused microwave beam back to collectors on Earth. A special receiving antenna on the ground - called a rectenna would then turn the microwave energy back into electricity, which would be fed into the power grid.

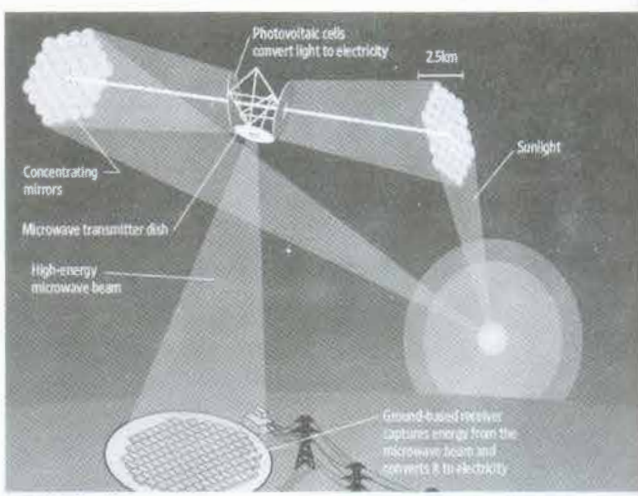


Figure 43 : is an Image from New Scientist. Sunlight is reflected off giant orbiting mirrors to an array of photovoltaic cells; the light is converted to electricity and then changed into microwaves, which are beamed to earth. Ground-based antennas capture the microwave energy and convert it back to electricity, which is sent to the grid.

5.1.4 Future Gyrotron

Currently Many Research & development organizations are working on high frequency and power Gyrotrons like CEERI, Pilani is working on efficient 42 GHz Gyrotron. Japan has built 1 MW Power Gyrotron shown in figure 44 whereas Europe is working on 2 MW at 170 GHz frequency and figure 45.

Figure 44 the Japanese 1 MW gyrotron

Figure 45 The 2MW Gyrotron developed by Europe at the frequency of 170 GHz

5.1 .5 Megha Tropiques

Megha-Tropiques is an Indo-French Joint Satellite Mission. The main objective of this mission is to understand the life cycle of convective systems that affect weather and climate

5.1.6. Terahertz

Terahertz (> 1012 Hz) region have lead to various applications in astronomy, atmospheric research, defense and medical field due to recent technological developments. The Terahertz instrumentation has improved drastically over the past two decades with the availability of sensitive detectors and new generation telescopes.

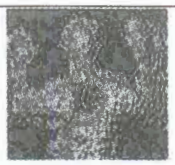
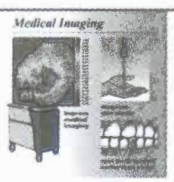
	THz imaging of a man who hinders a plastic bomb
	• Explosive detection • Concealed weapons detection
	High Resolution Imaging
	Examination of Packaged Goods
	Biomedical Applications Revealed for Terahertz Spectrosc opy

Table 6 : for the Terahertz Application

6. Frequency spectrum with application

Band name	Abbreviation	ITU band	Frequency and wavelength in air	Example uses
			< 3 Hz > 100,000 km	Natural and man-made electromagnetic noise
Extremely low frequency	ELF	1	3–30 Hz 100,000 km – 10,000 km	Communication with submarines
Super low frequency	SLF	2	30–300 Hz 10,000 km – 1000 km	Communication with submarines
Ultra low frequency	ULF	3	300–3000 Hz 1000 km – 100 km	Submarine communication, Communication within mines
Very low frequency	VLF	4	3–30 kHz 100 km – 10 km	Navigation, time signals, submarine communication, wireless heart rate monitors,geophysics
Low frequency	LF	5	30–300 kHz 10 km – 1 km	Navigation, time signals, AM longwave broadcasting (Europe and parts of Asia),RFID, amateur radio

Band name	Abbreviation	ITU band	Frequency and wavelength in air	Example uses
Medium frequency	MF	6	300–3000 kHz 1 km – 100 m	AM (medium-wave) broadcasts, amateur radio, avalanche beacons
High frequency	HF	7	3–30 MHz 100 m – 10 m	Shortwave broadcasts, citizens' band radio, amateur radio and over-the-horizonaviation communications, RFID, Over-the-horizon radar, Automatic link establishment (ALE) / Near Vertical incidence Skywave (NVIS) radio communications, Marine and mobile radio telephony
Very high frequency	VHF	8	30–300 MHz 10 m – 1 m	FM, television broadcasts and line-of-sight ground-to-aircraft and aircraft-to-aircraft communications. Remote Sensing, Land Mobile and Maritime Mobile communications, amateur radio, weather radio
Ultra high frequency	UHF	9	300–3000 MHz 1 m – 100 mm	Television broadcasts, microwave ovens, microwave devices/communications, Remote Sensing, radio astronomy, mobile phones, wireless LAN, Bluetooth, ZigBee, GPS and two-way radios such as Land Mobile, FRS and GMRS radios, amateur radio

Band name	Abbreviation	ITU band	Frequency and wavelength in air	Example uses
Super high frequency	SHF	10	3–30 GHz 100 mm – 10 mm	radio astronomy, microwave devices/communications, Remote Sensing, wireless LAN, most modern radars, communications satellites, satellite television broadcasting, DBS, amateur radio Sir J.C. Bose generated 12 GHz frequency
Extremely high frequency	EHF	11	30–300 GHz 10 mm – 1 mm	radio astronomy, high-frequency microwave radio relay, microwave remote sensing, amateur radio, directed-energy weapon, millimeter wave scanner Sir J.C. Bose generated 60 GHz frequency
Terahertz or Tremendously high frequency	THz or THF	12	300–3,000 GHz 1 mm – 100 µm	Terahertz imaging – a potential replacement for X-rays in some medical applications, ultrafast molecular dynamics, condensed-matter physics, terahertz time-domain spectroscopy, terahertz computing/communications, sub-mm remote sensing, amateur radio

7. Conclusion

Here in this Sir J.C. Bose Memorial lecture there has been a great opportunity for learning about the work done by Sir J.C. Bose. His work includes development of the instruments/plant Biology/Fatigue in materials etc. to name a few. It is the GOAL oriented work and that should be pursued till it is achieved irrespective of HURDELS obstruction people bring.

Sir J.C. Bose was intellectual giant is a genius indeed excellent experimentalist and a great Technologist of his times who could develop instruments with the help of the elements which were used by common man. The present Generation is enjoying and Future Generation will enjoy the Fruits of the plants which were planted by Sir J.C. Bose. And Future generation will enjoy, for all times to come, the fruits of his works.

This work will be used in Medical Application, Communication, Astronomy, and Search for Extra Terrestrial Intelligence, Remote Sensing, Plants Biology, Physiology, Industrial Applications, Planetary Exploration, Scientific application and other application which are not known now but will appear in due course of time like Microwave Remote Sensing which was not in use decades ago.

Sir J.C. Bose is scientifically a culmination and consummation of the work done in past by Indian Seers in science. He can be considered as INCARNATION OF VISHWAKARMA who is responsible for making gadgets (mechanical). Here the difference is that Sir J.C. Bose made Mechanical, Electrical and Electronic gadgets which can be seen as the evolution of Technology from the days of Vishwakarma to this century in which Sir J.C. Bose lived and did manifest.

The Microwaves have unique applications in remote sensing. Also along with optical and infrared they provide complimentary and supplementary information about the targets. The Sensing of planets remotely is also possible using microwave sensors. As can be seen the hitherto unexplored surface in planets can be explored by microwaves. Thus the microwave remote sensing bound to play a major role in exploration of earth as well as other planets.

The Scientists should celebrate the Birth day of Sir J.C. Bose as Radio day all over India and abroad in absence of information on the date of experiment the birthday should be celebrated as RADIO DAY. To my knowledege Alexander Stepanovich Popov's Birthday is celebrated as Radio Day in russia. This way we will be able to pay real TRIBUTE to Sir J C Bose and coming generation will be motivated to work in the FIELD WHICH WAS INITIATED BY SIR J C BOSE

I bow to Sir J.C. Bose, his wife and his parents. Whatever ICRS is working in the areas, have become

possible because of Sir J.C. Bose. Existence of all these Activities is due to HIM WHO IS **FATHER OF RADIO WAVES.**

ACKNOWLEDGEMENT

The presentation material given in this 17th Sir J.C. Bose Memorial Lecture has been obtained from various sources Author. Thanks all who have been responsible for creating this knowledge base.

Bibliography

1. F.T,Ulaby, R.K.Moore, A.K.Fung "Microwave Remote Sensing" Vol.I, II, III, 1981, 1982, 1986, Addison-Wesley Publishing Company.

2. O.P.N.Calla "Applications of Microwave in Remote Sensing", Indian Journal of Radio and Space Physics (IJRSP) Vol. 19,Oct. & Dec.1990 ,pp.343-358.

3. O.P.N.Calla, S.Agarwal, S.K.Agarwalla, R.Bhattacharjee and A Kalita "Comparative Study of the methods of measurement of dielectric constant at microwave frequencies for dry and wet soil", IJRSP,Vol.32,April 2003,pp. 108-113.

4. O.P.N. Calla, Uttra Purohit, Deepti Sharma, Study Of Delineation of Black Soil Areas Using Multi frequency Scanning Microwave Radiometer (MSMR) Data At 6.6 GHz.

5. Remembering Sir J. C. Bose. D. P. Sen Gupta, M. H. Engineer and V. A. Shepherd, Indian Institute of Science, Bangalore and World Scientific Publishing Co Pte. Ltd, Singapore. 2009. 169 pp

6. Sisir Kumar Mitra A Pioneer in Radio Physics, Vigyan Prasar Science portal.

7. V.K. DADHWAL, R.P. SINGH, S.DUTTA & J.S. PARIHAR, Remote sensing based crop inventory: A review of Indian experience.

8. O P N Calla et. Al.,Study of Delineation of Rice Fields Using MSMR Data of IRS-P4 Satellite At 6.6 GHz

9. Neils Skou, Microwave Radiometer Systems

10. O.P.N.Calla "Microwave Sensors (Present and Future)",Proc. of Indian Academy of Sciences(Engg. Sciences),Vol.6,Pt. 2 June 1983,pp. 109-119.

11. O.P.N. Calla, G.Raju, S.S.Rana, S.Balasubra-maniam, "India's First Remotely Sensed Satellite Data from 'Bhaskara' using 'SAMIR' ", JIETE ,Vol. 25, No.8, 1979, pp. 321-324.

12. O.P.N.Calla,G.Raju,S.S.Rana,S.Balasubra-maniam, "Multispectral Microwave Observations of earth by SAMIR On-board 'Bhaskara-II",JIETE Vol.28, No.5,1982,pp.212-215.

13. "eesa" Earth Observation Applications,19th Feb 2004

14. Darrel T. Emerson,NRAO, "The Work of Jagadis Chandra Bose: 100 Years of Millimeter-Wave Research," IEEE Transactions on Microwave Theory and Techniques, Vol. 45, No. 12, pp. 2267-2273, Dec. 1997

15. Calla O P N et. al., a method for calibration of space borne passive microwave sensor.

16. Riding on Radio Waves Part II Dr V B Kamble

17. www.nasa.gov

18. www.isro.gov.in

19. www.aero.org

20. www.vigyanprasar.gov.in

21. www.windows2universe.org

22. www.nplindia.org

23. http://gmrt.ncra.tifr.res.in

24. http://www.radiofrequency.com

25. http://www.microdry.com

26. http://www.wastemed.com

Author :

E-mail : opnc06@gmail.com

Prof O P N Calla, FNAE, Dist. FIETE, FIE, FGAS, SMIEEE, FVEDA, MGBMS, did his Post graduation (ME) in Electronics from Birla Engineering College PILANI and secured second rank in college and was awarded with a silver medal. At the time of retirement in December 1995, He was Scientist 'H' and Deputy Director, Satellite Communication Area of SAC, Ahmedabad. He is responsible for initiating the work in the field of Microwave Remote Sensing in India. He is known as father of Microwave Remote Sensing in India. Presently, He is Director of ICRS from May 1996 and continues to work in the field of Microwave Application and Design & Development of Hardware.

After completing his Masters, Prof OPN Calla was involved in research and development work at Atomic Energy Establishment and INCOSPAR from 1962-70.

Photonic Crystals - Artificial Materials to Control Light

R K SHEVGAONKAR

Director, Indian Institute of Technology, Delhi

Photonic Crystals - Artificial Materials to Control Light

(J.C. Bose Lecture, IETE New Delhi)

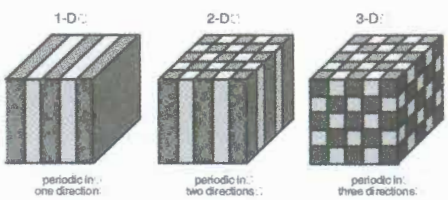
R. K. Shevgaonkar
Director
I.I.T. Delhi

Colors Everywhere

Why do we see colors?

Photonic Crystals

periodic electromagnetic media



Photonic Crystal Defects

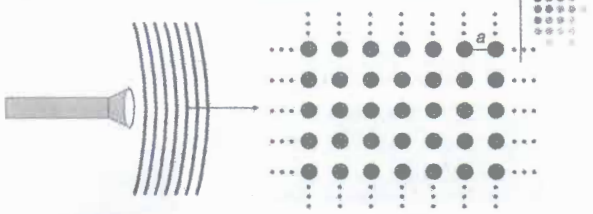
periodic electromagnetic media

can trap light in cavities

and waveguides ("wires")

Wings under microscope

Light Beam in Periodic Material

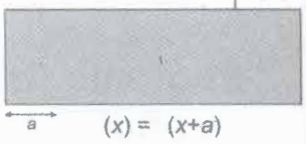


for most λ, beam(s) propagate through crystal without scattering (scattering cancels coherently)

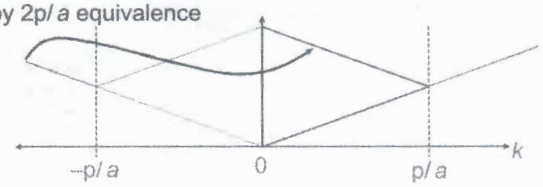
...except for some λ (~ 2a), no light can propagate: a photonic band gap

1d Notionally Periodic System

Treat it as "artificially" periodic

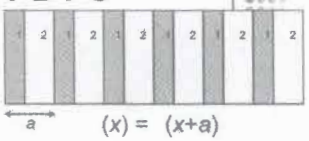


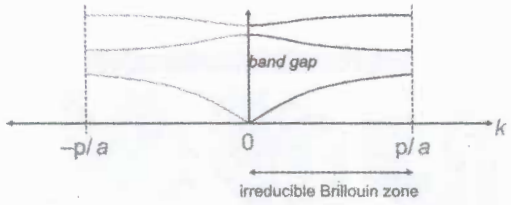
bands are "folded" by 2p/ *a* equivalence



Band diagram for 1-D PC

k is periodic:
k + 2p/ *a* equivalent to *k*
"quasi-phase-matching"



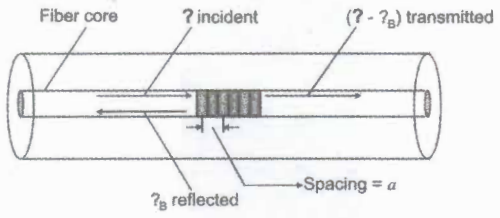


PC Features

- Photonic Crystals (PC) - Artificial materials in which the dielectric constant (ϵ_r) varies periodically.
- Ability to suppress/enhance or control the propagation of electromagnetic waves.
- Photonic Bandgap – Certain range of frequencies which cannot propagate through the PCs.

Fiber Bragg Grating (FBG)

- Periodic perturbation of refractive index of the core of an optical fiber along its length.
- Bragg Wavelength $?_B = 2\, n_{eff}\, a$ (where n_{eff} - modal index)



Applications of FBGs

- Spectral characteristics can be precisely controlled by
  - Grating period
  - Refractive indices of the layers
  - No. of grating layers
- WDM Communication Systems
  - Add-Drop Multiplexers
  - Routing
  - Filtering
- DFB laser to achieve high coherence in the emitted light

Bragg Fibers

- Refractive index remains constant inside the annular rings
- For Bragg Wavelength, radial propagation is inhibited due to photonic band gap.

Cross section of Bragg Fiber

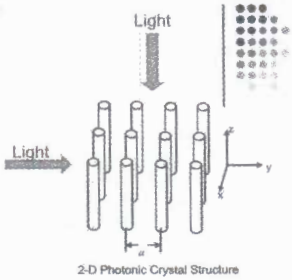
Bragg Fibers

- Hollow (air) core Bragg Fibers
  - Low loss propagation (below 0.2 dB/Km)
  - Capable of handling high power signals
- Dispersion Compensating Bragg Fibers
  - Refractive index contrast of 4.6:1.5
  - Negative dispersion of -20000ps/Km/nm
- Silica core Bragg Fibers
  - Refractive index contrast of 2%
  - Zero dispersion at 1550nm

2-D Photonic Crystal

- Homogeneous in z direction.
- Periodic in x-y plane.
- Square lattice of dielectric columns of radius r and dielectric constant ϵ_r
- Primitive crystal lattice vector

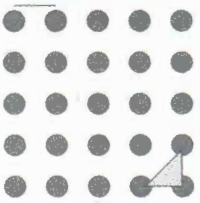
$$\vec{R} = m\,a\,\hat{x} + n\,a\,\hat{y}$$

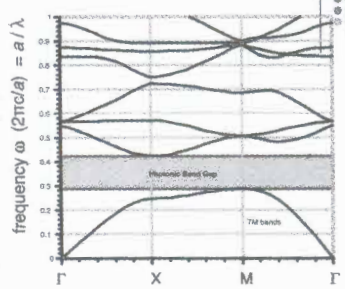


- Dielectric constant

$$\varepsilon(\vec{R}) = \varepsilon(\vec{\rho} + \vec{R})$$

2d periodicity, ε=12:1





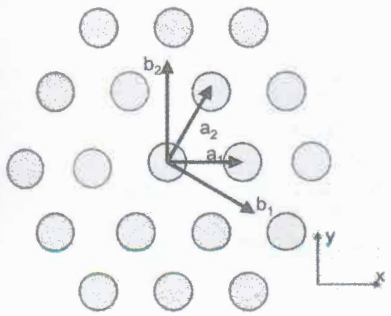
irreducible Brillouin zone

$\vec{k}$

TM $\odot E$ / H

gap for n > ~1.75:1

Hexagonal lattice



Photonic Crystal Fibers

- Light propagation transverse to the plane of periodicity –
  - Photonic Crystal Fibers (PCF)
    - Solid core / Hollow core PCF
- Conventional SMFs
  - Bend Loss
  - Group Velocity Dispersion and Birefringence
  - Power handling
  - Nonlinear response

Photonic Crystal Fiber (PCF)

- Can manipulate refractive index without using different materials
- Can achieve better dispersion characteristic for a wide range of optical wavelengths
- Periodically placed air tubes running along the fiber axis

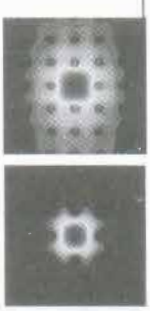
Applications of PCF

- High Power and Energy Transmission
  - Solid Core PCF (Endlessly single mode) –
    - Superior power handling properties.
    - Core area can be increased without introducing higher order guided modes.
    - Hence ability to transmit much higher power in single mode.
    - Utilization in the field of laser machining and high power fiber lasers and amplifiers.
  - Hollow Core PCF –
    - Due to guidance in air core, transmission of high continuous wave-power as well as ultra-short pulses with very high peak powers is possible.

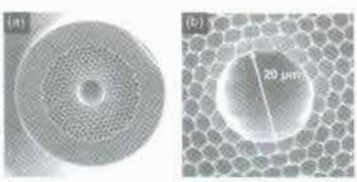
Single Mode operation with PCFs

Dwivedi and Shevgaonkar 2009

- For longer wavelengths,
  - Fields are distributed more uniformly over glass and air
  - Hence, $n_{air} < n_{clad} < n_{glass}$
  - NA is higher
- For shorter wavelengths,
  - Fields get more confined to the glass region between air holes
  - Hence, $n_{clad} \rightarrow n_{glass}$
  - NA is lower
- Ratio NA/? remains constant over a wide wavelength range. Hence V < 2.4



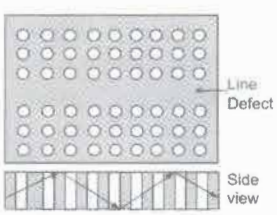
Hollow Core Photonic Crystal Fiber



Example of a low-loss hollow-core PCF (fabricated by Blaze Photonics Ltd.). The attenuation approaches 1dB/km at 1550 nm wavelength.

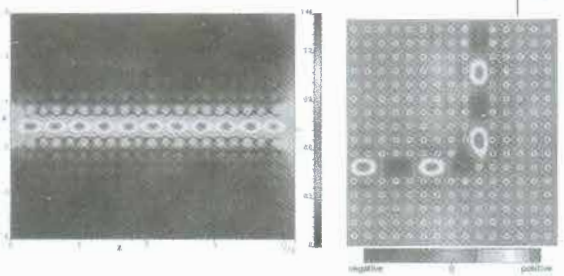
Photonic Crystal Waveguide (PCW)

- Confinement of light for Slab structure
  - In the plane of periodicity is by photonic band gap of the PC
  - perpendicular to the plane of periodicity is by total internal reflection

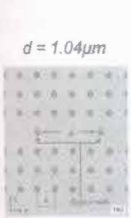


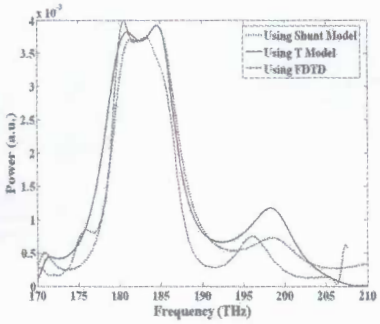
Wave on PC waveguide

(Patil and Shevgaonkar 2009)



Spectral Characteristics of PCW with Defects



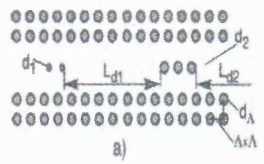


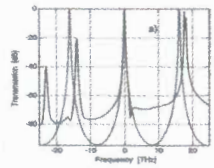
P.B. Patil, R.K. Shevgaonkar, MOTL to appear 2012.

Bandpass Resonant Filter

First cavity of a resonant bandpass filter realized by cascading Fabry Pérot cavities in a one-missing-row PC waveguide

Spectral response of the third-order synthesized PC (—) and ideal (– – –) filter at = 1615 nm.

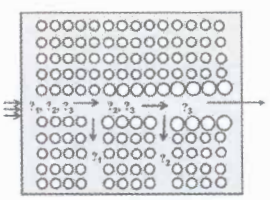




R. Costa, A. Melloni, and M. Martinelli, "Bandpass resonant filters in photonic crystal waveguides," *IEEE Photonics Tech. Lett.*, vol. 15, no. 3, pp. 401-403, Mar. 2003.

Devices using PCW

- Wavelength Demultiplexer using PCW
  - Shift of cutoff frequency of the fundamental mode in a PCW.
  - Size of the border holes adjacent to the waveguide core is varied.
- Polarization Beam Splitter
- Triplexers
- Resonant filter



Two channel demultiplexer using planar PCW

Triplexer

Field distributions simulated with an FDTD method for the present triplexer at (a) ? = 1310 nm; (b) ? = 1490 nm; (c) ? = 1550 nm.

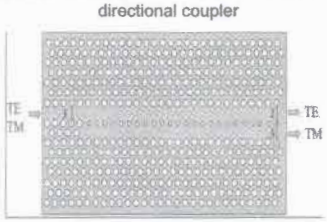
Output powers of three wavelengths at three ports of the triplexer

Input Wavelength (nm)	Port # 1 (dBm)	Port # 2 (dBm)	Port # 3 (dBm)
1310	-0.03	-23.2	-28.8
1490	-15.6	-0.16	-20.2
1550	-17.2	-20.2	-0.13

Y. Shi, D. Dai, and S. He, "Novel Ultracompact Triplexer Based on Photonic Crystal Waveguides," *IEEE Photonics Tech. Lett.*, Vol. 18, No. 21, pp. 2293-2295, Nov. 2006.

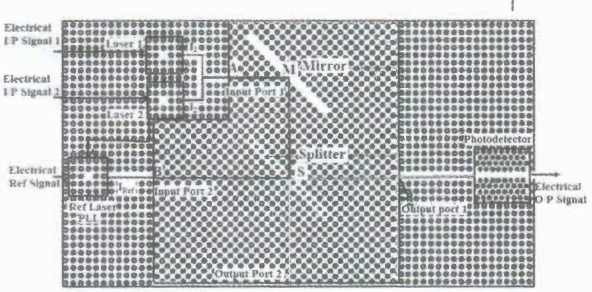
Polarizing Beam Splitter

Proposed Polarizing Beam Splitter based on a PC directional coupler



T.Liu, A. R. Zakharian, M. Fallahi, J. V. Moloney, and M. Mansuripur, "Design of a Compact Photonic -Crystal-Based Polarizing Beam Splitter," *IEEE Photonics Tech. Lett.*, Vol. 17, No. 7, pp. 1435-1437, July 2005.

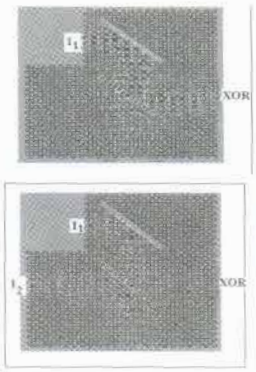
Logic Gate using 2D PC



Logic Gates using 2D PC structures

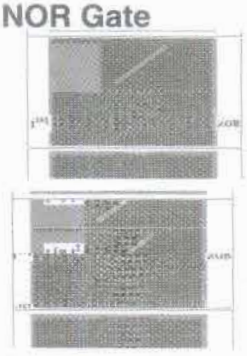
- Interference of Coherent light beams and a Reference signal
- Photonic Crystal Mirrors
- Photonic crystal splitters to give 50% reflection with +/- 90 deg phase shift.
- Reconfiguration of the gate using the reference signal

XOR Gate



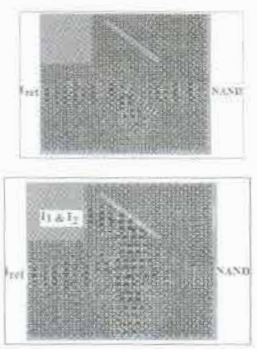
I1	I2	XOR O/P Power	XOR Logic Level
0	0	0	0
0	1	0.5P	1
1	0	0.5P	1
1	1	0.001P	0

NOR Gate



I1	I2	NOR O/P Power	NOR Logic Level
0	0	0.759P	1
0	1	0.25P	0
1	0	0.25P	0
1	1	0.25P	0

NAND Gate



I1	I2	NAND O/P Power	NAND Logic Level
0	0	1.25P	1
0	1	0.756P	1
1	0	0.756P	1
1	1	0.25P	0

Spontaneous Emission Control using PC (3-D Photonic crystal)

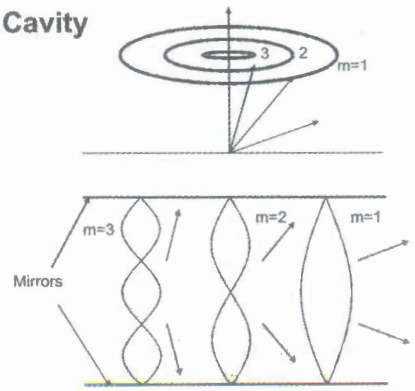
Typical LED

- External Quantum Efficiency ($?_{ext}$)–
  - Efficiency of extraction of generated photons
- Depends upon –
  - Critical angle cone
  - Fresnel transmission coefficient
  - Material absorption
- For typical LED, $?_{ext}$ <<1%

Spontaneous Emission Control using PC

- PCs – to enhance external quantum efficiency of a LED
- Concept of single mode LED – By introducing a defect in a 3-D PC.
- Purcell Effect
  - Spontaneous emission is not an intrinsic property
  - Depends upon coupling between emitter and its electromagnetic environment

1-D Cavity



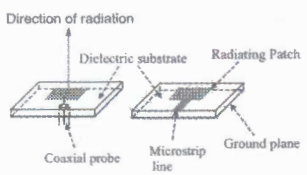
Spontaneous Emission in 1-D Cavity

- Transmission of the cavity – Airy function
- Use of the directionality of the emission to enhance the photon extraction
- True enhancement of photon extraction → Single peak in the Airy function inside the critical angle cone
- Maximum cavity order $m < 2n^2/(NA)^2$
- An overall efficiency of 23% at 980nm for GaAs microcavity placed between metallic mirror and a Bragg mirror with a reflectivity of 60%
- An efficiency enhancement of more then 75% with the help of PC at 642nm

Microstrip Antennas with PC substrates

Microstrip Antennas

- Metallic patch printed on a dielectric substrate, the other side of which is grounded
- Patch is excited by a microstrip line or a coaxial cable
- Maximum radiation is along the direction perpendicular to the patch

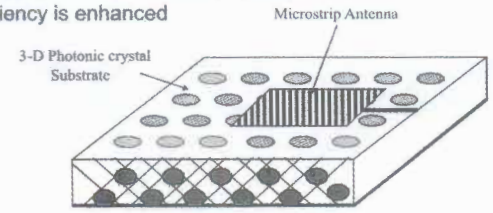


Microstrip Antennas Efficiency

- Radiation leaks into the substrate – surface modes
- Surface modes –
  - Reduce main lobe width
  - Increase side lobe width
  - Increase mutual coupling between substrates in case of antenna array.
- Overall Reduction in Antenna efficiency

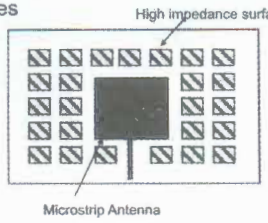
Photonic Crystal Antenna

- Normal dielectric substrate replaced by PC
- Frequency of operation lies within photonic band gap of PC.
- Energy is not lost in surface modes
- Efficiency is enhanced



PC substrates for Antenna

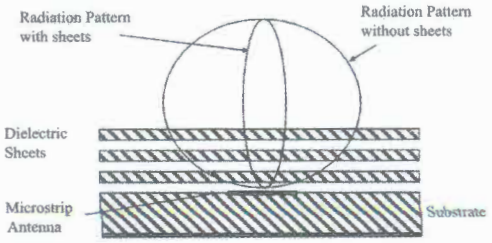
- Substrates with the help of structures of high impedance surfaces
- Microstrip antenna placed between the square lattice of metallic boxes



PC Antenna with Superstrate

- To improve radiation characteristics –
  - Beam width
  - Directivity
- Superstrate – Single or multilayer dielectric structure mounted above the microstrip patch
- Provides spatial filtering
- Superstrate and substrate form a resonant cavity

Microstrip Antenna with 1-D PC Superstrate



Microstrip Antenna with 1-D PC Superstrate

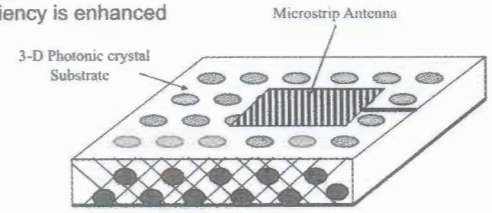
- Superstrate – 3 dielectric planes to act as a Bragg reflector
- Antenna excited by Bragg frequency
- Gain of Antenna increased by about 24dB
- Effective size of the antenna is about 25 times of that of the original antenna.

Summary

- PC devices have wide applications in optical communication and microwave antennas
- Devices based on 1-D PC, like Bragg reflectors, Fiber Bragg gratings etc have already been deployed
- Devices based on 2-D and 3-D PCs are at research level
- New impetus for
  - High brightness high efficiency LEDs using PCs
  - Microstrip Antennas with PC substrates for higher efficiency and gain

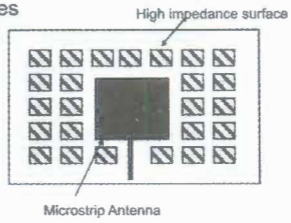
Photonic Crystal Antenna

- Normal dielectric substrate replaced by PC
- Frequency of operation lies within photonic band gap of PC.
- Energy is not lost in surface modes
- Efficiency is enhanced



PC substrates for Antenna

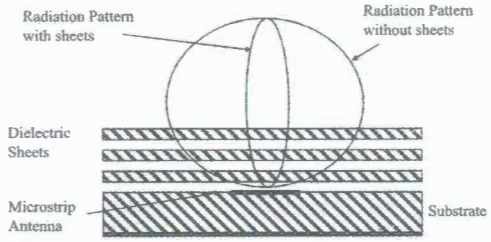
- Substrates with the help of structures of high impedance surfaces
- Microstrip antenna placed between the square lattice of metallic boxes



PC Antenna with Superstrate

- To improve radiation characteristics –
  - Beam width
  - Directivity
- Superstrate – Single or multilayer dielectric structure mounted above the microstrip patch
- Provides spatial filtering
- Superstrate and substrate form a resonant cavity

Microstrip Antenna with 1-D PC Superstrate

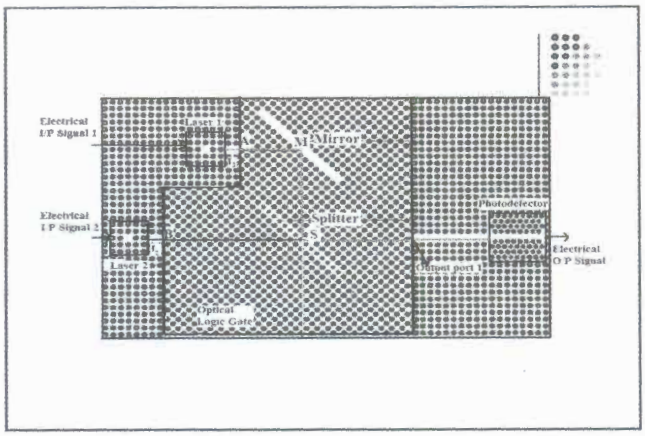


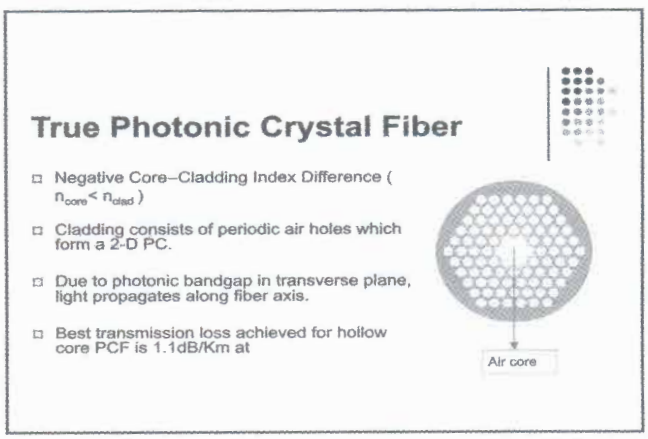
Microstrip Antenna with 1-D PC Superstrate

- Superstrate – 3 dielectric planes to act as a Bragg reflector
- Antenna excited by Bragg frequency
- Gain of Antenna increased by about 24dB
- Effective size of the antenna is about 25 times of that of the original antenna.

Summary

- PC devices have wide applications in optical communication and microwave antennas
- Devices based on 1-D PC, like Bragg reflectors, Fiber Bragg gratings etc have already been deployed
- Devices based on 2-D and 3-D PCs are at research level
- New impetus for
  - High brightness high efficiency LEDs using PCs
  - Microstrip Antennas with PC substrates for higher efficiency and gain





Author :

Email : director@admin.iitd.ac.in

Prof R K Shevgaonkar received his B.E. degree with Gold Medal in Electrical engineering from Jiwaji University, M.Tech from IIT, Kanpur and PhD from IIT, Bombay. He was a Scientist at Indian Institute of Astrophysics and Raman Research Institute. After doing his Post Doctoral fellowship at University of Maryland, USA, he joined IIT, Bombay. He has occupied various positions at IIT, Bombay like Dean of Students' Affairs, Dean, Resource Mobilization, Head, Department of Electrical Engineering, Head, Centre for Distance Engineering Education Programme, and Deputy Director. He was the Vice Chancellor of University of Pune and presently he is the Director of IIT Delhi. He has been a Visiting Professor at University of Lincoln, USA, and ETH, Zurich, Switzerland, and ISEP Paris, France.

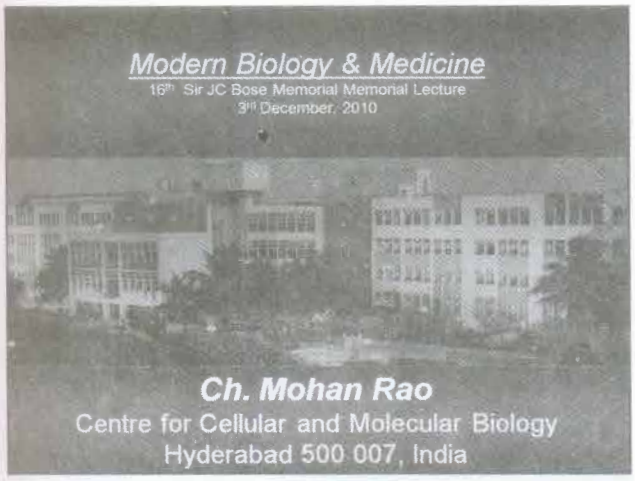
Prof. Shevgaonkar has been an active researcher in the area of Optical communication, Image processing, Antennas, Microwaves, Radio astronomy etc. He has published more than 150 papers in international journals and conferences, and two books namely Electromagnetic Waves and Transmission lines for Electrical Engineers. He has guided 18 PhDs and more than 30 M.Tech. dissertations. His video and web lectures on Electromagnetics and Fiber optic communication are used worldwide through Youtube.

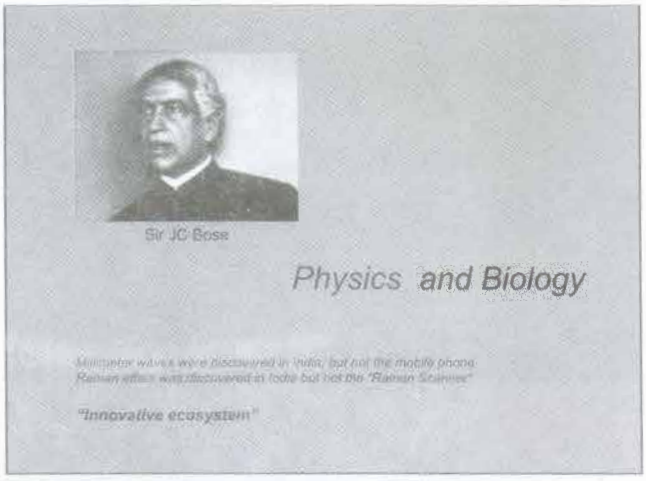
Prof. Shevgaonkar is recipient of IEEE Undergraduate Teaching award 2011, IETE award for his outstanding contribution to Optical communication, and the 'Excellence in Teaching' award of IIT, Bombay. He is Fellow of IEEE, Fellow of Indian National Academy of Engineering, Fellow of National Academy of Science, India, Fellow of Institution of Electronics and Telecommunication Engineers, Fellow of Optical Society of India, and Member of International Astronomical Union and Astronomical Society of India. He has been a member of many international and national research and educational committees.

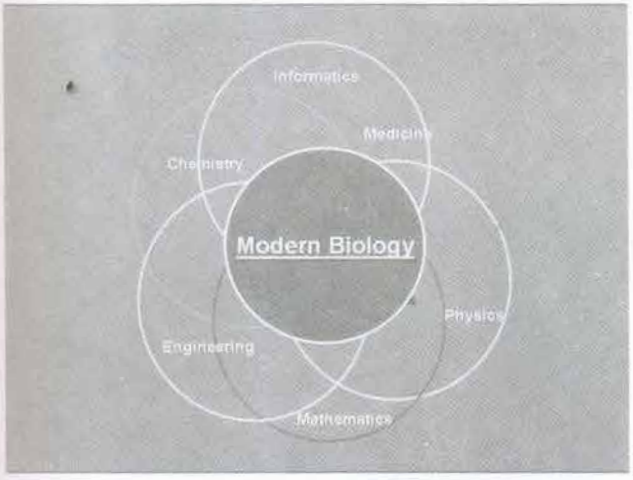
Modern Biology and Medicine

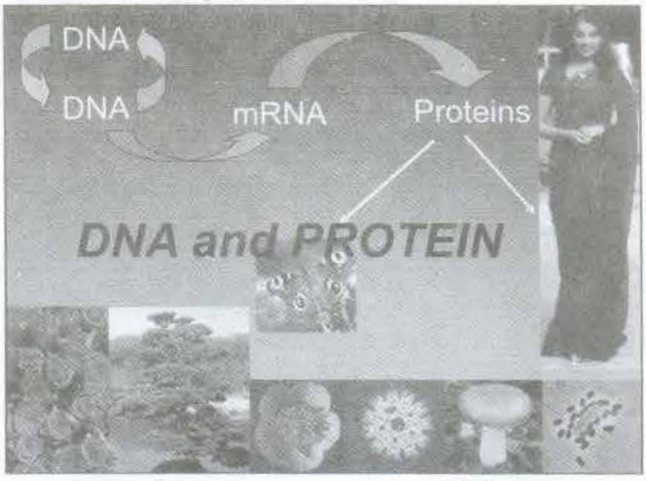
CH. MOHAN RAO

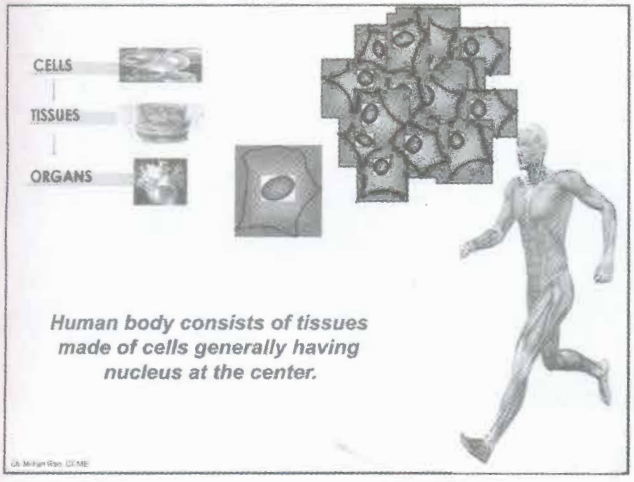
Centre for Cellular & Molecular Biology, Hyderabad

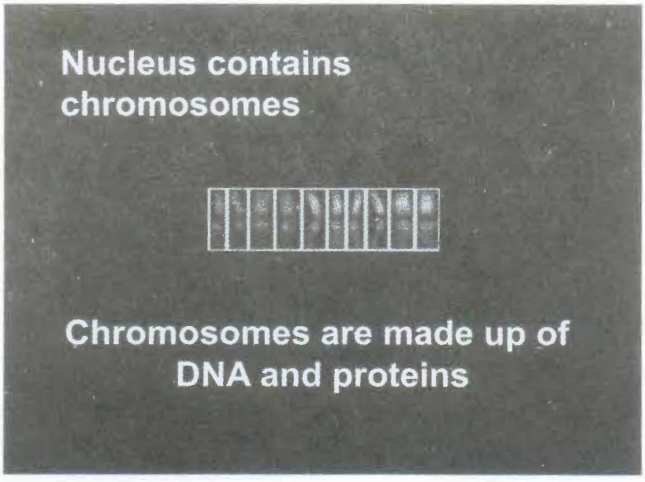












Fritz Miescher (1869)

Discovered that the nuclei of pus cells contain an acidic substance, he called it 'nuclein'

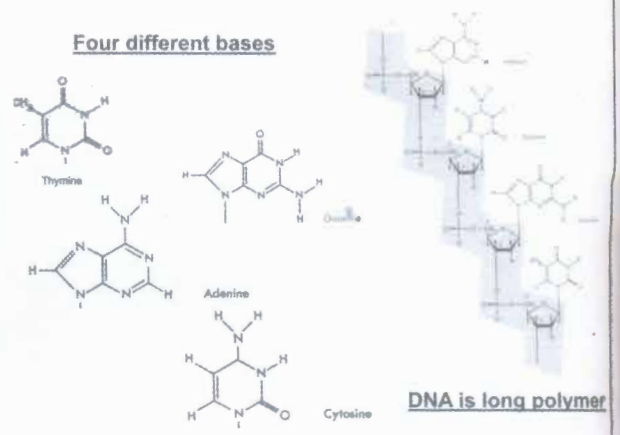
Pheobus Levene DNA

Nucleic acids contain five carbon sugar, ribose (1909)
An unknown sugar, deoxyribose, also present (1929)

There are two types of nucleic acids , one containing ribose (latter known as RNA) and the other containing deoxyribose (latter known as DNA)

He also found bases, phosphate and the linkage.

Four different bases



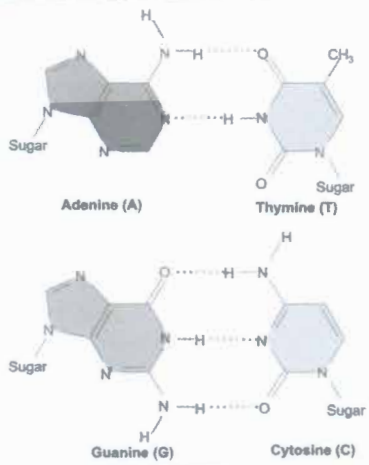
DNA is long polymer

Erwin Chargaff (1949)

Rosalind Franklin

Ratio between A and T, G and C remain the same (1:1)

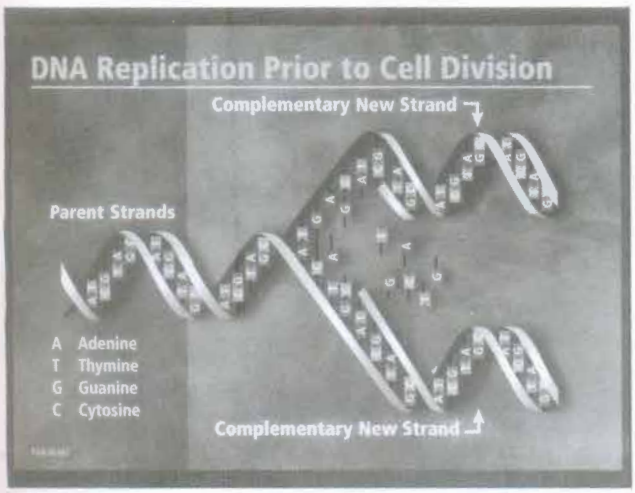
The "photo 51"

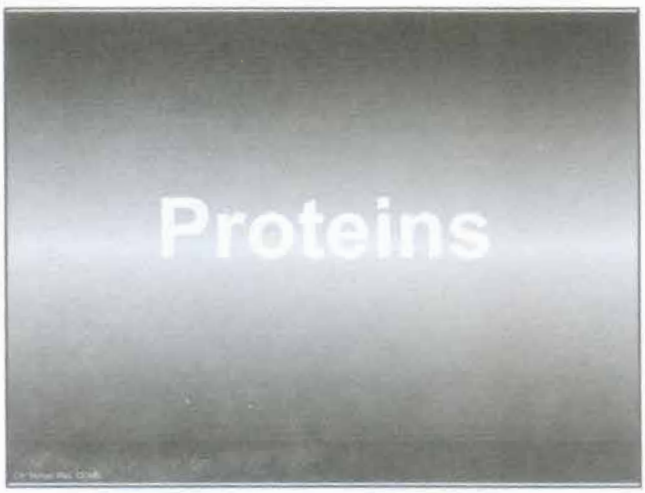


DNA is a double helix

FRANCIS CRICK AND JAMES WATSON

Two DNA strands are held together by complementary NUCLEOTIDES.





Proteins:

i) *help DNA replicate, thus preserve 'genetic' information*
ii) *regulate their own synthesis on the DNA template*
iii) *manifest all activities of life*
iv) *organize their degradation*

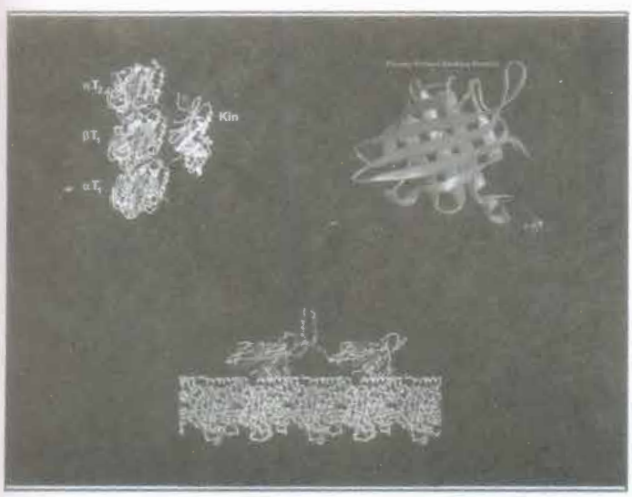
Enzyme activity, transport, storage (ferritin)
Structure (collagen), contraction (myosin/actin)
Protection (antibodies, fibrinogen), hormones, toxins etc.

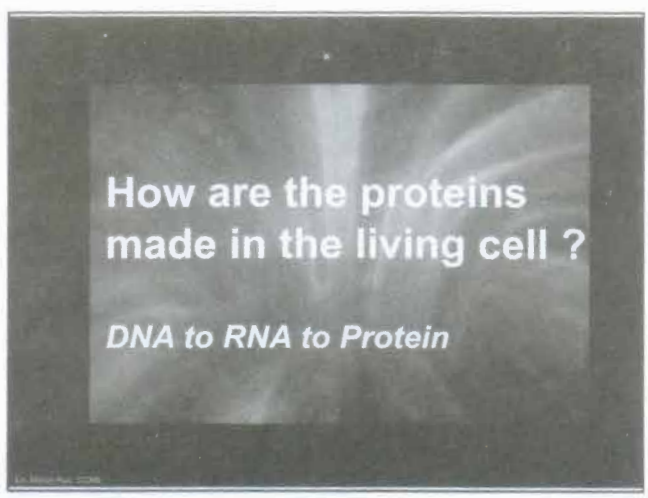
Geradus J. Mulder (1838) , introduced the term "Protein"
(Jons Jacob Berzelius ?)

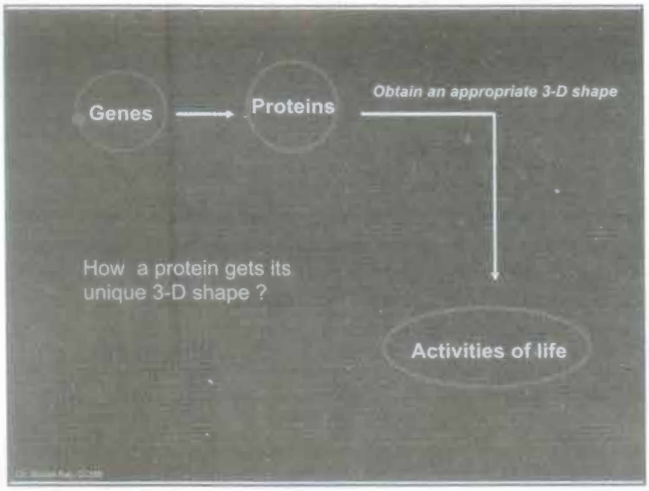
"..... there is present in plants and animals a substance which ..... is without doubt the most important of the known substances in living matter, and without which life would be impossible..... The material has been named protein"

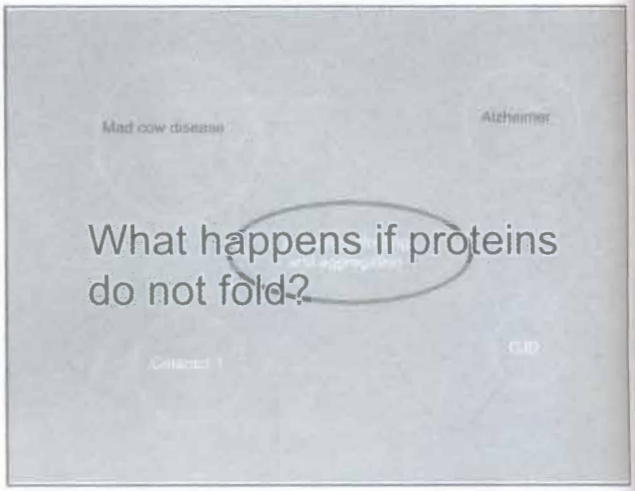
'Proteis', a Greek word, First rank (of importance)

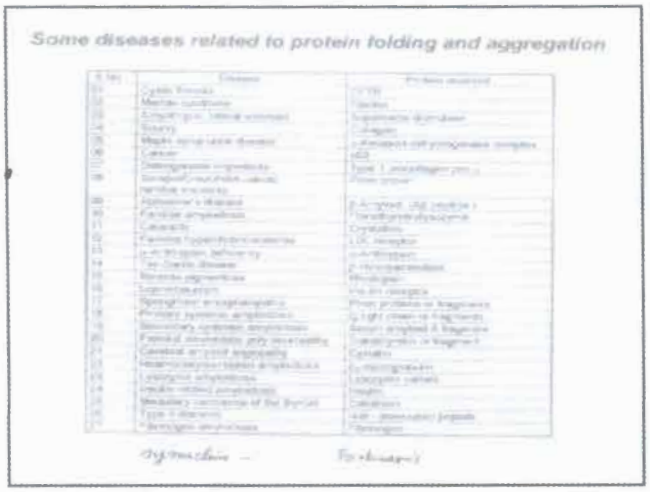
Emil Fischer : (1890-94)
'proteins are polymers built from small molecules called amino acids'



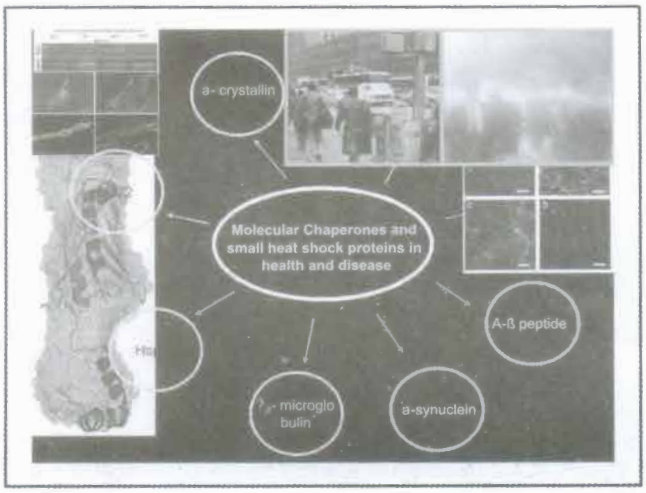



Genes
Proteins
Obtain an appropriate 3-D shape
How a protein gets its unique 3-D shape ?
Activities of life

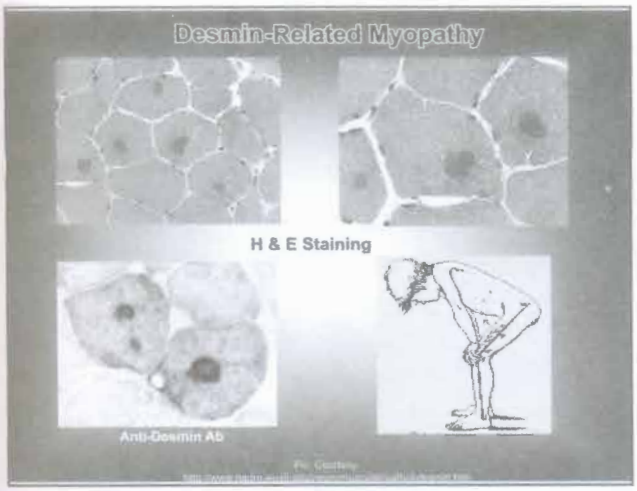

Mad cow disease
Alzheimer
What happens if proteins do not fold?
CJD

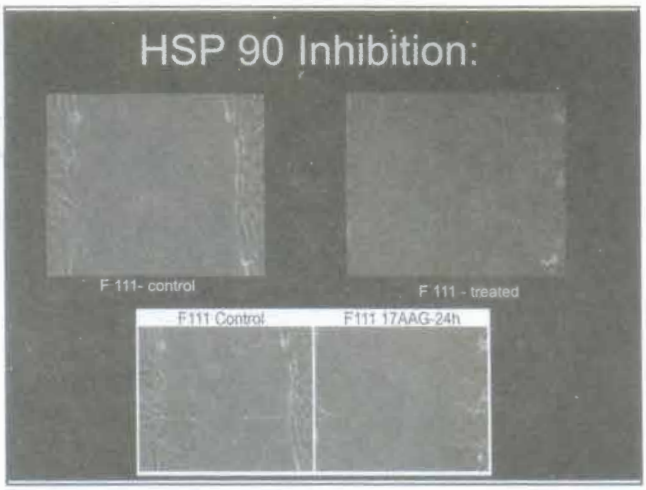

Some diseases related to protein folding and aggregation

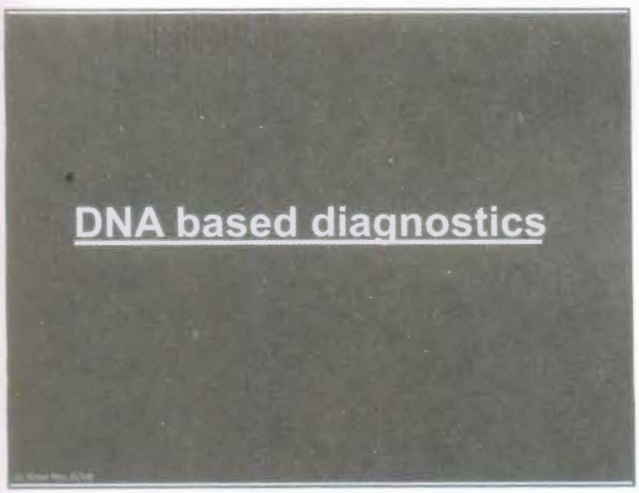

In a crowded cellular environment, there is neither space nor time for the nascent protein to fold correctly.
Heat shock proteins help protein folding and assembly.
The primary function of heat shock proteins and chaperones is to prevent aggregation and keep it in folding competent state

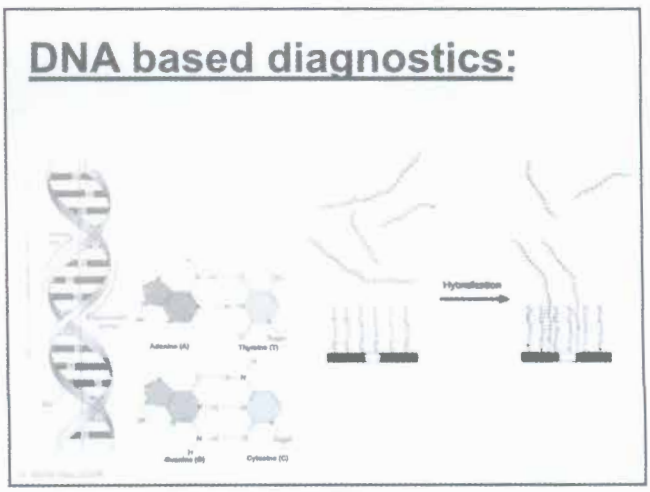

a- crystallin
Molecular Chaperones and small heat shock proteins in health and disease
A-ß peptide
a-synuclein

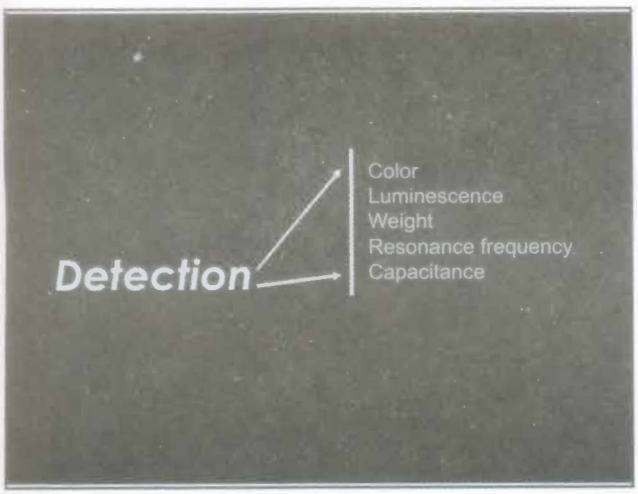

αB-Crystallin in vivo activity
C2C12, Mouse skeletal myoblasts
H9C2 cells, rat cardiomyoblasts
Neonatal Rat Ventricular Myocytes (NRVMs)

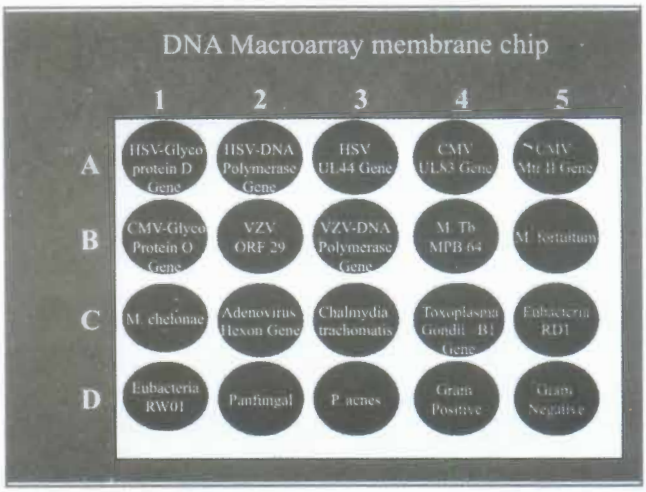

Desmin-Related Myopathy
H & E Staining
Anti-Desmin Ab

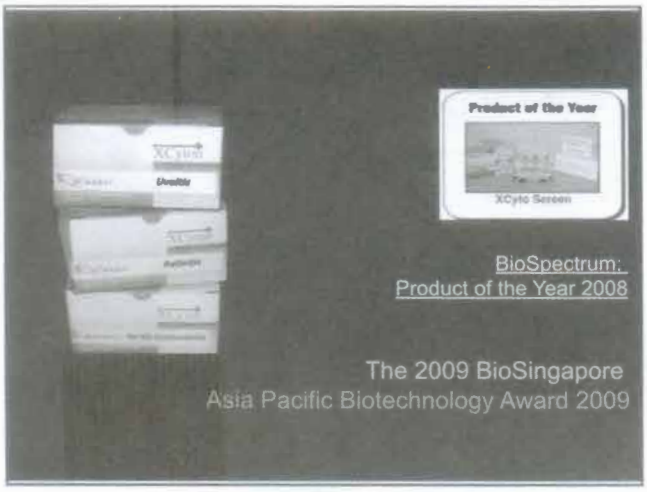

HSP 90 Inhibition:
F 111- control
F 111 - treated
F111 Control
F111 17AAG-24h

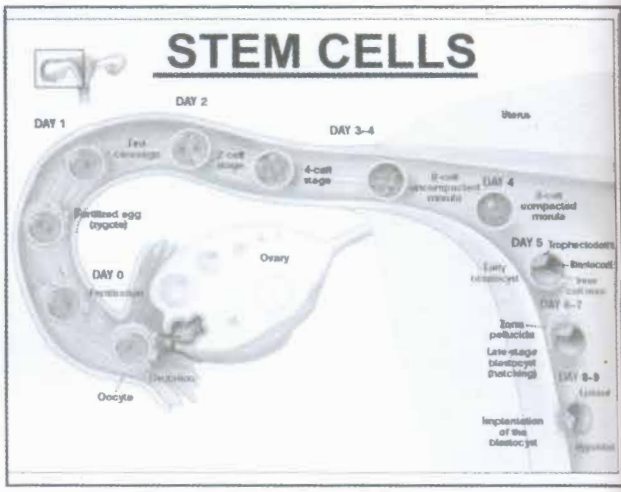

DNA based diagnostics

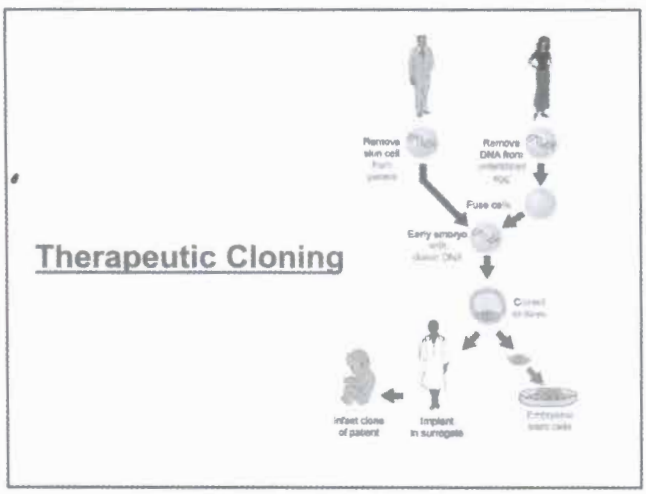

DNA based diagnostics:
Hybridization

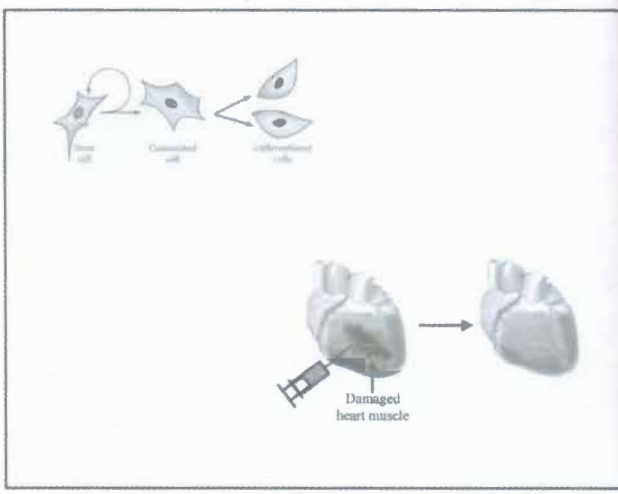

Detection
Color
Luminescence
Weight
Resonance frequency
Capacitance

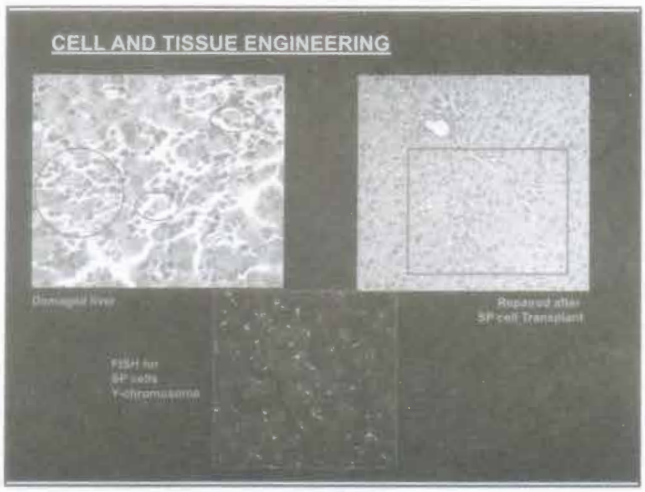

DNA Macroarray membrane chip
1 2 3 4 5
A
B
C
D
HSV-Glyco protein D Gene
HSV-DNA Polymerase Gene
HSV UL44 Gene
CMV UL83 Gene
CMV Mtr II Gene
CMV-Glyco Protein O Gene
VZV ORF 29
VZV-DNA Polymerase Gene
M. Tb MPB 64
M. fortuitum
M. chelonae
Adenovirus Hexon Gene
Chalmydia trachomatis
Toxoplasma Gondii B1 Gene
Eubacteria RD1
Eubacteria RW01
Panfungal
P. acnes
Gram Positive
Gram Negative


Product of the Year
XCyto Screen
BioSpectrum:
Product of the Year 2008
The 2009 BioSingapore
Asia Pacific Biotechnology Award 2009


STEM CELLS
DAY 1
DAY 2
DAY 3–4
DAY 4
DAY 5
DAY 0
Ovary
Oocyte
Zona pellucida


Therapeutic Cloning
Remove skin cell
Remove DNA from
Fuse cells
Early embryo
Implant in surrogate


Damaged heart muscle


CELL AND TISSUE ENGINEERING
Repaired after SP cell Transplant


Nanotechnology:
Bio-Medical Applications
Nanotechnology is designing, fabricating and studying things at the nanometer scale.
At least one dimension of such things should be 1-20 nm (1-100?)
Hemoglobin = 6.5nm
Viruses are 10-100 nm
Human hair = 100,000nm

Ayurveda

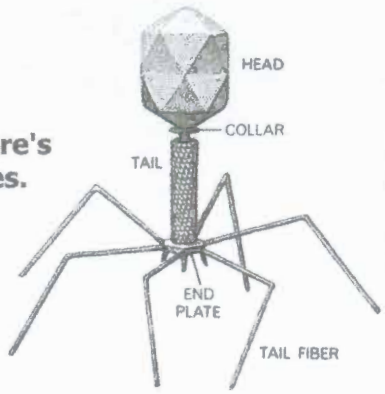
Michael Faraday, the Bakerian lecture:

"Experimental relation of gold (and other metals) to light"

Philo. Trans. Royal. Soc London 1857, 147, 145-153

Ancient Romans

Cells are Nature's Nano machines.



Nanobiology

Mainly refers to two aspects.

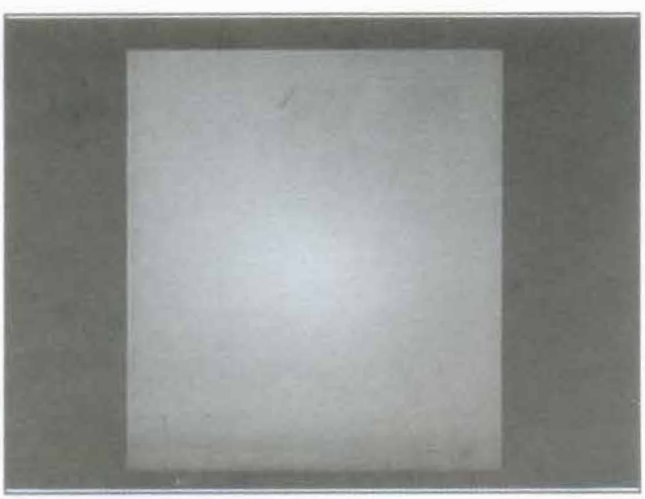
1. Study of biological problems at the nanoscale.
   STM, AFM, TIRM (single molecule fluorescence) etc.,
   (leading to nano scale understanding of life process)
2. Making molecular devices and molecular machines by bio-macromolecules.
   (learning from biology)

Learning from Nature:

Microscopic bumps on a lotus leaf transform its waxy surface into an extremely water repellent, or superhydrophobic, material.

Superhydrophobic surface: greater than 150 degrees

The large angle results from bumps that trap air between water and the surface, minimizing contact with the surface.



NANOPARTICLES FOR DRUG DELIVERY

Drug solubility issues (many are hydrophobic and insoluble in water)

Targeted delivery, increased residency time, lower dose, less toxicity

Particles (such as drug carrying liposome) would be removed from the circulation with in 0.5 to 5.0 minute by opsonization and phagocytosis.

If the particle is less than 100 nm they will be masked from recognition and remain in circulation longer

Selective coatings:

Hydrophobic coatings: extensive opsonization and localization to spleen, liver etc

Hydrophilic coatings: less opsonization, longer circulation – to tumors due to extensive vascularization (and retention in some cases)

Targeting:

1. Passive targeting: by desired coating, antibody etc
2. Active targeting: Magnetic nanoparticles, by external magnetic fields

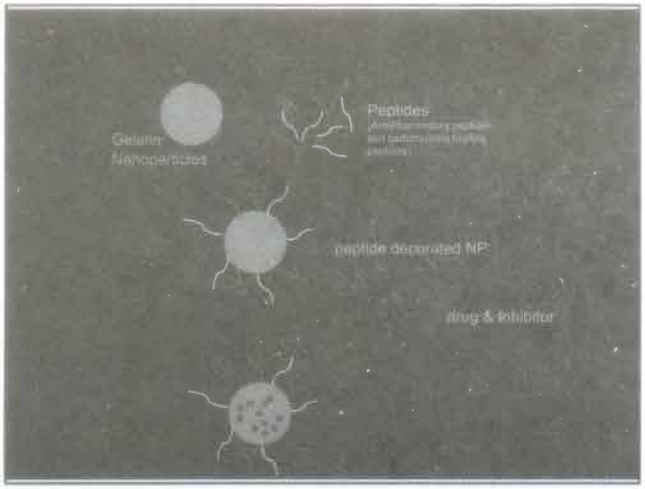
Hyper thermia: *Localized magnetic nanoparticles can be subjected to oscillating magnetic field causing local heating to kill the cells*

After treatment

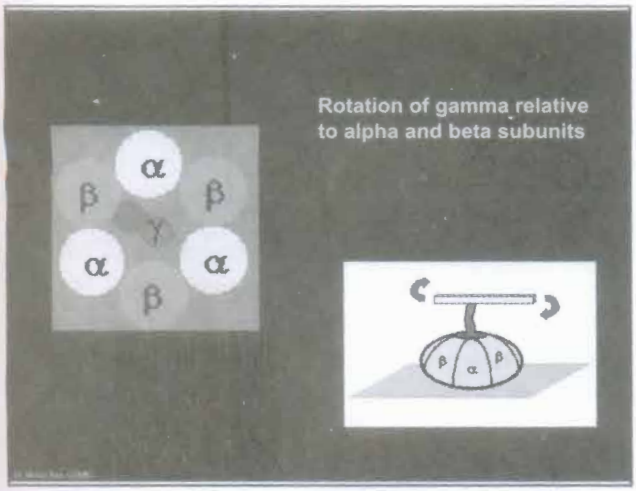
Blinking, tear film.
Develop formulation and delivery modalities

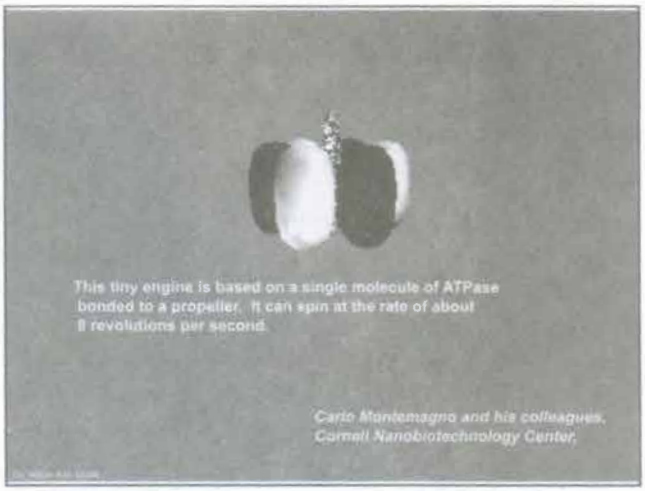
Gelatin Nanoparticles

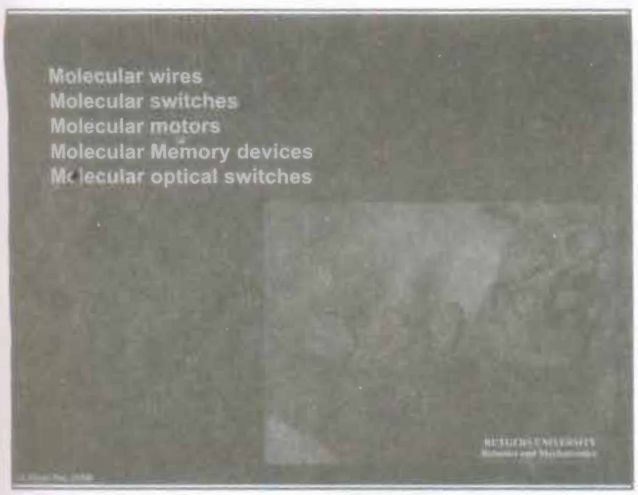
(By Sodium sulphate Precipitation)

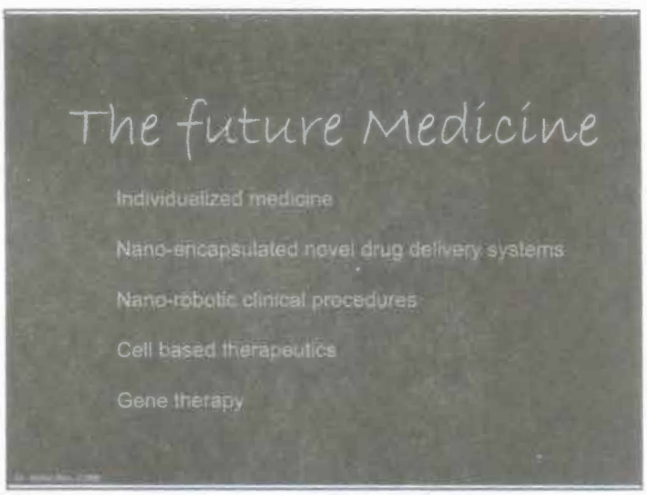


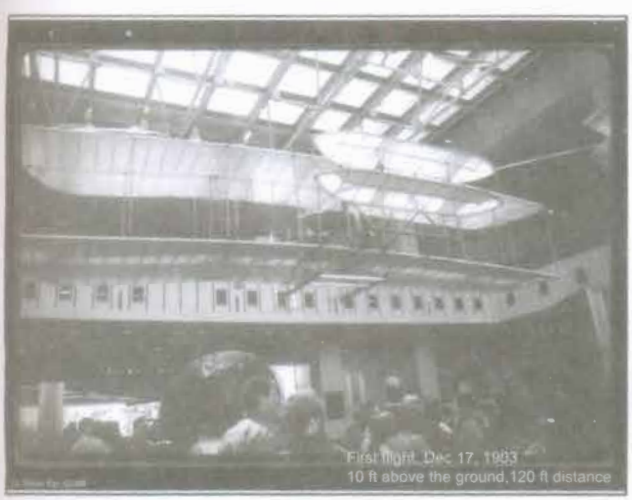
Nanotechnology for Biomedical Applications- Future


Rotation of gamma relative to alpha and beta subunits
α
β
γ


This tiny engine is based on a single molecule of ATPase bonded to a propeller. It can spin at the rate of about 8 revolutions per second.
Carlo Montemagno and his colleagues, Cornell Nanobiotechnology Center.


Molecular wires
Molecular switches
Molecular motors
Molecular Memory devices
Molecular optical switches


The future Medicine
Individualized medicine
Nano-encapsulated novel drug delivery systems
Nano-robotic clinical procedures
Cell based therapeutics
Gene therapy


First flight, Dec 17, 1903
10 ft above the ground,120 ft distance


July 16, 1969

Author :

Email: mohan@ccmb.res.in

Dr Ch Mohan Rao combines biophysical, molecular biological and cell biological approaches to address problems of biomedical importance. His research interests include protein folding, molecular chaperones and heat shock proteins, molecular basis for lens transparency, cataract and keratitis; Biosensors, DNA based diagnostics, Nanobiology, Photoacoustic spectroscopy and its application to biomedical problems.

His recent research addresses role of small heat shock proteins in gene expression, cell division, differentiation and apoptosis. He has obtained his PhD from the University of Hyderabad in Chemistry. Later he joined CCMB and initiated intact lens spectroscopic investigation. During 1990-92, he visited National Eye Institute of the National Institutes of Health, Bethesda, USA. He was a visiting Professor at the Tokyo Science University, Japan during 1996, Visiting Scientist at the University of Texas Medical Branch, Galveston, USA during 2000, Visiting Professor at the Institute for Protein Research, Osaka, Japan during 2002 and JSPS invitation fellow at the University of Tokyo, 2004. He is a Fellow of the Third World Academy of Science; Fellow of Indian National Science Academy, Fellow of National Academy of Sciences, India; Fellow of Indian Academy of Science and Andhra Pradesh Akademi of Sciences. He is the President of the Indian Biophysical Society and Vice President of Asian Biophysics Association, Honorary President, Jana Vigyana Vedika (Andhra Pradesh). He is recipient of several awards including Ranbaxy Award for Basic Medical Sciences (2000) and the Shanthi Swarup Bhatnagar Prize (1999). He is a section editor for BBA-Proteins and Proteomics. He is presently the Director of Centre for Cellular and Molecular Biology, Hyderabad.

1888 - 1970

SIR CHANDRASEKHARA VENKATA RAMAN *was the first noble laureate of India. Raman became professor of Physics at the University of Calcutta in 1917. Studying the scattering of light in various substances, in 1928 he found that when light of one frequency was transmitted through a transparent medium, other frequencies were added and that they were characteristic of the material. These so - called Raman frequencies are equal to the infrared frequencies for the material and are caused by the exchange of energy between the light and the material. This phenomenon is known as "Raman Effect". Raman was knighted in 1929, and he received 1930 noble prize for Physics for his discovery. In 1933 he moved to the Indian Institute of Science, at Bangalore, as head of the department of Physics.*

In 1947 he was named director of the Raman Research Institute, Bangalore and in 1961 became a member of the Pontifical Academy of Sciences. He contributed to the building up of nearly every Indian Research Institution in his time, founded the Indian Journal of Physics and the Indian Academy of Sciences, and trained hundreds of students who found important posts in universities and government.

The IETE has instituted a prestigious annual lecture series in the memory of Sir C V Raman. The venue for this lecture alternates between New Delhi and Bengaluru every successive year.

X-Ray Crystallography: Applications to Materials Science including Bio-molecules

J SHASHIDHARA PRASAD
Vice Chancellor, University of Mysore, India

This article reviews the x-rays diffraction effects through different crystalline structure of matter. It also describes how X-ray crystallography helps in study of the structure of materials including bio-molecules. It is the text of Sir C V Raman memorial lecture delivered by the author during February 2005 at Mysore.

The exploratory inquisitiveness of mankind has been continuously advancing in two opposite directions to unravel the mysteries pertaining to the structure of Universe, which falls in the realm of macrocosm and to delve deep into the micro-structure of matter and materials, which encompasses microcosm. The rapid advances that have taken place in the understanding of properties and functions of variety of materials, organic, inorganic, bio-chemical and biological has been possible due to the advent of sophisticated new ultra structural techniques which have revealed the geometrical nature of three dimensional array of atoms or molecules within the materials and also the nature of molecules themselves. The most important technique that has made this possible is X-ray crystallography.

The terminology of X-ray crystallography implies that X-rays are used in the study of materials that can be obtained in crystalline form. The technique has been applied with great effect in the analysis of both biological and engineering materials which in turn has helped in tailoring/modifying materials to the benefit of the mankind.

X-rays were discovered by Wilhelm Conrad Rontgen in the year 1895. They were conclusively shown to be electromagnetic waves by C G Barkla. It was suggested by Max von Laue in 1912 that X-rays could be diffracted by crystals just as optical waves could be diffracted by gratings. The edifice of X-ray crystallography which renders it possible to obtain the three dimensional structure of crystalline materials is centered around the diffraction of X-rays by crystals. The immediate question that occurs to our mind is as to whether three are techniques which allow for direct investigation of the micro structure of solids. Optical microscopes give a magnified image of any object and the resolution is limited by the wavelength of light scattered by the object and the angle of viewing. This sets a limitation as the human eye can perceive light up to the blue region. This limitation has been overcome to some extent by the electron and field ion microscopes that are analogous to light microscopes in that electrons or ions are used instead of light based on their wave like behavior. Even though one can reach very high magnification/resolution to the scale of interatomic and intermolecular distances, it is not possible to get three- dimensional structures as electrons or ions cannot penetrate deep into crystals due to their strong interaction with matter. This sets a limit on the information they can carry out with them to provide a complete three dimensional structure. It is here that X-rays come to our rescue.

The single central principle behind all diffraction theory deals with interference properties of two or more waves. X-rays being electromagnetic waves with very short wavelength can penetrate into material media. They interact with electrons and the electrons in turn scatter

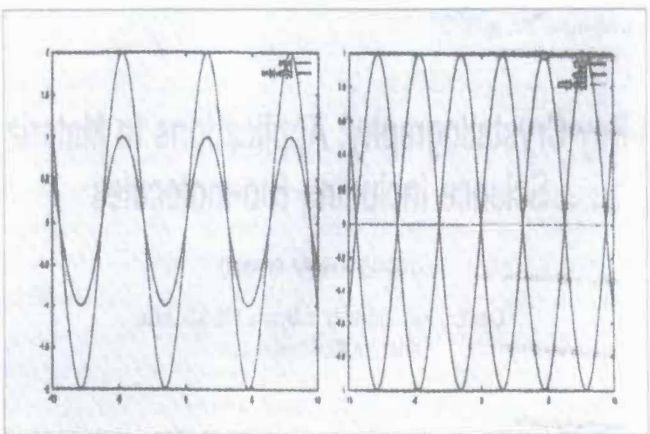


Figure 1 : Interference of waves of same amplitude in phase (left) is constructive, and out of phase by 180° (right) is destructive

the X-ray photons in all directions. Photons interact with each other in a manner that can be explained in terms of their wave character. Two extreme modes of photon interactions are constructive and destructive interference (Fig 1).

If the waves are partially out of phase they will result in a wave that has an amplitude and a phase angle (relative position of peaks and troughs) that are intermediate between constructive and destructive interference (Fig 2). The actual amplitude, which is the square root of the intensity of the resultant wave can be measured by the amount of darkening on a photographic film or the signal in a scintillation counter.

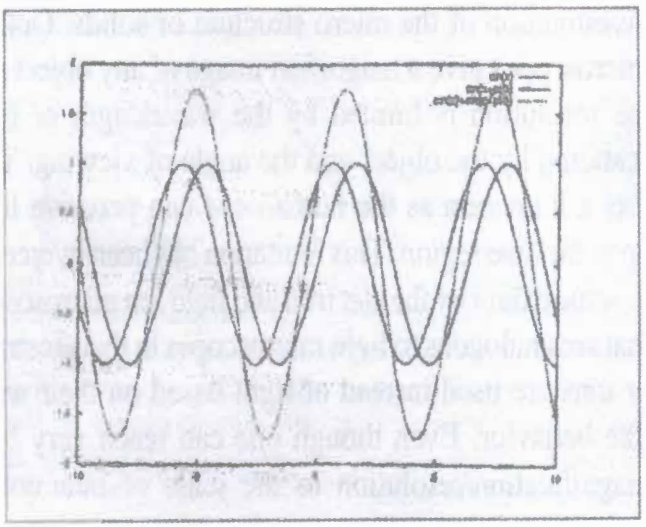


Figure 2 : Interference of waves with a phase difference of π/3

Unfortunately there is no way to measure the relative phase angles of the waves. We can do so if we have access to a measuring, device which can respond to any influence as fast as 10^{18} times per second and a measuring scale that could measure distances accurately down to 10^{-11} mm and the time correlations for the incident X-rays. This is known as the phase problem. Thus when an X-ray beam is incident on a group of atoms, the electrons of each atom in the group will scatter the X-rays in a particular direction in space and all the scattered X-rays from each atom will add up to give a resultant wave which will have a particular amplitude and relative phase. In some directions the amplitude F_{hkl} of the resultant wave will be large and its intensity I_{hkl} can then be easily measured. In other directions destructive interference may occur and so nothing can be recorded. As a whole one can observe a characteristic pattern from the object. Any object will give rise to a diffraction pattern but only regular periodic objects give rise to regular diffraction patterns. It is such patterns which are useful in micro-structural research. X-ray diffraction patterns therefore tend to provide information about regular periodic arrangements of atoms or molecules. We are all aware that crystals are naturally occurring systems in which there is regular three dimensional periodic arrangements of atoms or molecules. Further a crystal may be visualized to comprise of a conceptual array of points in space called a lattice and a motif being the structural unit repeated in space and being associated with each one of the lattice points. The lattice is a geometrical abstraction relating the exact geometry of the crystal which endows the crystal with several different types of symmetries. The motif is a highly specific entity which concerns the local arrangements of molecules and the structure of molecules themselves. Therefore in any experiment designed to investigate crystal structure, it is likely that the data from which we may derive the answers to the questions of the motif and the lattice will be different. This means that by looking at certain features of the diffraction pattern we will be able to decode the lattice and by investigating other features of the pattern we will be able to decipher the motif. Consider the constructive interference between the beams reflected from successive motif (atom) layers which are regular and periodic (Fig 3).

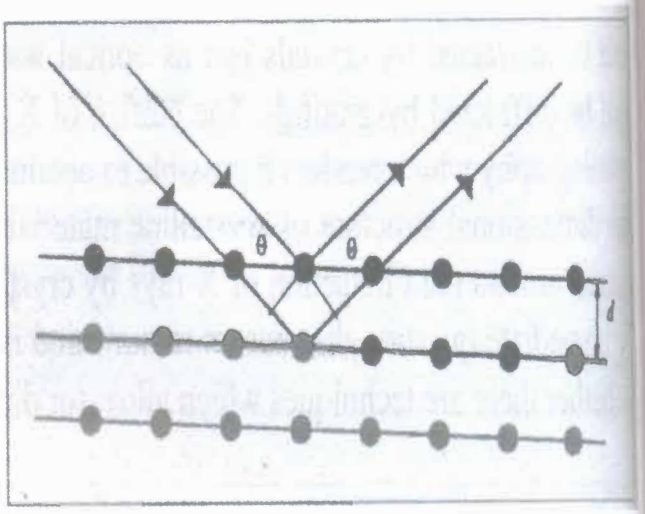


Figure 3 :- Reflection of waves from Bragg planes

The path difference between the beams reflected from two successive layers is 2d sin θ. The condition for constructive interference to occur is $2d \sin \theta = \eta\lambda$.

This is called Bragg's law first arrived at by WH Bragg and WL Bragg to describe X-ray diffraction. The angles at which the first order diffraction maxima are observed (corresponding to n=1) are given by $\theta = \sin^{-1}(\lambda/2d)$.

We see that the spread of diffracted rays depends on the periodicity and the spread increases with decreasing d indicating a reciprocal relationship (Fig 4). This suggests that the diffraction patterns are sampled in reciprocal space or Fourier space. This combined effect of the diffraction from motif and lattice is going to be equivalent to the diffraction pattern of the motif of the crystal multiplied by the diffraction pattern of the lattice. The 'motif' diffraction pattern will be sampled by the 'lattice' diffraction pattern (reciprocal lattice). It will be clear that the positions at which constructive interferences occur are defined by lattice, but the relative intensities of the diffraction peaks are determined by motif. Thus the intensities of the diffraction peaks will contain detailed information about the arrangement of atoms in a motif (Fig 5), the structure factor F_{hkl} being the square root of I_{hkl} can be obtained experimentally for all the diffraction events represented by the Miller indices (hkl). It is possible to evaluate the electron density and hence the position of atoms by Fourier synthesis and the structure so evaluated can be further refined by several refinement techniques that have been developed.

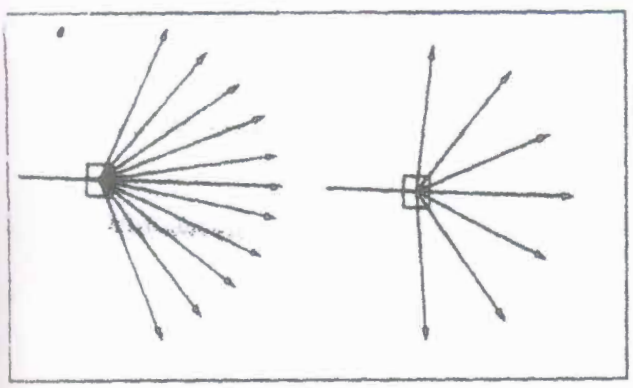


Figure 4 :- Diffraction from an object with large d (left) and small d (right) respectivcly

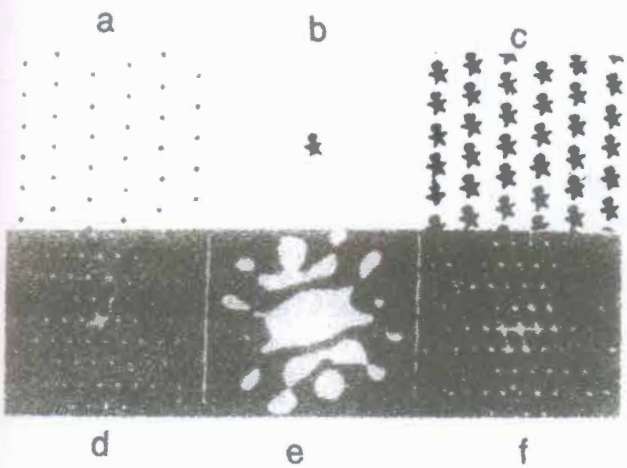


Figure 5 : Diffraction from a 2-dimensional pattern

The electron density function at any point (x,y,z) is given by

$$\rho\,(x,y,z) = \frac{1}{v} \sum_h \sum_k \sum_l F_{hkl} \exp -2\pi i\,(hx + ky + lz)$$

In order to perform this mathematical operation one requires θ_{hkl} for each F_{hkl} and the predicament caused by the lack of this information is called the 'phase problem'. This is illustrated in Fig 6.

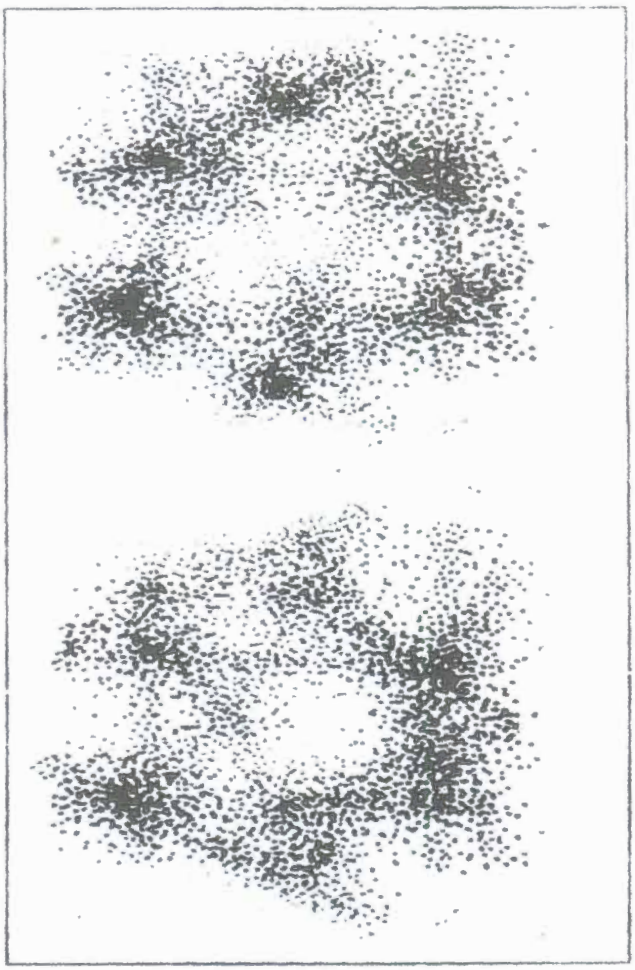


Figure 6 : Each dot in the figure refers to one of the amplitudes. With proper phasing one can perceive the electron density of a benzene molecule (top). The situation when the phases are not correct and correlated can also be seen (bottom)

Over the course of development of X-ray crystallography a number of direct and indirect techniques have been evolved for the solution of the phase problem.

The chemical modification methods:

- Isomorphous addition method
- Isomorphous replacement method

- Anomalous scattering method
- The heavy metal method

The above methods rely on Patterson synthesis.

The direct methods which are used extensively these days are straight forward and phase relationships are obtained by comparing the structure factor magnitudes of the diffraction events obtained from various data collection techniques. The data collection techniques were developed in the following order:

- Laue camera
- Rotation camera

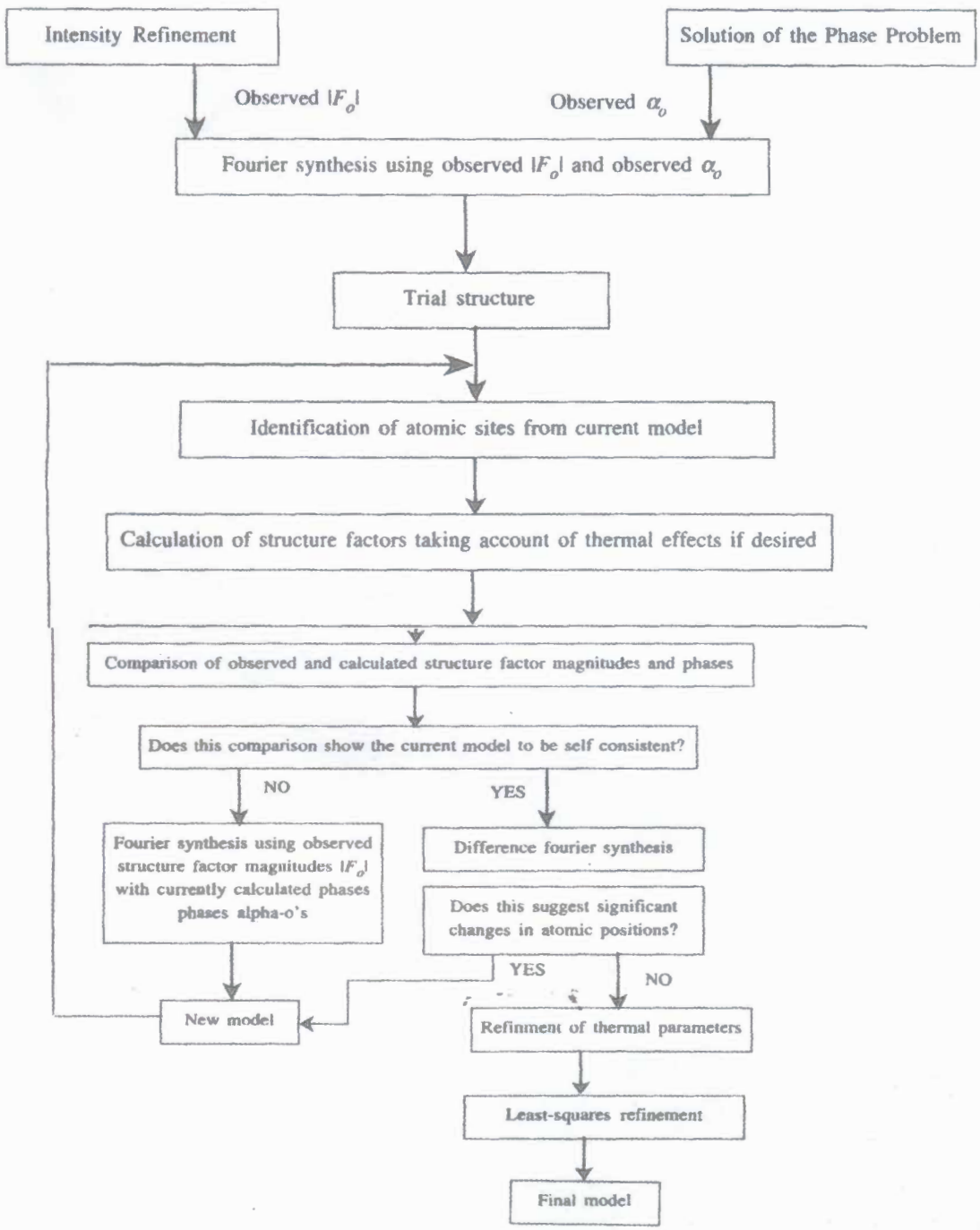


Figure 7 : Block Diagram of Structure Refinement

- Oscillation camera
- Weissenberg camera
- Precession camera

The above methods generally use photographic films for recording the diffraction events.

The diffractometers were developed after the advent of computers.

- Linear diffractometers
- Four circle diffractometers
- Kappa axis diffractometers

The above methods use single photon counters such as scintillation detectors or Multi -photon detectors such as imaging plate systems/CCD detectors. The source of X-rays may be from a sealed tube or rotating anode tube or synchrotron. The X-rays will be monochromatized by using filters or crystal monochromators. One has to apply a number of corrections to the raw intensities before evaluating F_{hkl}'s for performing Fourier synthesis. The corrections are:

Correction for back ground scattering

- Lorentz factor (rate of scan through reflection point)
- Polarisation of diffracted beam
- Absorption (shape of the crystal)
- Extinction-primary and secondary
- Temperature factor

The steps involved in the structure determination and refinement are shown in the Fig 7.

The advent of powerful PC systems and software have brought in a revolution in data collection, through derived parameters such as position of atoms, thermal parameters, planarity of atomic groups and molecule, bond lengths and angles, torsion angles and conformation of the molecule itself. Myriad of structure have been and are being solved-organic, inorganic, bio-molecular, etc and the results have been successfully used to understand the properties and function and so on.

There is no more basic enterprise in chemistry than the determination of the geometric structure of the molecule. Such a determination when it is well done ends all speculation as to the structure and provides us with the starting point for the under-standing of every physical, chemical and biological property of the molecule.

-Hoffmann

The relation of crystallography to other sciences is illustrated in Fig 8. It can be seen that it is of highly inter-disciplinary nature. This can also be seen in the relation of materials design (Fig 9).

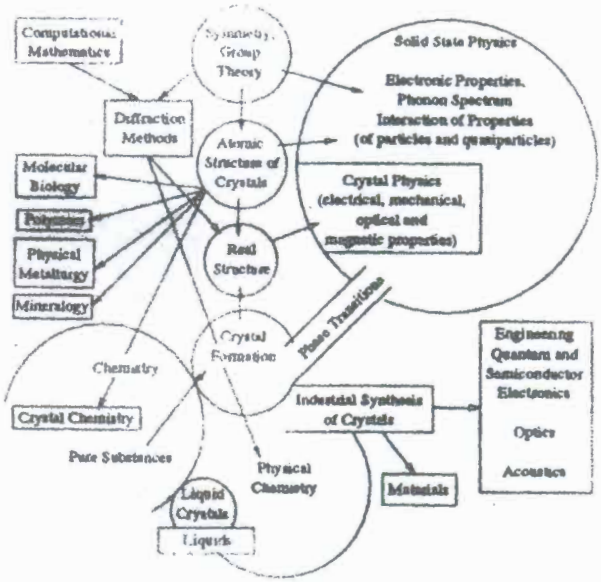


Figure 8 : Relationship of crystallography to other sciences

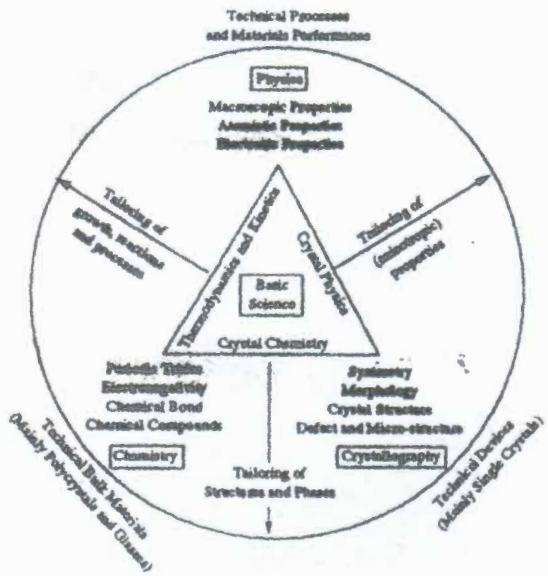


Figure 9 : Relationship of crystallography to materials sciences

Few examples of how molecular structure plays a dominant role in the understanding of the physical properties of the materials and function, activity and evolution of bio-molecules are illustrated below:

Consider the closely arranged chlorobenzene molecules in different orientations (Fig 10). As can be seen, the molecular architecture in the crystal determines whether the material can have dipole moment or not.

The tetrahedral covalent binding of carbons in diamond endows it with extreme hardness as compared to the sheets of carbon molecules in the graphite which is so soft as to be scratched on a paper (Fig 11).

The exotic and subtle behavior of liquid crystalline phase, one of the most important states of matter (soft matter), could be understood and appreciated by the molecular architecture in the crystalline phase of the materials. The subtle intermolecular interactions are revealed by the structure analysis (Fig 12)

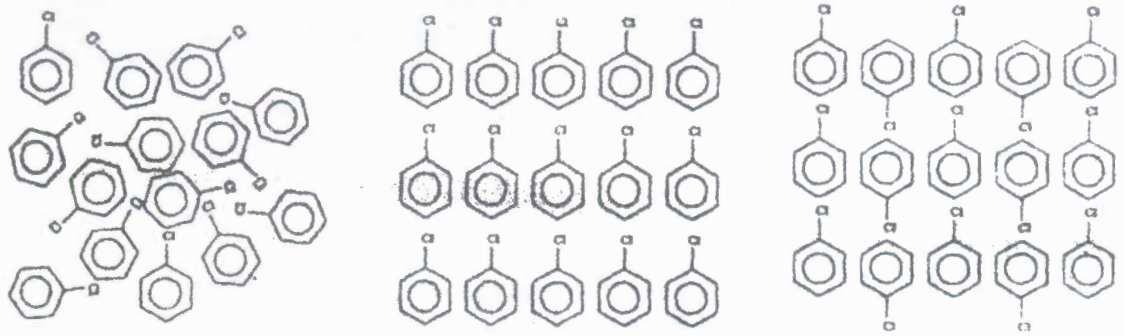


Figure 10 : Arrangement of chlorobenzene molecules

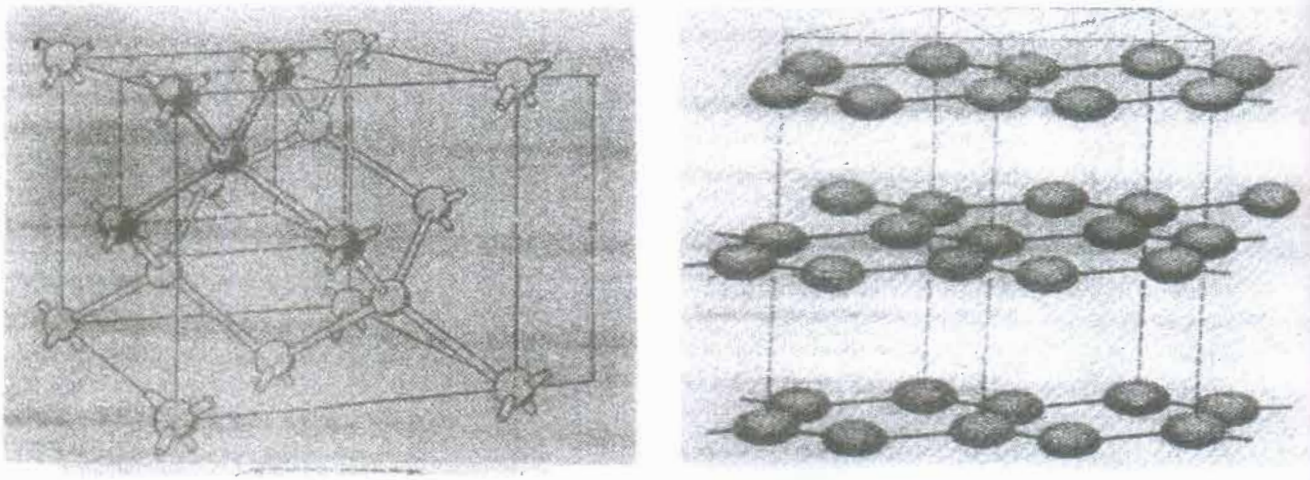


Figure 11: Structure of diamond endows

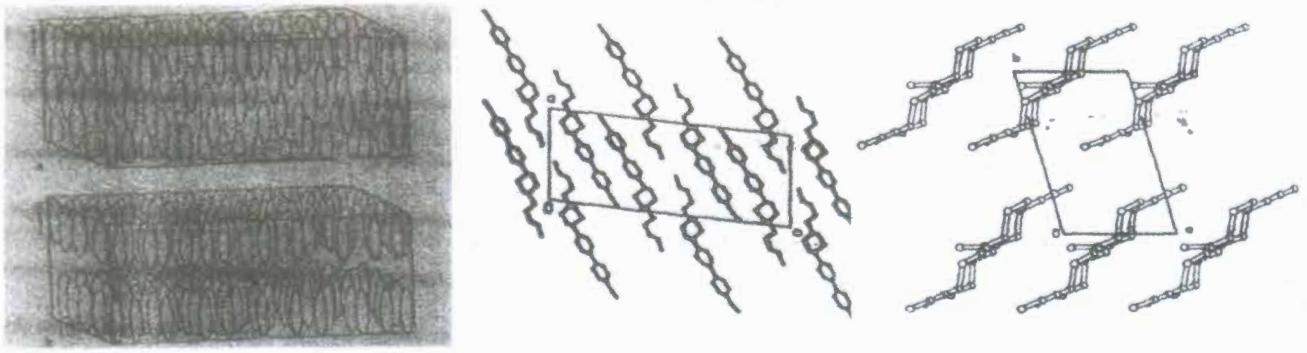


Figure 12 Molecular arrangement of nematic (a), smectic (b) liquid crystals imbrication (left) and layering (right) in crystalline phase

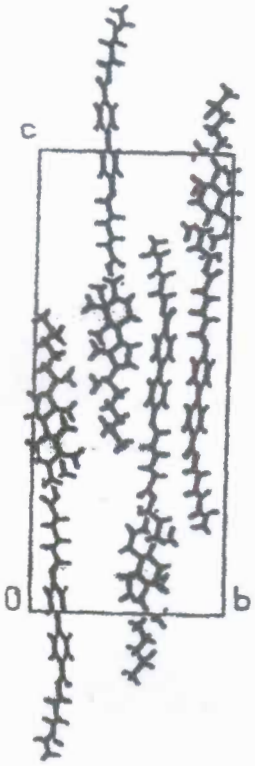


Figure 13 : Structure of a dimesogen

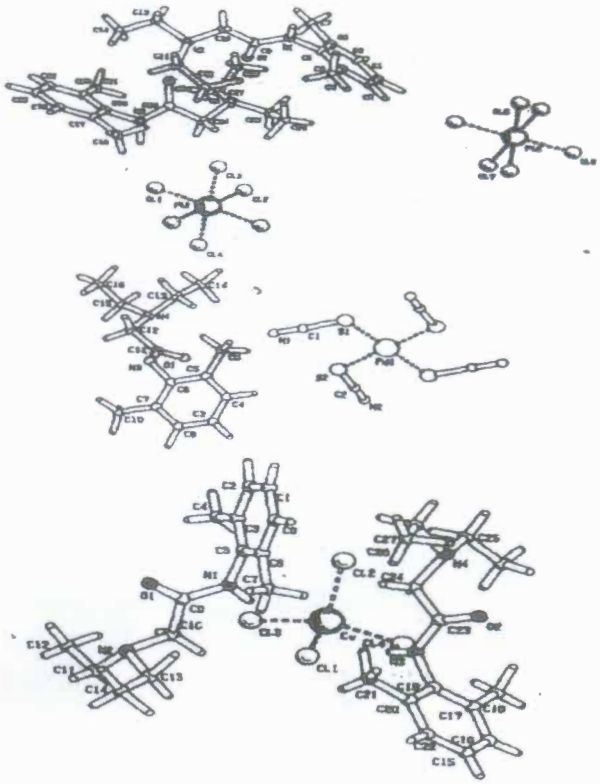


Figure 14 : Structure of lignocaine complexes

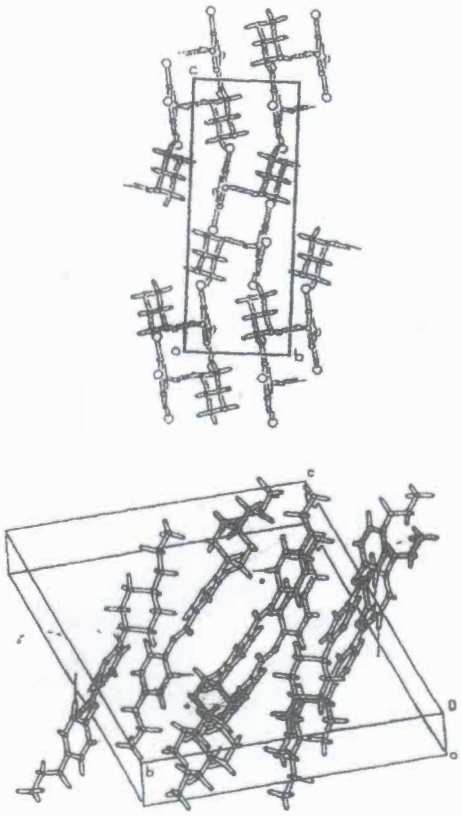


Fig 15 : Supramolecular assemblies

The dimesogen structure (Fig 13) shows a large number of intermolecular contacts that are less than van der Waal's radii which account for the exotic properties.

The molecular recognition processes in simple organic and inorganic systems can be appreciated by the knowledge of molecular architecture. Figure 14 shows the structures of the platinum, palladium and copper complexes of lignocaine.

The supramolecular assemblies which have interesting behavior of physical properties of homologous series can be explained only in terms of the molecular structure. The examples of nonyl benzoic and undecyloxy benzoic acids clearly indicate that the higher member bends at a points unlike the lower member (Fig 16).

TABLE 1: Conformational results of some phenoxazine derivatives

Phenoxazine derivative of rings	Conformation of the central rings	Torsional angles of the central ring	Conformation three fused
10-N- Piperidinoacetyl	Distorted boat	34 19, 1.49, -33.87 37.24, -1.84, -36.78	Nonplanar
10-N- Chlorobutyl	Planar	9.55, 3.65, -10 12, 15.22, -2.45, -15.89	Planar
10-N-(Chloropropyl) 2-chloro	Planar	11.06, -1.45, -9.49, 10.96, -1.66, -9.44	Planar
10-N-(Piperidinoacetyl) trifluoromethyl	Distorted boat	27.28, -2.75, -26.77, 31.33, 1.40, -30.75	Nonplanar
10-N-Morpholinopropyl trifluoromethyl	Planar	0, 0, 0, 0, 0, 0	Planar
10-N-Morpholinoacetyl trifluoromethyl	Distorted boat	33.88, 0.46, -32.76, 36.54, -2.53, -33.59	Nonplanar
10-N- Morpholinopropyl trifluoromethyl (HCl)	Planar	10.57, 1.42, -11.36, 11.87, 0.27, -12.77	Planar
10-N-Pyrrolidinopropyl trifluoromethyl	Planar	16.11, -0.02, -17.04, 14.58, 1.81, -15.50	Planar

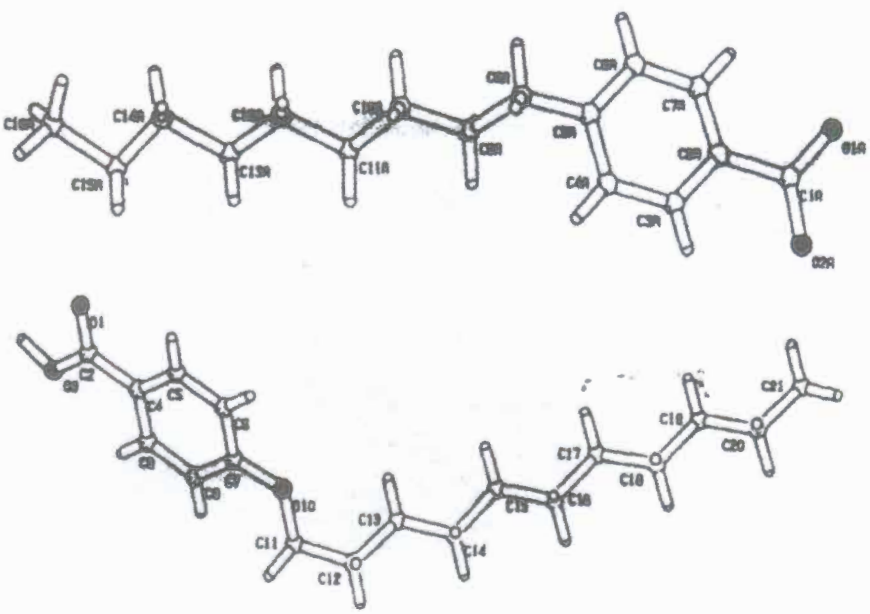


Figure 16 : Higher member bends at a points unlike the lower member

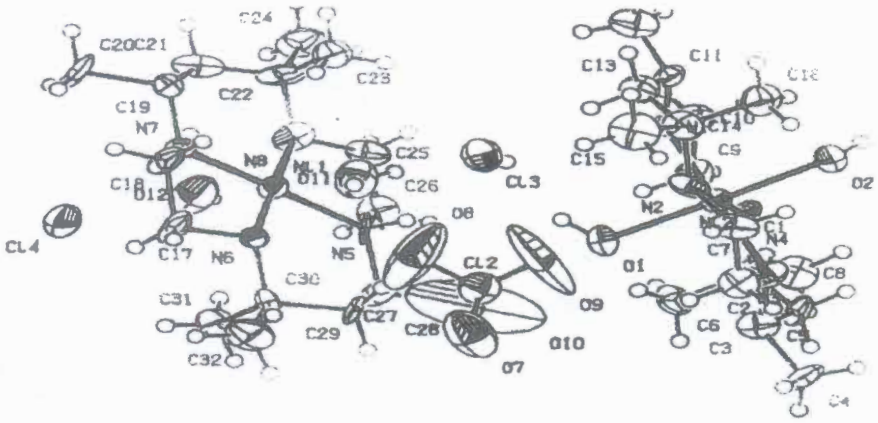


Figure 17 : Structure of Ni (III) complex

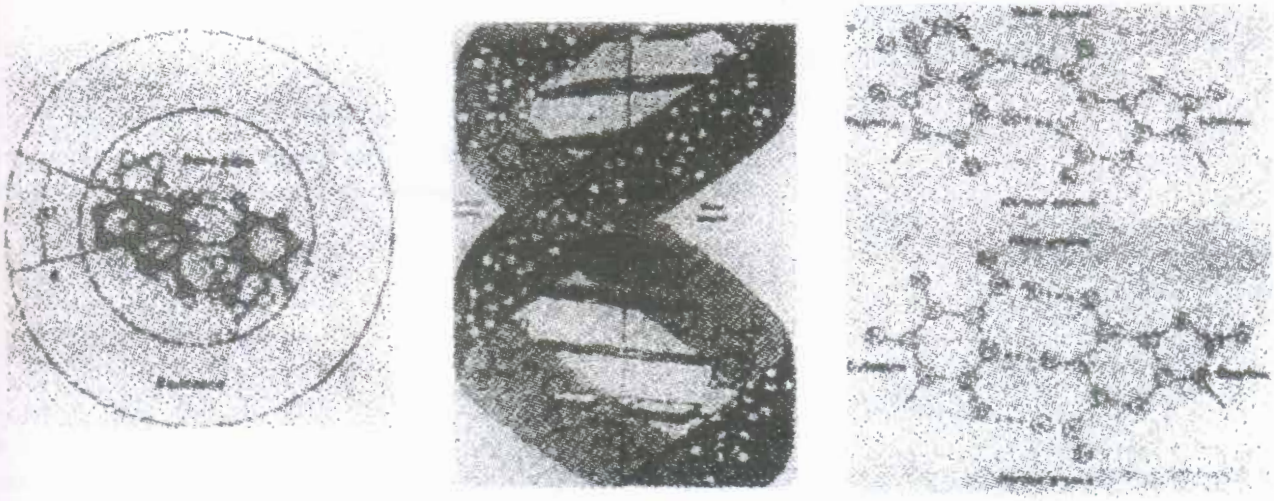


Figure 18 : The structure of DNA, the molecule of life

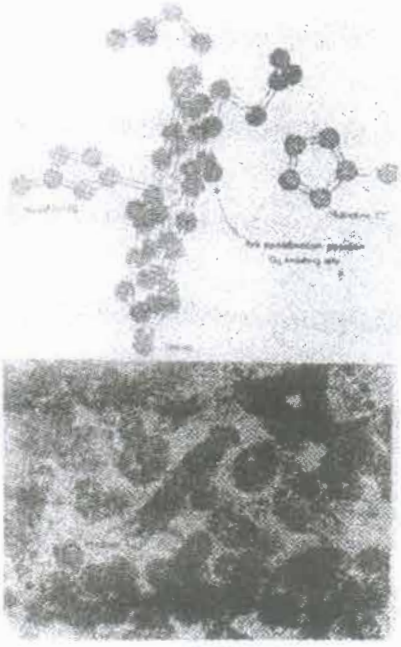


Figure 19 : Structure of the heme group with histidine along with the electron density map

Restructuring Indian Universities: Renewed Focus on the Research

P BALARAM

Director, Indian Institute of Science, Bangalore

"Restructuring Indian Universities: Renewed Focus on the Research"
or
"Reforming Indian Universities: Triad of Universities, Research Institutes and Industries"

Restructuring: "Perestroika" ("Glasnost")

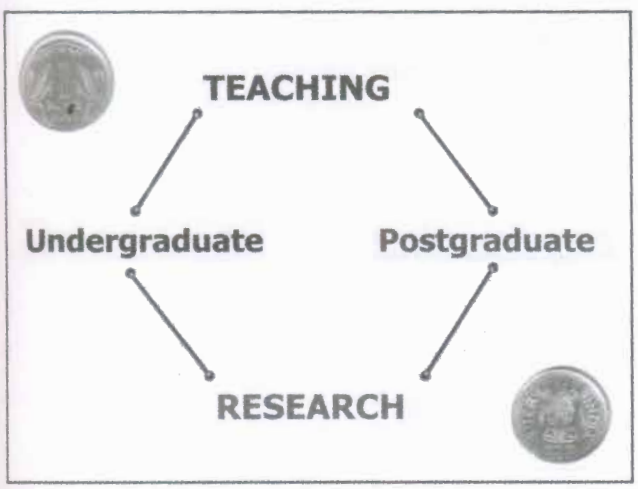
Reform: "Paradigm Shift"

Research and Higher Education : Indian Challenges

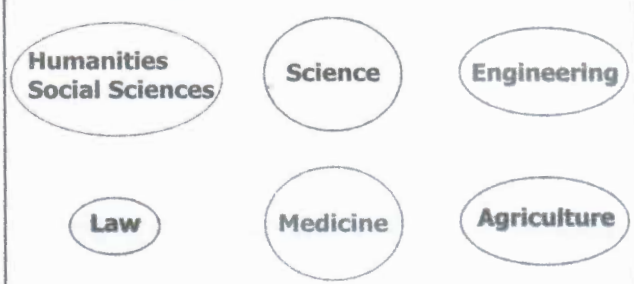
Science
Engineering
Medicine
→ Scientific Research "Science"

Humanities, Social Sciences, Economics and Management

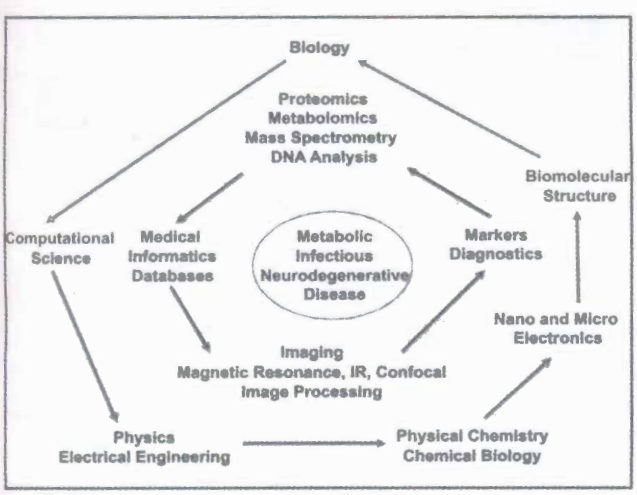
Fragmentation Vs Integration

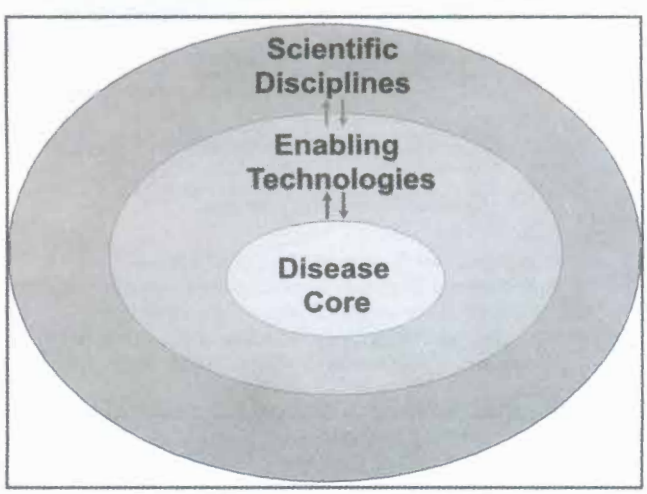


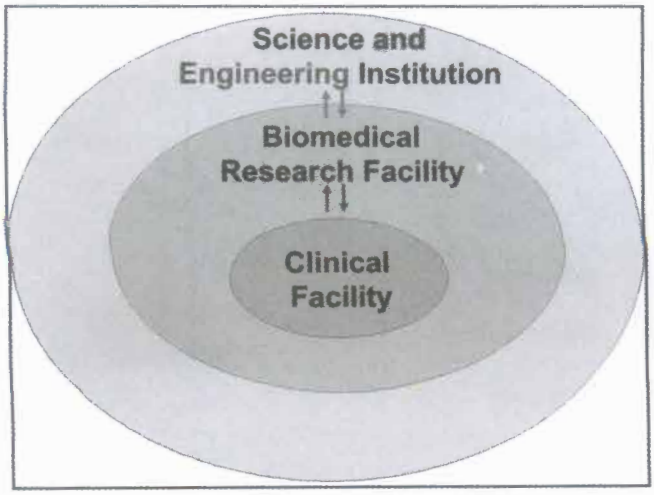
Segregating Disciplines

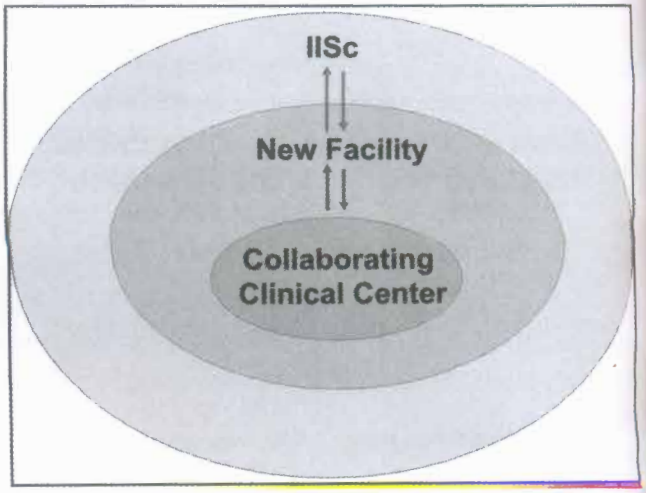


The diminishing core of universities









Measuring and Assessing Science

Academic Science (Uncertain utility)

Applied Science (Clear goals and targets)

Assessing Scientific Activity

1. **Personal Judgments** (Informed or prejudiced)
2. **Impersonal Quantitation** ("Scientometrics")

Scientometrics

" The study of the measurement of scientific and technological progress"

"Citation Indexes for science: A new dimension in documentation through association of ideas" - E.Garfield Science 122, 108-111 (1955)

Science Citation Index

↓

Web of Science

Science, Scientists and Scientometrics

Man is an Animal that writes Letters

-- Charles Dodgson (Lewis Carroll)

Scientists are animals who like to publish papers

Science Publishing Journals

Quality	Cost	Cost
↓	↓	↓
Assessing Science	Author or Reader	" Open Access " Digital

HISTORY

Current Contents

↓

Science Citation Index

↓ Print /CD /on-line

Web of Science

(Links to the literature)

Eugene Garfield

Citation Indexes for Science: A New Dimension in Documentation through Association of Ideas

Garfield, E., *Science*, 1955, 122, 108-111

"The new bibliographic tool, like others that already exist, is just a starting point in literature research. It will help in many ways, but one should not expect it to solve all our problems"

The Journal Impact Factor

- A Double Edged Sword

The Impact Factor : Views and Evaluation

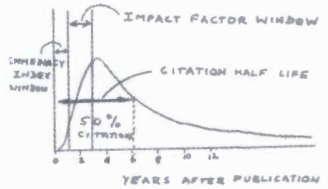
K. Bhatia and D N. Gandhi, *J. Inf Mgmt.* 40, 179-198 (1993)

$$IF_{2003} = \frac{\text{2003 citations to articles publ. in 2001-2002}}{\text{Number of articles publ. in 2001-2002}}$$

1. Ranking of Journals
2. Ranking of Institutions and Individuals (The Insidious " Average Impact Factor ")
3. Effects on the " Mores of Publishing Science "

Citation Counting

Impact Factors : Use and Abuse
- M. Amin & M. Mabe
Perspectives in Publishing Elsevier Science (News letter for Journal editors)



Subject variation in impact factors (Mean "IF" 1998)

Life Sci. ~ 3.0	Earth Sci. ~ 1.1
Physics ~ 1.5	Chemistry/Chem Eng. ~ 1.5
Maths/Comp.Sci. ~ 0.5	Materials Sci/Eng. ~ 0.6

'h index' : Comparing Performance

An index to quantify an individual's scientific research output
J.E. Hirsch arXiv : physics/0508025 23 Aug 2005
PNAS | November 15, 2005 | vol. 102 | no. 46 | 16569-16572

"A scientist has index h if h of his/her N_p papers have at least h citations each and the other (N_p – h) papers have fewer than h citations each".

N_p -total number of papers over n years

N_c^j -number of citations for each paper j

$N_{c,\,tot}$ -total number of papers

$N_{c,\,tot} = ah^2$ "Empirically, 'a' ranges from 3 to 5"

"h is preferable to other single number criteria commonly used to evaluate scientific output of a researcher".

The Median Isn't the Message

- Stephen Jay Gould

Mark Twain's famous quip

(sometimes attributed to Disraeli)

-- "Identifies three species of mendacity, each worse than the one before -- lies, damned lies, and statistics".

'.....the growth of science is dependent upon an accumulation of many "mediocre" results that are produced by hard work'.....

....'Long live the mediocrities. Without them how could there be geniuses?'

Garfield, E., *Current Contents* Nov. 4, 1970;
Essay of an Information Scientist,
ISI Press, Philadelphia, 1977, p. 131

Measures for measures

S. Lehmann, A. D. Jackson and B. E. Lautrup
Nature, Vol. 444, 1003, 2006 (Dec 21/28)

"There have been few attempts to discover which of the popular citation measures is best and whether any are statistically reliable."

" Institutions have a misguided sense of the fairness of decisions reached by algorithm ; unable to measure what they want to maximize (quality), they will maximize what they can measure"

Correlating the Uncorrelated

Decline of Science in India Correlates with Improvement in Technology

Swaminathan Aiyar, Times of India

Decline in Indian Political Standards Correlates with Improvement in the Indian Economy

(Anonymous)

The Increasing Dominance of Teams in Production of Knowledge

Stefan Wuchty,[1*] Benjamin F. Jones,[2*] Brian Uzzi[1,2*†]

Science, 2007, 316, 1036 (18 May 07)

"Teams typically produce more frequently cited research than individuals do, teams also produce the exceptionally high impact research even where that distinction was once the domain of solo authors"

Sciences and engineering, social sciences, arts and humanities, and patents

"The process of knowledge creation has fundamentally changed"

Why Do Team-Authored Papers Get Cited More?

Science, 2007, 317, 1496 (14 Sep 07)

Academic Ranking of World Universities – 2003

N.C. Liu et al . Shanghai

Methodology (5 parameters, 21 Subject categories)

*(Life Sci., Medicine, Phys. Sci., Engineering and Social Sciences)

1. Nobel Laureates (Differential weight for award dates)
2. Papers in Nature and Science (2000-2002)
3. Highly cited researchers 1981-1999
4. Articles in SCI (Exp) and Social Science CI.
5. Academic performance (1-4) per faculty

The List (Top 500)

1. Harvard
2. Stanford
3. Caltech
4. Berkeley
5. Cambridge
6. MIT
7. Princeton
8. Yale
9. Oxford
10. Columbia

19. Univ. Tokyo

25. ETH, Zurich

251-300 IISc

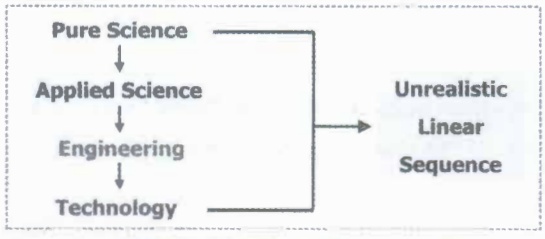
451-500 IIT Delhi

IIT Kharagpur

The scientific impact of nations

- D.A. King *Nature* 2004 430 : 311 (July 15 issue)

Rank order	Nations	1997-2001	Share of Top 1% cited publications
1	USA	23723	62.76
2	UK	4831	12.78
3	GERMANY	3932	10.4
4	JAPAN	2609	6.9
5	FRANCE	2591	6.85
6	CANADA	2195	5.81
7	ITALY	1630	4.31
.			
19	CHINA	375	0.99
20	S. KOREA	294	0.78
21	POLAND	231	0.61
22	INDIA	205	0.54
	Total	38,263	136.5 Collaboration



Science by itself provides no panacea for individual, social and economic ills. It can be effective in national welfare only as a member of a team. But without scientific progress, no amount of achievement in other directions can insure our health, prosperity and security.

Vannevar Bush

"Endless Horizons -1946"

SCIENCE & ENGINEERING

Scientists as Inventors

"Often considered distinct, engineering and science are frequently difficult to distinguish"

Henry Petroski, American Scientist, 2008, Vol 96, 368.

"The scientist seeks to understand what is : the engineer seeks to create what never was"

Theodore von Karman

Discovery : Penicillin

Invention : Light Bulb
Relativity

Innovation : Retail Store

Ideas

Translation

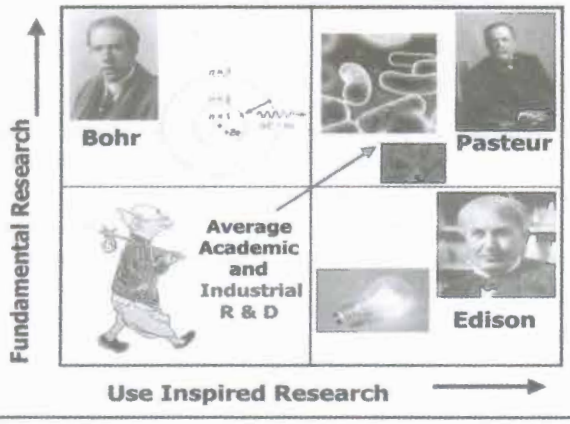
Development

Marketable Product

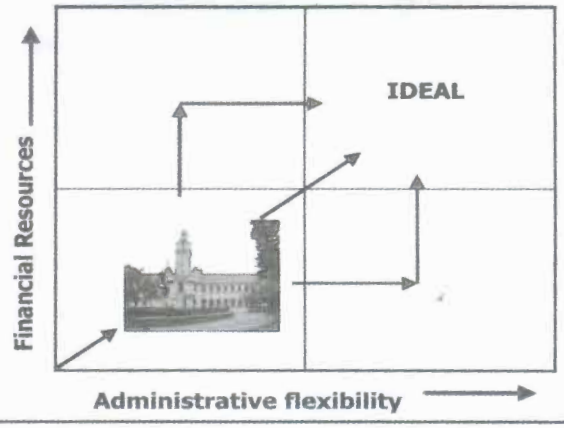
" Success in the laboratory does not always translate into success in the market place "

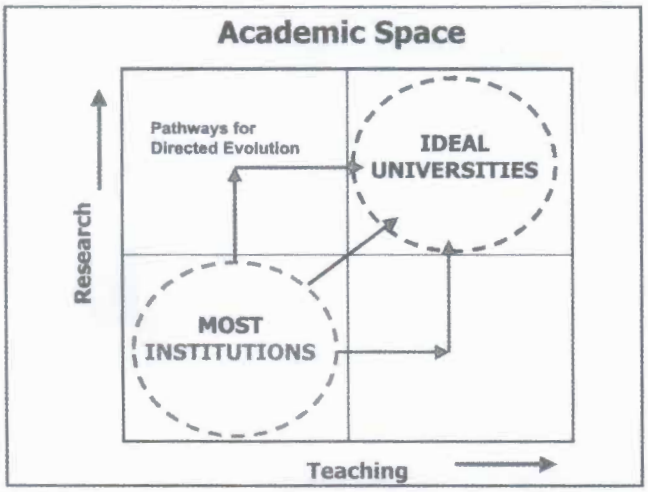
1997

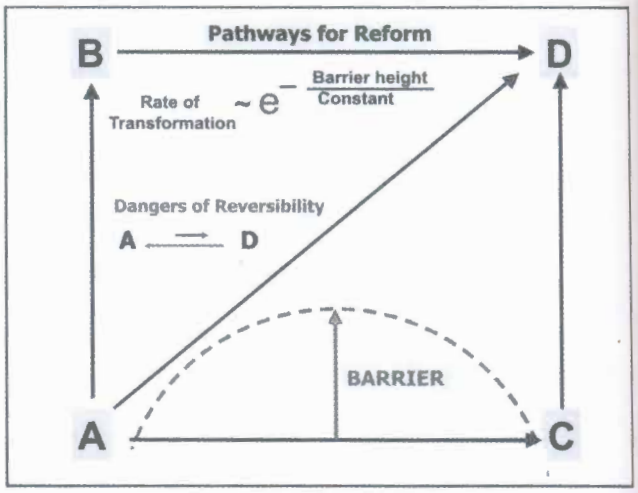
Pasteur's Quadrant

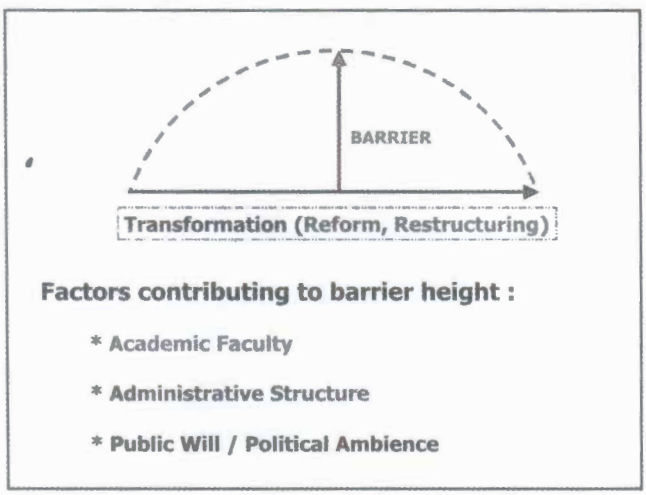


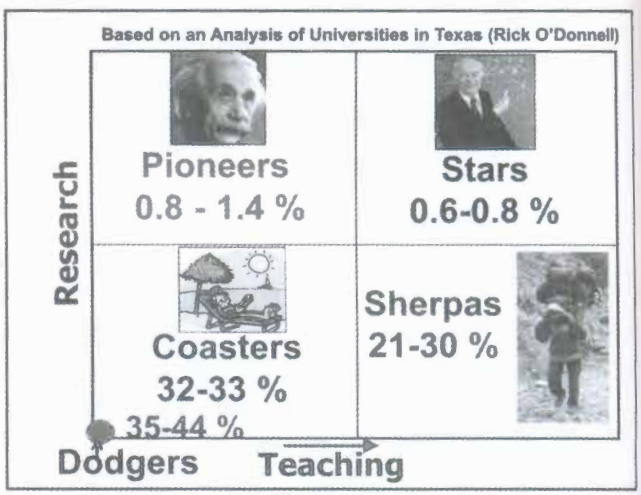
Extending Stokes Diagram











Those who can teach, should

Editorial, Nature Chemical Biology, Dec 2007, 737

Universities :	Teaching without Research
National Laboratories:	Research without Teaching

Role of Research Projects in Undergraduate and Postgraduate Education:

Writing and Communication Skills

" He who can, does; and he who cannot, teaches"

George Bernard Shaw on creative work

" Contrary to popular opinion, it is not usually the equations which need to be understood for the effective communication of science, it is the words. Literacy is important as well as being the door to the world of literature; why is it not taught to graduate students ?"

George Batchelor, Research as a life style, Applied Mechanics Reviews, 50, R11, 1997

Higher Education and Research in India

1857 Universities: Calcutta, Bombay, Madras
Training of graduates for government service

1876 Indian Association for the Cultivation of Science, Calcutta
Mahendralal Sircar (Father LaFont)
1913: C.V.Raman, 1928: Raman Effect

1896 J.N.Tata Endowment (Rs. 30, 00, 000)
Request to government: £ 5000 per year
Curzon on the Tata Scheme (1901): ".....appears to have no relation either to charity, or to suffering or to the Queen or to 300 million of India."

Deepak Kumar, *Ind. J. Hist. Sci.*, 19, 253-260 (1984)

1909 Vesting order for establishing Indian Institute of Science

Indian Institutes of Management (IIM)

- Student Selection
- Placement Performance
- Alumni
- Industry - Interface

Indian Institutes of Technology (IIT)

- Student Selection
- Undergraduate Engineering Education
- Post-graduate Teaching / Research
- Alumni ..... " Brand Equity"
- IIT Review 2004

Indian Institute of Science (IISc)

- Post-graduate Teaching / Research
- Science and Engineering
- Faculty Research Emphasis / PhD degrees
- Life Sciences

Indian Institutes of Science Education and Research (IISER) – Pune / Kolkata....

Undergraduate Science Education in a Research Ambience

Affiliated College:	Undergraduate teaching
Autonomous College:	Undergraduate and Postgraduate teaching
University:	Affiliation centre Postgraduate teaching Research
Research Institutions:	Postgraduate teaching Research
National Laboratories: (CSIR, DAE, ICMR, ICAR...)	Research
Deemed Universities:	Degree granting device
Deemed and Customized Universities:	Dept. Atomic Energy (DAE), Dept. of Space, Defence Research and Development Organization (DRDO)

Models

Research Universities

- Harvard, Stanford, Berkeley, Cambridge, Oxford .....
  Faculty and Student Scholarship

- Indian Models
  Kolkata, Madras, Delhi, Banaras, Allahabad .....

Pre-independence : Primarily Teaching

Post-independence :
1950s – 1960s —— Surge of Research
1970s —— Accelerating Decay of Research

- Specialist Institutions versus the Broad – Based Institutions

Small or Large ??

Creating an Ambience

- Governance
  - Institution Building
  - Consolidation
  - Expansion / Modernization
- Faculty / Student Performance
  - Evaluation
  - Carrot and Stick (Tenure and Rewards)
- Research Facilities
  - Funding
  - Development Corpus
- Promoting Scholarship
  - Academic Debate
  - Participatory Governance
  - Interdisciplinary Dialogue

Parameters of Institutional Performance

- Students Trained / Degrees Awarded
  Performance of Alumni
- Research Papers Published
  Impact
- Intellectual Property
  Patents / Technology Transfer
  Licensing / Royalty Income
- Resources Generated
  Magnitude of Corpus

The Role of Private Philanthropy
Public – Private Partnership

National Knowledge Commission Recommendations on Higher Education 2007

Expansion

* Create more Universities (1500 by 2015)
* New Regulatory Body (Oversee UGC, AICT, MCI, BAR Council .....)
* Increase Public Spending (1.5 % GDP / 6 %) Higher Education / Education Sector
* 50 National Universities

National Knowledge Commission Recommendations on Higher Education 2007

Excellence

* Reform Existing Universities
* Restructure Undergraduate Colleges: Autonomous Clusters
* Promote Enhanced Quality: Student Choices, Teacher Evaluation
* Salary Differentials

Inclusion

* Ensure access for all deserving students: (Needs – Blind admission) National Scholarship Scheme

Affirmative Action:

* Reservation
* Use of Deprivation Index

Action

* Reforms within Existing Systems
* Changes in Government Policies
* Amendments / New Statutes or Legislation

Issues

Faculty / Students : Recruitment Regional / National

Resources : State / Central

Governance : Autonomy Academic Responsibility

Challenges in Creating World Class Educational (Research) Institutions

- Enabling role of Government
- Organizational Imperatives
- Role of Academic Leadership
- Academic and Infrastructure Enablers to Identify and Foster Talent
- Governing Mechanisms
- Funding
- Indian Experience

Higher Education : Public or private ?

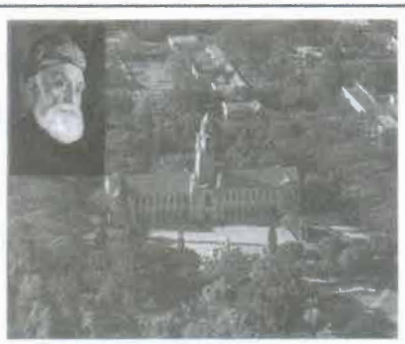
Research : Public Funding

Tata's request (1899) £ 5000 per year

↓

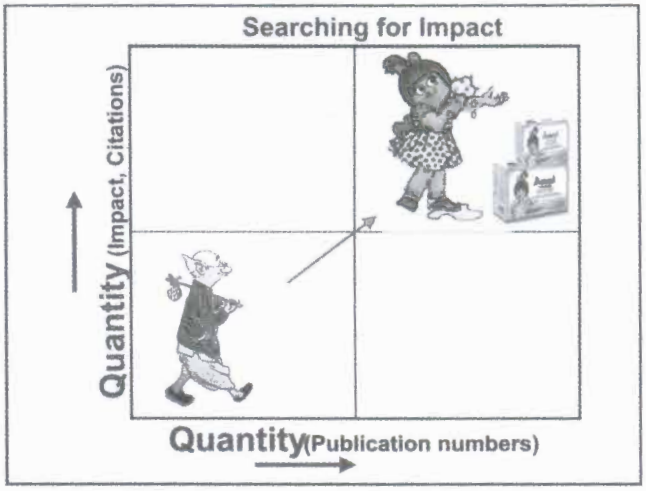
Curzon's response (1901)

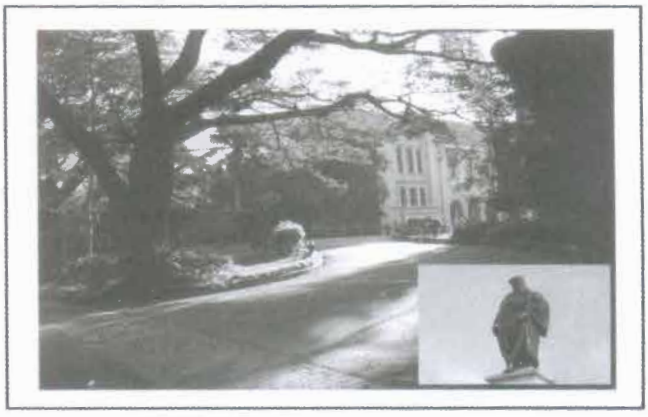
↓



"....Tata entirely owes it to me that he gets anything; and if he is not wise enough to accept it, I am ready to drop the whole thing tomorrow."

Deepak Kumar, *Ind. J. Hist. Sci.*, 19, 253-260 (1984)





Author

Email: diroff@admin.iisc.ernet.in

Prof Padmanabhan Balaram is an Indian biochemist and the director of the Indian Institute of Science in Bangalore, India.

Prof Balaram received his Bachelors degree in Chemistry from Fergusson College, University of Pune followed by a Master's degree from the Indian Institute of Technology, Kanpurand his PhD degree from Carnegie Mellon University with Aksel A. Bothner-By. After a postdoctoral stint at Harvard University with Nobel laureate Robert Burns Woodward, he returned to the Indian Institute of Science, where he has been ever since as a faculty member in the Molecular Biophysics Unit. During his PhD, Balaram studied the use of negative Nuclear Overhauser effect signals as probes of macromolecular conformations. As a postdoc with Woodword, Balaram worked on the synthesis of the antibiotic erythromycin.

Prof Balaram's main area of research has been the investigation of the structure, conformation, and biological activity of designed and natural peptides. To do this, he has extensively used techniques such as Nuclear Magnetic Resonance spectroscopy,Infrared spectroscopy, and Circular Dichroism, along with X-ray crystallography. He has been a major contributor to the evaluation of factors influencing the folding and conformations of designed peptides, and has investigated structural elements playing a key role in the formation of secondary structural motifs such as helices, beta turns, and sheets. Along with Isabella Karle, a frequent collaborator, he has also pioneered the use of alpha-amino isobutyric acid to induce and retain helicity and constrain peptide conformations.

Prof Balaram has authored more than 400 research papers, and is a fellow of the Indian National Science Academy. He was also a colleague of late Prof G. N. Ramachandran at the Molecular Biophysics Unit of IISc. He is presently the director of the Indian Institute of Science and is also the editor of the journal Current Science.

RAM LAL WADHWA AWARD LECTURES

Electronic Instrumentation and Control Systems for Agro-Based Industries

PAWAN KAPUR

Former Director & Outstanding Scientist CSIR-CSIO, Chandigarh

Keywords: Measurement techniques, instrumentation & control, agro-based industries

Although India is a leading nation in agri-production in several crops yet it comes under the hunger hotspots of Asia Pacific-Sub National level as per the published reports available on network. It is also estimated that the future requirement of food (peta calories/day) will be far more than in the past history. In order to make the agriculture and food processing sector sustainable one has to have optimum blend of economic profitability, social equity and environmental integrity.

Agrionics, a new branch making a convergence of agriculture & food sciences and engineering & technology to innovate and develop appropriate automation system for various applications in pre-harvest, post-harvest, storage/food processing and quality estimation of food stuff etc. The author has spent his major part of research career at Central Electronics Engineering Research Institute, Pilani (Rajasthan), a unit of CSIR in developing electronic instrumentation and control systems for key agro-based industries like sugar, tea, mushroom farming and has come out with several technologies & products backed up with IPR and quality publications. Subsequently he moved over to Central Scientific Instruments Organisation, Chandigarh, as its Director and guided various projects leading to technology generation and product design in the agro-based sector. The material presented here is a compilation of the work carried out by him and his colleagues under his guidance at the above two premiere institutions of CSIR. This work was presented before the august gathering during the annual technical convention held at Ahmadabad in September 2011. The author was honoured with the Ram Lal Wadhwa gold medal award followed by the special lecture, the highlights of which are described below through a series of slides/transparencies most of which are self explanatory while explanation is given on key research findings of the principal author.

Introduction

The scenario of worldwide hunger map, calorific requirements of future years and the sustainability aspects of the agro based sector are well known and reported in literature. Agro-based is a multi-facet activity (Figure 1) with the active involvement of several branches of sciences namely botanical sciences, genetic engineering, plant physiology, entomology, food chemistry, mechanical engineering, chemical technology, measurement sciences and instrumentation technology, electronics and information technology, etc. this makes the subject more interesting and demanding at one end while challenging at the other end due to large number of factors and faculties involved in the subject. Development of appropriate course content encompassing the research and relevant fields is yet another hindrance making with developments in this area mostly experienced and passion oriented. The work being interdisciplinary in nature also call for joint work based on the expertise created under one roof or pooled up across the institutions to tackle such issues of national relevance. The author has worked on few agro-based problems with active associations with the counterpart R&D institutions with a clear cut objective of technology generation leading to product design of relevance to the agro-climatic conditions. For instance, the work on sugar automation was done in active association with the National Sugar Institute, Kanpur, Vasant Dada Sugar Institute, Pune, National Federation of Co-operative Sugar Development, Sugar factories and the government agencies like Department of Information and Communication Technology, Department of Science and Technology. The work fetched several laurels including the prestigious CSIR - Technology Shield Award 1992 and a host of cups/medals by the sugar Technologists Association of India and the IETE. Highlights of work has been presented in the subsequent sections.

The work on tea automation was taken up in different phases; beginning with the support of Tea Research Association, Calcutta and subsequently on a much larger platform to design and develop a model tea factory at Tocklai Experimental Station , Jorhat with active participation by CEERI, Pilani, CDAC-Kolkata and TRA Kolkata and funding support from CSIR/DIT and Ministry of Commerce through its functionary unit Tea Board , Kolkata. The technology was developed to the User satisfaction and Commercialized, the highlights of which are outlined here.

Figure 1: Faculties involved in the agro sector

Instrumented precision farming programme was taken up jointly with Directorate for Mushroom Research(DRM), Solan a unit of ICAR and CEERI-Pilani under the funding support of DIT to develop monitoring and control systems for compost pasteurization and cropping house in quality cultivation of white button mushrooms with energy economization and enhancement of yield. The work is briefly outlined in the subsequent sections.

During my tenure as Director, CSIO, Chandigarh focus was given towards sensors and instrumentation systems for some of the key unit operations in Pre -Harvest (Soil conductivity mapping, soil moisture and temperature, photo synthesis rate, electrostatic flow nozzle, etc; post harvest systems (Pulsed electric field based preservation ,grading and sorting of food stuff ,storage automation for potato etc.) and quantification of quality based on instrumentation(tea, honey, etc). This work has been carried out by various researchers under my research guidance as the head of the national laboratory which had Agrionics as one of the strongest R & D activity which not only lead to quality publications but also a few product of relevance to the Indian agro-based industry. Highlights of work is outlined in the subsequent sections.

Electronic Monitoring and Control Systems

The technological aspects behind the research and development of electronic monitoring and control systems witnessed a phenomenal change over the last couple of decades. The analog part although dominated in the seventies gradually squeezed to a minimum level mostly cantered around the sensors for precision amplification and essential signal conditioning tasks to enhance the signal to noise ratio without affecting the dynamic response characteristics of the sensing device. Most of the other functions were progressively transformed into digital domain with its journey starting from microprocessors to the micro-controllers and ultimately directed towards the personal main frames computers in performing various tasks.

The hardware design went through various phases with the ultimate objectives of higher package density of gates, enhanced speed and memory, reduced power consumption and maximizing the number of instruction sets per second so as to handle complex tasks. Multi co-processors also appeared up in the scenario which could enhance the computational power of the CPU. Many advanced architectures also appeared which facilitated the pipe-lining of instruction sets and also provided the power of parallel processing so that multi-tasking under real time environment could be performed efficiently.

Software too went through many transformations providing flexibilities in the programming particularly with the incoming of MATLAB and LABView packages. Many web-based solutions gave more flexibilities to the system design leading to variety of problem solving situations.

The applications mentioned in this paper covered most of the above mentioned aspects of hardware and software design as per the desired specifications. These are highlighted in the subsequent sections while describing individual case studies.

Agrionics - Application Paradigm

Agrionics as such has several areas of applications but can be broadly be classified as Pre-harvest, Post-harvest, Informatics and quantification of quantity. Overview of the R&D work carried out is outlined below.

- Electronic Instrumentation & Control Systems for various critical operations in Agriculture and Agri-industries

- Work on Pre-harvest Instrumentation include:
  - Soil conductivity, moisture and salinity
  - Precision Farming:

  Monitoring & Control for white button Mushroom
  - Electrostatic Spray nozzles for pesticides
  - Photosynthesis Rate for crop health
- Post-harvest Instrumentation Systems include:
  - Grading & Sorting of Apples based on machine vision
  - Storage under controlled Environmental conditions
  - Electric-pulsed based Pasteurisation system for Liquid Foods
- Food Processing Automation Systems For
  - Sugar Industry
  - Tea Industry
- Quantification of Quality
  - Tea Quality
  - Adulteration in Honey
  - Pesticide detection

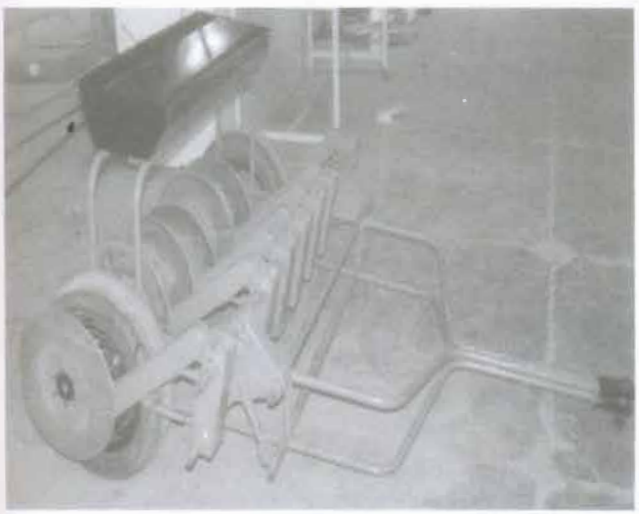


Figure 2a: Soil mapping system

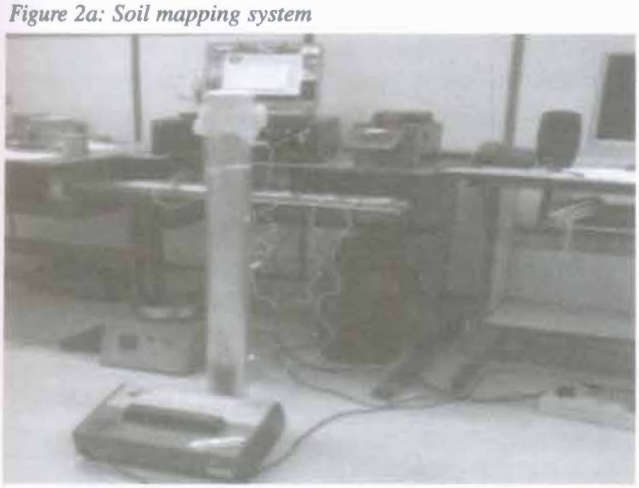


Figure 3: FBG based experimental setup and results obtained on moi...

- Academics

  M.Tech level Programme on Agrionics- AcSIR

4. Instrumentation for Pre-harvestoperations

4.1 Soil multi-parameters mapping system

The soil conductivity monitor development at CSIO was based on 4-probe principle with multiple probes dynamically configurable and having variable excitation pattern. This instrument helped in spatial distribution of soil physico-chemical properties on site-specific manner. Figures 2a give the typical configuration of measurement setup while some of the results obtained are depicted in Figure 2b along with the statistical correlations established. Using Fiber Bragg Grating sensor fabricated in the laboratory temperature and moisture measurement of soil has been carried out across the field depth. The experimental setup and results obtained are depicted in Figure 3.

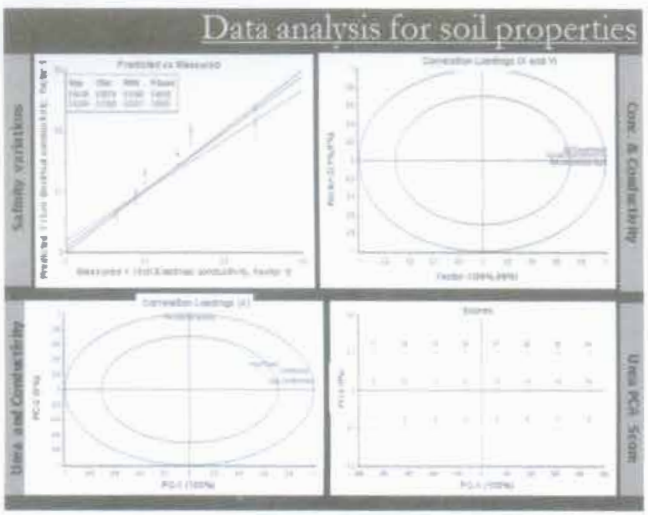
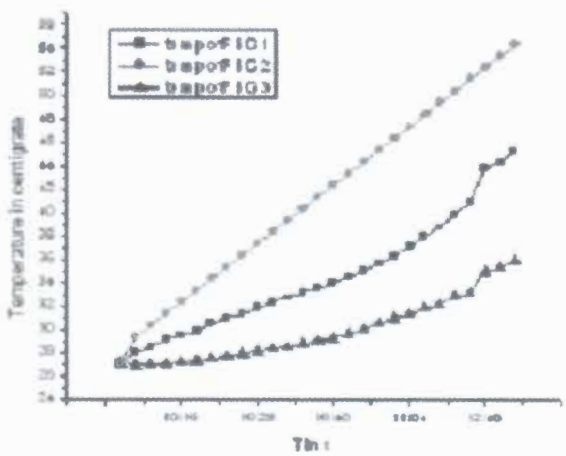


Figure2b: Results obtained on different soils parameters



4.2 Photosynthesis Rate Measurement

Plants convert carbon dioxide into oxygen and glucose in the presence of water vapours (humidity) and sunlight (E=h) for generation of its food for growth. The rate kinetics of this process carried lot of information about the growth rate of plant and hence its health. The photosynthesis rate measuring setup developed in the laboratory along with the results obtained is depicted in Figure 4. Various parameters considered were leaf area, leaf moisture, air humidity, oxygen/carbon dioxide concentration to work out the expression for estimating the photosynthesis rate. Such type of measurements are very helpful in green houses/nurseries for cultivation of medicinal and ornamental plants under controlled environmental conditions.

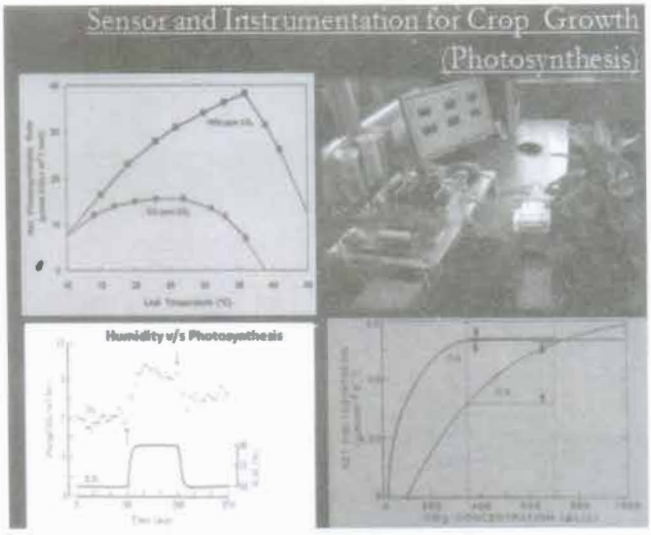


Figure 4: Photosysnthesis rate measurement

4.3 Electrostatic Nozzle For Agricultural Applications

Usually the pesticides are mixed with the irrigation water and spread over the crops by any of the conventional techniques which usually result in excessive use of chemicals and are wasted in the field ultimately mixing up with the water table. An innovative technique was developed in the laboratory using an electrostatic nozzle which was subjected to a high voltage supply to create an electrostatic field pattern thereby creating a cloud of charged spray particles forming a large canopy and getting attached to both the sides of the crop without either hanging in space or falling on the ground due to the changed nature of droughts. The working principle, design layout and the fabricated part of the device are depicted in the Figure 5.

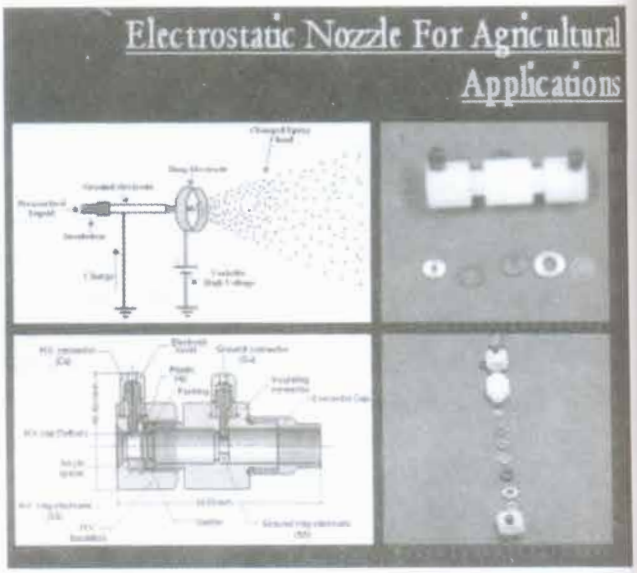


Figure 5: Electrostatic nozzle- principle and components

Instrumentation for post-harvest operations

5.1 Grading and sorting system for agri-produced

Grading of food stuffs is another important application of instrumentation is where imaging techniques backed up with classification methods can be applied for automatic sorting applications. Figure 6(a) is a scanner based rice grading system which works on the image processing technique to acquire data ultimately to classify rice in terms of size, shape, colour and size distribution acceptable for quantification of quality. The unit has been extensively been tested on a variety of rice samples. Figure 6(b) describes the automatic grading of apples as per its size, shape, colour and dry substance. Apples coming through the hopper are sequentially spread on the grooved conveyor belt where each apple is weighted through a load cell fitted on the belt system. The apple train then enters the Illumination chamber where 6 photographs are taken per rotation of the apple and image processing techniques are applied for size, shape and colours. Knowing the weight and volume of each apple its density is calculated on-line. NIR-based sensors are placed to know the spectral reflectance/ absorbance characteristics at two different wavelengths to know about the dry substance and the sugar content thereby completing the entire grading and sorting exercise automatically. The system was developed jointly by CSIR-CSIO, CSIR-CMERI and CSIR-CEERI and extensively tested for long term field applications.

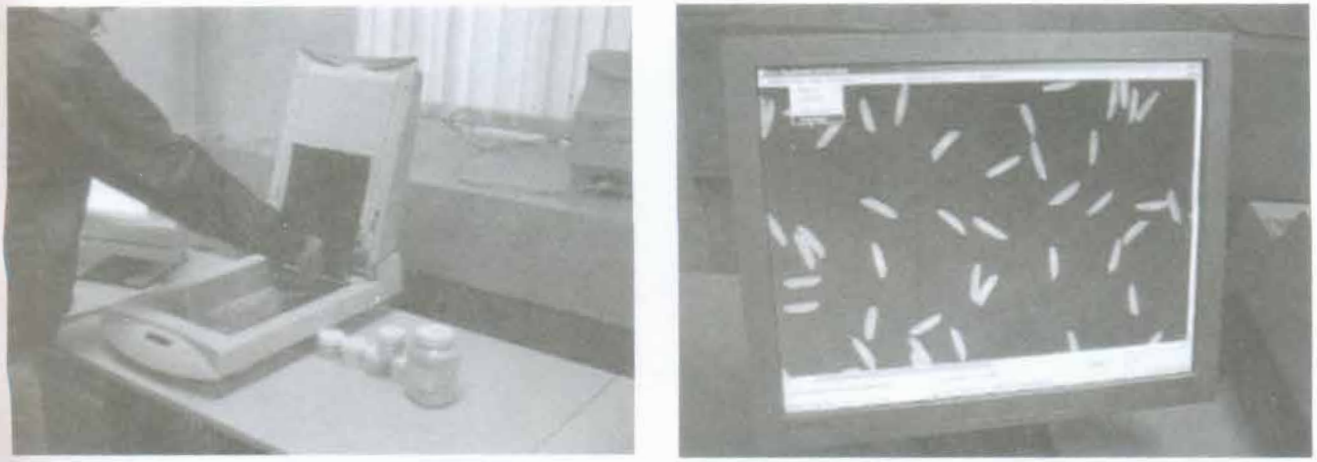


Figure 6a: Rice grading and classification system

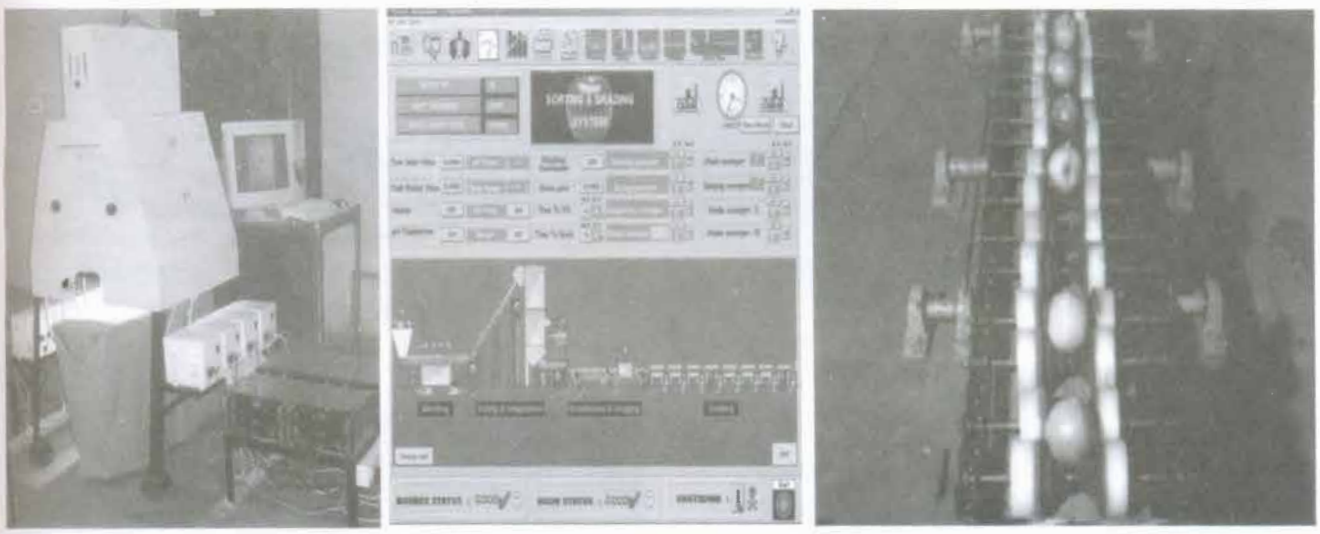


Figure 6b: Grading and sorting system for apples

5.2 Storage Automation System for Potatoes

Potato is a three month crop and has to be stored for the remaining 9 periods in cold storage under controlled environment of relative humidity, temperature, CO_2 production, aeration (O_2) across the storage chamber, etc. There being several varieties of potato each one requiring a specific set of parameters for efficient storage with quality preservation .Storage at elevated temperatures of 12-13^0 C under permissible chemical fumigation treatment can lead to enhanced shelf life thereby leading to significant energy saving. The project was jointly carried out by CSIO and Central Potato Research Institute (ICAR) Shimla and the technology is now being up scaled for commercial level trials. Figure 7a shows the schematic of 4 cold storage chambers where 4 different varieties of potatoes were simultaneously stored for elongated periods with the climate in each chamber automatically regulated by the individual Air Handling Unit on the basis of sensing of process variable such as temperature of potato, ambient temperature, relative humidity of air, moisture content, O_2/CO_2 ratio, etc. Figure 7 b & c indicate changes in reducing colour and the potato chip colour against the number of days of storage for three different temperature ranges around 4^{0}C, 8^{0}C and 12^{0}C. One can easily conclude that the storage at elevated temperature could be possible for achieving energy conservations by maintaining controlled conditions of environment inside the chamber. On can easily see that parameter settings play a key role in the quality of product for best possible results.

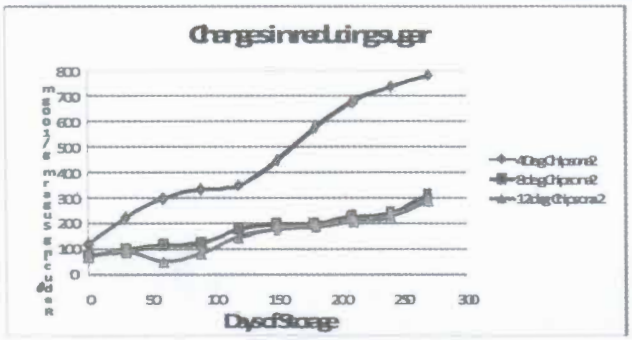


Figure 7: Controlled atmosphere storage of potato and results obtained

5.3 Pulsed Electric Field Based Pasteurization

The conventional thermal based pasteurization techniques commonly adopted in agri-products like milk are not only energy inefficient but also affect its characteristic behavior including the quality attributes. One of the emerging techniques in pasteurization is based on pulsed electric field applied over a short duration in juices/milk to kill unwanted microbes without affecting the quality parameters such as vitamins/energy ingredients. One need to optimize the spatial and temporal components of electric field as per the pH/electrical conductivity of slurries/liquids as per the targeted microbial activity. The system developed at CSIO will opened up new avenues in the pasteurization of agri-produce contributing significantly in energy saving and quality preservation. The research work carried out in the laboratory has been published in reputed journals and also presented at important food science seminars/ conferences in the country.

6. *System Oriented R&D leading to Technology Utilization for the Indian Sugar Industry*

During the eighties an ambitious program was taken up at CEERI-Pilani for the modernization of Indian Sugar Industry through the interaction of electronic monitoring and control Systems specifically developed for the Indian conditions of direct consumption plantation white sugar production.

The work was carried out in the laboratory in active collaboration with various institutions like NSI, Kanpur, VSI, Pune, Sugar Factories and supported by various sponsoring agencies in the Government and Private Sectors. Some of the specific outcomes of the project are outlined below:

- Microprocessor based pH control system for juice clarification process
- Microprocessor based Pan Monitoring System

- Microprocessor based 100 Point Temperature System
- PC-based Fuzzy logic control system for Sugar crystallization process

Technologies : 7

Products : 6 (main), 8 (spin-off)

Sugar Factories where Trials were conducted : 25

Specific Benefits Incurred:

- Energy Conservation : 25%
- Increased Throughput : 25%
- Process Optimization
- Reduction In Sugar Losses

Figure 8 and 9 depict some of the photographs/results obtained at different Sugar factories based on direct digital control, model based control and Fuzzy logic control for the Sugar Crystallization process which bagged several awards, honours and recognition at the national & international levels.

Figure 8: Sensors and Transducers installed at low grade vacuum pans of sugar industry

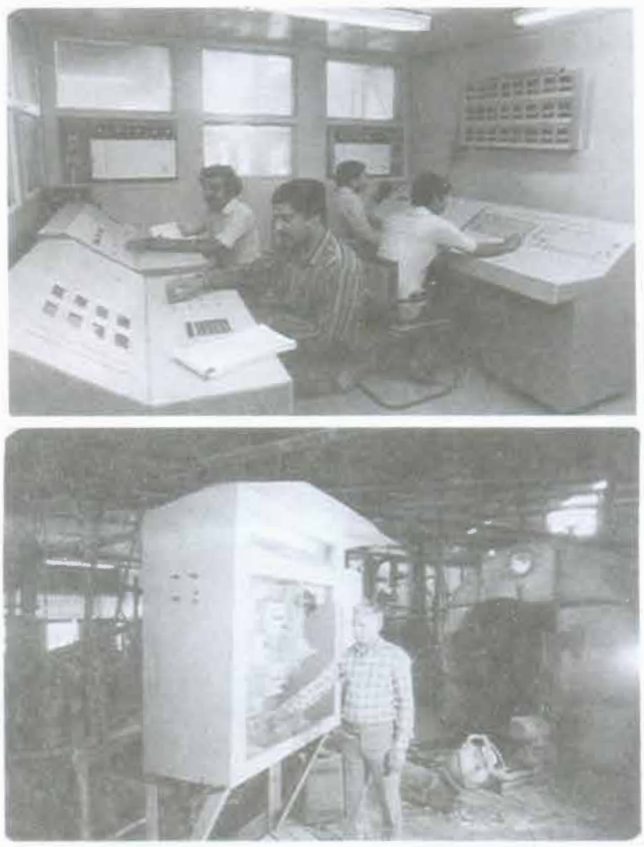


Figure 9: Transmitters and system installed at central control room at Anoop Shehar, Sugar Mills, UP

Automation in Indian Tea Industry

Although quality aspects in tea are developed in the bushes but the quality tea production depends heavily on the style in which the green leaf is processed in different unit operations. Various process steps involved in the black tea manufacturing include: withering, rolling (orthodox tea), rotor vane/CTC mechanisms (CTC tea), fermentation, dying, grading, sorting and packaging. Withering is the most critical step in manufacturing because it sets a pace for enzymatic reactions to proceed at optimum rate in such a way that at the end of the process physical wither (physical conditioning of the leaf) and the chemical wither (enzymatic reactions producing the desired level of bio-chemicals responsible for quality attributes) end up concurrently.

The initial work was taken up for the tea withering automation and subsequently towards the setting up of a fully automated model tea factory. The earlier work was carried out by CEERI-Pilani under the financial support of Tea Research Association (TRA) and the technology was fully commercialized. The subsequent work was

taken up jointly by TRA (for modern machines), CDAC-Kolkata (for computer interfacing) and CEERI-Pilani (monitoring and control systems for various units operation) and the entire project was jointly supported by Ministry of Commerce (Tea Board), CSIR and DIT.

Figure 10 presents an overview of model tea factory established at the Tocklai experimental station, Jorhat along with the instrumentation aspects and the associated sensors and control systems.

For small tea growers, one need to have an integrated environmentally controlled manufacturing system where quality tea can be processed at small volumes. Figure 11 shows the typical configuration of such processing unit which can help farmers having small holdings which contribute to about 28 % of the country's total tea production which is significant. Such a system has a direct relevance to the rural development as small tea cultivators are scattered across the country (Himanchal Pradesh, Uttarakhand, North East States and Southern regions in Nilgiris).

Figure 10: Model tea factory at TES Jorhat and its sub-sections

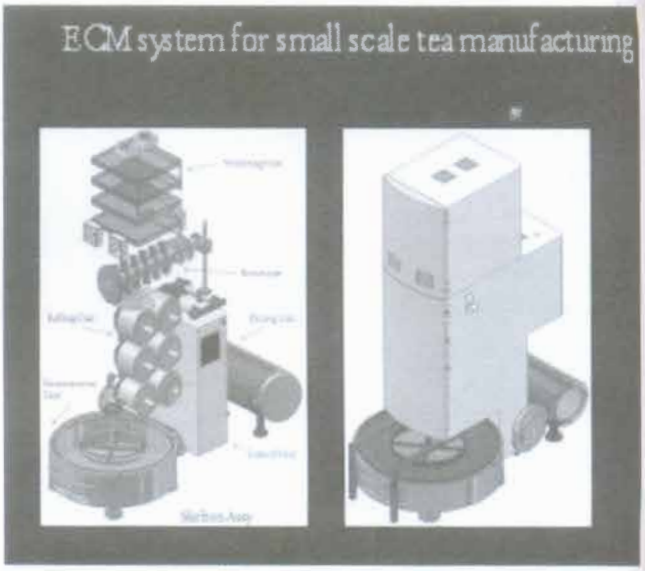


Figure 11: ECM machine layout

Quality Assessment through Machine Intelligence-Quantification of Quality

All foods are ultimately tested by the users as per their taste habits thereby making a product acceptable in the market. Quality being a highly subjective parameter, efforts are continuously being made to evolve quality standards, figure of merit of quality, quality score, etc using instrumental methods of analysis. CSIO has been focusing on evolving innovative transduction techniques and instrumentation based thereupon for the quantification of quality. Specific case studies on quality assessment of tea, honey and pesticide estimation have been briefly touched upon in the article along with the specific results obtained.

8.1 Tea Quality Parameters

Physical parameters	Chemical/Biochemical parameters	Techniques
Shape and Density	Taste	Multi array non specific sensors
Colour	Aroma	PCA / Pattern recognition
Brightness	Moisture	Digital Imaging

The physical parameters essentially involved are colour, size and texture which are estimated using image processing. Figure 12 describes the vision system developed in the laboratory. The other supporting parameters being moisture content and liquor-colour.The bio-chemical parameters describing the quality aspects are too many but to a greater degree of approximation key parameters identified were polyphenols, total oxidisable matter, water soluble substance, caffeine content, etc. Although exact quantification can be made using HPLC/GLC but these are analytical techniques which requires offline analysis and are unfit for in-situ applications. Various approaches were followed towards innovative materials which could be used for sensor development such as conducting polymers along with statistical analysis techniques for feature extraction. A novel technique of impedance tongue was used to estimate the taste part using societal mathematical models for sensor fingerprint identification. The sensor developed and the computational intelligence for optimum classification is shown in Figure 13.

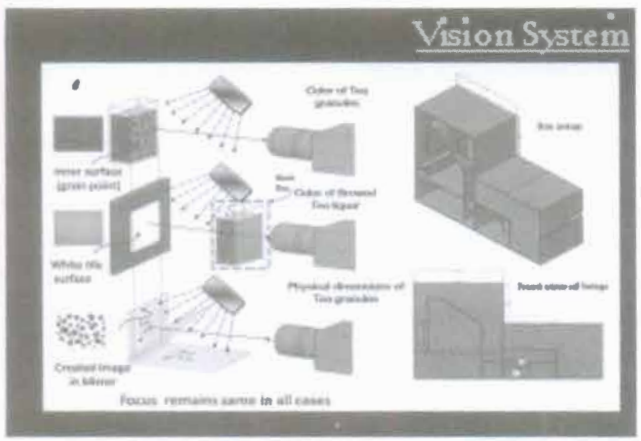


Figure 12: e-Vision System

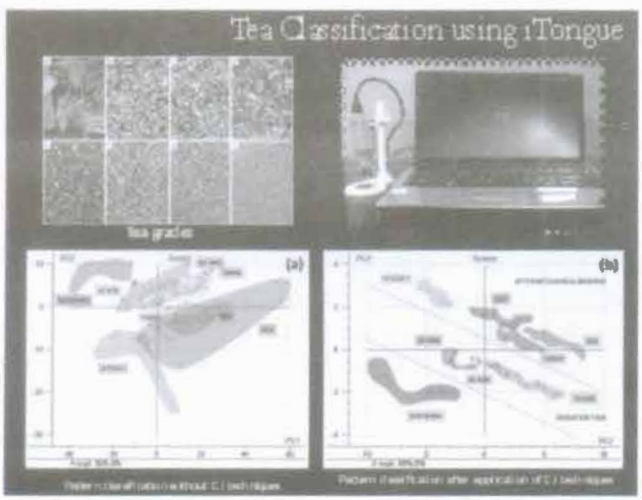


Figure 13: e-Taste System

8.2 Quality assessment of Honey

Honey is an important energy food apart from its extensive use in ayurvedic medicines. There are cases of adulteration reported in honey by mixing with cheap sugar/ jaggary and suitably matching the rheological properties. One therefore requires to know about the purity of honey by having a quick assessment of its quality attributes. The biological/genetic aspects in honey need elaborate measurement system but the physical properties in terms of conductivity, brix and NIR spectroscopy can help in the quick assessment of the quality. Figure 14 shows the technological pathways for the assessment of the quality of honey in terms of adulteration levels.

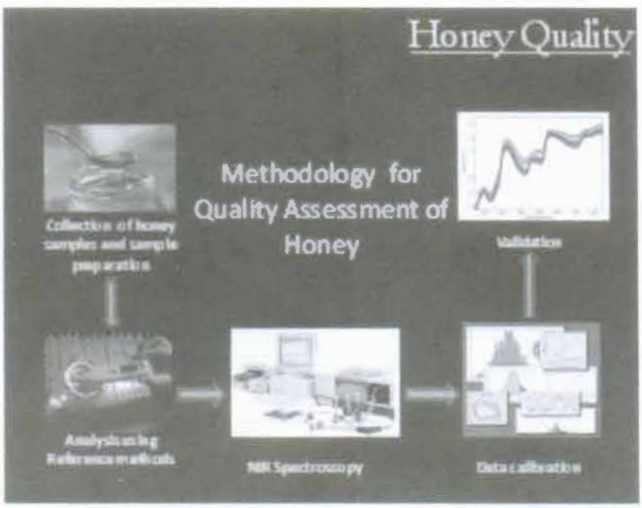


Figure 14: NIR techniques of quality assessment of honey

8.3 Pesticide detection using Fluorescence Techniques

Excessive use of pesticides in the fields often leads to the penetration into the food chain causing several hazardous effects. The challenge in measurement lies in the lower level of concentrations usually in ppb levels. One of the techniques commonly used is a bio-marker based which forms a bond with the pesticides at a specific pH level causing fluorescence affect which can be detected easily. Figure 15 a shows the experimental setup for pesticide detection using fluorescence studies which Figure 15 b depicts the emission spectra of fluorescence in Isothiocyanate (FITC) at different concentrations showing a linear relationship between intensity versus concentration that helps in the estimation of pesticides in the food stuffs. However, each type of bio-chemical based pesticide/insecticide would call for a matching bio-marker for the bonding to take place at the optimum pH range for best sensitivity.

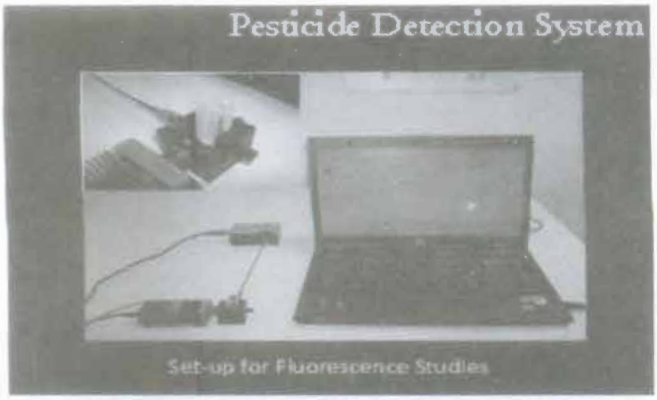


Figure 15a: Pesticide estimation system

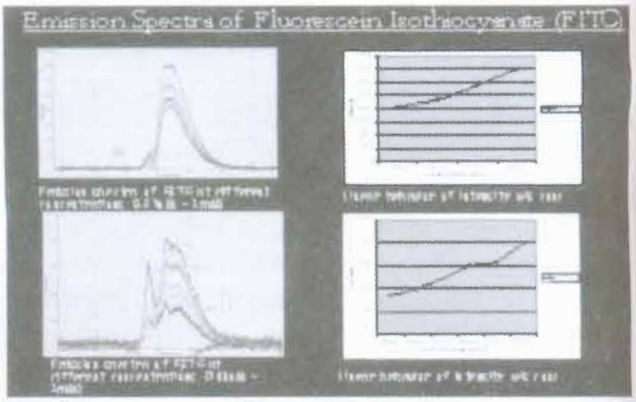


Figure 15b: Results obtained on FITC detection

Conclusions

The research work carried out by the author over the last more than 2-decades at two of the premier CSIR laboratories namely the CEERI-Pilani and the CSIO-Chandigarh has been briefly described here and was presented during the award ceremony of Ram Lal Wadhwa Award Lecture held in September, 2011 at Ahmedabad. On the basis of long experience of the author in the area of Agrionics, a trans -disciplinary area of research involving agricultural sciences and engineering & technology, were developed innovative products of relevance to the Indian agro-based industries which is employing major part of the Indian population which is mostly spread in the rural areas. Although India leads in many agri-produce in the world yet it in able to convert only 2% of its agricultural output into processed foods which is a behind the figures of 60-68% achieved in many developed nations.

Although significant progress has been witnessed in agricultural sciences including soil mapping, advanced cultivation practices, tissue culture and green house technology, genetic engineering, plant pathology, precision farming, etc but the area lacks heavily in engineering aspects in terms of agri-appliances, processing machinery, quality assessment gadgets and ICT based applications for integrated crop management through imaging and forecasting techniques for preventive measures. Food processing industry is coming up fast but it is mostly dominated by imported technology which are normally perfected on the crop as per the agro -climatic conditions and the varietal aspects prevailing in the host country making technology implantation bit difficult in the Indian scenario due to research gaps between the two countries.

The subject of food technology is catching up fast with the deep involvement of food chemistry, biological pathways, etc. after the establishment of Ministry of Food Processing Industry. The subject is therefore gaining impetus attracting several young researchers. Department of Biotechnology has already set up national Agri-Food and Biotechnology Parks to strengthen the research in this direction. Department of Information and Communication Technology and Ministry of Science and Technology have already given emphasis on the electronic sensors, devices and systems with particular reference to Agri and Food processing. ICAR has been long in this field and also encouraging trans-disciplinary areas of research.

Subsequently, the author gave impetus to Agrionics activities at CSIO-Chandigarh and specifically created Food Processing Instrumentation Laboratory, Analytical Instrumentation Lab for characterization and ubiquitous Measurement Facilities to strengthen research and innovative technology generation.

The author is of firm believes that new trans-disciplinary course curriculums at the M.Tech level need to be framed up and offered for quality manpower generation. One of the significant achievements has been the establishment of Academy of Scientific and Innovative Research (AcSIR) which is supporting post graduate programme in Engineering. CSIO is offering an M.Tech level course in Advanced Instrumentation Engineering with specialization in Agri-Control Systems. The author

has been involved in teaching assignments in broad subjects of sensors, devices & circuits, agricultural control systems, biological control systems, etc. The areas mentioned in this article are being researched further by PhD scholars in evolving end-to-end solutions for societal benefits.

Author wishes to thank the Institution of Electronics and Telecommunication Engineers (IETE) for considering him for the prestigious Ram Lal Wadhwa Award for the year 2011 and the special lecture delivered on a function organized during the IETE-Annual Technical Convention held in September 2011 at Ahmadabad. The author also wishes to thank all his colleagues, research scholars and student at CEERI and CSIO during the course of R&D work pursued under his guidance over these more than two decades.

Finally the author would like to end with a quote ***"there are people in the world so hungry, that God cannot appear to them except in the form of bread"***- M.K.Gandhi.

Author :

Email:drpawankapurchd@gmail.com

Dr Pawan Kapur, Distinguished Emeritus Professor of CSIR Academy of Scientific & Innovative Research (AcSIR), is the Former Director of Central Scientific Instrument Organisation (CSIO) Chandigarh, a constituent Laboratory of the CSIR, New Delhi. He is MTech & PhD from the Institute of Radio Physics & Electronics, University of Calcutta in Control Systems & Digital Techniques and Bio-medical engineering respectively.

He was earlier at CEERI-Pilani for about 30 years where he worked on Instrumentation & Control Systems for various Agro-Based Industries. He developed 17 products, 5 patents and has about 75 research papers in referred journals & more than 100 research papers in the Conference proceedings.

Dr Kapur has been instrumental in restructuring R&D structure of CSIO and has guided various prestigious projects in the Strategic Sector and Societal Applications such as health, agro-based and public utilities & safety, etc. He has setup many advanced research Labs such as Photonics, Advanced Optical Metrology, Virtual Instrumentation, GAIT-Lab, Food Processing Instrumentation Lab, etc.

He is a recipient of several prestigious awards which include: CSIR-Technology Shield-1992, 7th Hari Ram Toshniwal Gold Medal-1995, Sugar Cup Medal 1993, 1997, 1998, Noel Derr Gold Medal 2004, Anusandhan Vibhusan 2006,etc.

He is a member of various professional Societies. He was on deputation to countries like Germany, France, Australia, UK, USA, Brazil, Hungary, Singapore on projects related to Advanced Measurement Sciences & Instrumentation Technology.

Dr Kapur has been the Adjunct Faculty Member of BITS-Pilani, BESU-Shibpur Calcutta University and CSIR-PGRPE programme.

He has been the Chairman of IETE-Pilani Centre and IETE Chandigarh Centre, where he organized successful Mid-term Symposia of the institution. Currently, Dr Kapur is IETE Zonal coordinator of North Region.

His main areas of research have been Sensors & Systems for pre-harvest & post-harvest instrumentation, intelligent machine for quality estimation, Food Safety, Advanced Signal Processing & Electronic Perception Analysis.

Morphological Algorithms for Image Processing

BHABATOSH CHANDA
Image Processing Laboratory, Electronics and Communication Sciences Unit, ISI, Kolkata

Mathematical morphological operators are based on set theoretic approach and are suitable for extracting shape information. Some important operators are dilation, erosion, opening and closing. Image intensity profile may be viewed as a topographical surface, where pixel co-ordinate stands for the location and the intensity for the altitude. Thus, the surface relief and slope represent different types of object features. Hence, morphological tools are found very effective for image processing. In this paper we discuss various image processing algorithms using morphological tools and the results obtained by applying them on both grayscale as well as colour image.

INTRODUCTION

Human decision-making system depends on the information acquired from the environment. A major part of such information is visual in nature. Thus majority of automated decision-making or pattern recognition system are usually supported by some image processing techniques [1]. Image processing methodologies even also act as an aid to human expert by improving the quality of the viewed image. In the modern technology driven society, image processing techniques have proved themselves essential in image display, storing, retrieving, knowledge extraction as well as inference drawing. The techniques are; in general, categorized as image compression, quality improvement, segmentation, feature extraction, and scene analysis and understanding. An image processing system acquires information from 3-d objects or scenes, processes the acquired information, and builds knowledge about the viewed object or scene. A typical system acquires data employing suitable sensors, and processes them using standard image processing methodologies. Though the human visual system is more efficient than the computer vision system in terms of precision, speed of operation and accuracy, there are situations, like routine tedious job, hazardous environment, quantification of information etc., where the employment of image processing system is an acceptable solution. Secondly, human vision system depends solely on the eye in visualizing the objects, which is band-limited; on the other hand, computer vision system may employ various sensors (e.g., x-ray, infra-red ray, ultrasonic) with different ranges of visibility. As a result, image processing techniques have found numerous applications in the area of defense, medical science, remote sensing, natural resources management, disaster management, office automation, industrial automation, criminology, astronomy, and so on.

Image processing tools are developed in both spatial domain as well as frequency domain. Frequency domain tools rely on the transformation of image by some orthogonal transformation like Fourier transform, Cosine transform or Wavelet transform and all processing is done in the transform domain. In spatial domain, the image processing tools operate directly on the pixel value in the image. A relatively new kind of spatial domain operators, known as mathematical morphological operators [2], is being widely used in image processing. These operators are defined based on the concept of set theory. The main advantage of mathematical morphology is that it treats an image as a set, unlike the conventional operators including both spatial domain and frequency domain operators that treats an image as two-dimensional signal, Morphological operators, thus, can directly deal with the shape information with the help of a structuring element, which may be viewed as a probe. Morphological algorithms closely resemble the human strategy of image understanding, as both of them are neither fully subjective nor fully objective, but a judicious combination of the two. In mathematical morphology, the operations are precisely defined but the selection of structuring element is an ad-hoc process and deepens on the application and the data.

In this work we present a generalized mathematical morphological framework for image processing and then

show the application of this framework to various image processing problems with the help of suitable tuning. This paper is organized as follows.

Section 2 describes the preliminaries of mathematical morphology including multi-scale morphology. Morphological algorithms for various image processing problems and corresponding results are shown in section 3. Finally, brief discussion and concluding remarks are presented in section 4.

MATHEMATICAL MORPHOLOGY

Morphological operators are primarily binary operators that are defined on some set or object (an image or part of it) using another set, called the structuring element. We may classify images into two groups: (i) two-valued or binary images, and (ii) multi-valued images, which include gray level and colour images. In binary images the pixel value is either 0 or 1. In gray level images, the pixel value may be any integer between 0 and some high value, say, L-1 inclusive. Colour image is further extension of gray level image where the value at each pixel is represented by a vector of three elements corresponding to red, green and blue components of colour information. In other words, a colour image is comprised of three gray level images each corresponds to red, green and blue components respectively. Accordingly, morphological operators may be grouped as binary and grayscale morphology.

2.1 Binary Morphology

In case of binary image, the object may be formed as a set of point (Fig 1):

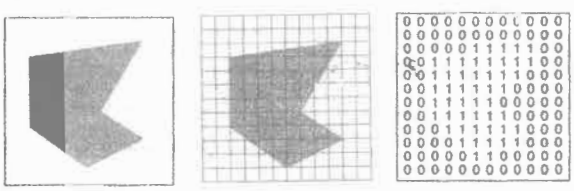


Fig 1 Binary image and the point set used for morphological treatment

$$A = \{(r,c) \mid f(r,c) = 1\} \quad (1)$$

where f (r,c) is the value at pixel (r, c). Most elementary operations are dilation and erosion which may be defined with the help of more primitive operations union and intersection as

$$\text{Dilation: } A \oplus B = \{a+b \mid a \in A, b \in B\} = \cup_{a \in A} B_a \quad (2)$$

$$\text{Erosion: } A \ominus B = \{a \mid B_a \subset A\} \quad (3)$$

It may be noted that the dilation inflates an object, whereas erosion shrinks the object. In other words, what dilation does to the object erosion does to its complement or background. Two more useful operations, namely Opening and closing, are defined in terms of dilation and erosion as follows

$$\text{Opening: } A \circ B = (A \ominus B) \oplus B \quad (4)$$

$$\text{Closing: } A \bullet B = (A \oplus B) \ominus B \quad (5)$$

Opening retains only those parts of the objects that can fit in the structuring element. That means it removes, from the object(s), small components and isthmuses. Closing fills up small holes and gulfs. Thus they both can extract fine shaped features that are narrower than the structuring element.

2.2 Properties of mathematical morphological operators

A mathematical operator T on A by B, denoted by $T(A, B)$, may be analyzed in terms of following properties:

Increasing: $A \subset B \Rightarrow T(A,C) \subseteq T(B,C)$

Idempotent: $T(T(A,B),B) = T(A,B)$

Associative: $T(T(A,B),B) = T(A, T(B,B))$

Extensive: $T(A,B) \supset A$

Anti-extensive: $T(A,B) \subset B$

Commutative: $T(A,B) = T(B,A)$

Distributive: $T(A \otimes B, C) = T(A,C) \otimes T(B,C)$, where $\otimes$ is a binary operator.

Hence, we can summarize that dilation is increasing, commutative, associative, distributive over union, and extensive if structuring element contains the origin (0,0). Erosion is increasing, distributive over intersection, and anti-extensive if structuring element contains the origin (0,0). Opening is increasing, idem potent and anti-extensive. Closing is increasing, idem potent and extensive. Dilation and erosion are dual. Similarly, opening and closing are dual, and they are filters too.

2.3 Grayscale morphology

In grayscale morphology, a graylevel image (Fig 2a) is considered as a topographic surface (Fig 2b). Thus, the object or the set of points may be defined as a set of triples:

$$A = \{(r, c, f(r, c)\} \quad (6)$$

So the two-dimensional representation of the binary morphological operators can simply be extended to three-dimension to define the grayscale morphological operators. Thus we have the grayscale morphological operators as

$$\text{Dilation: } (g \oplus h)(r,c) = \max_{(m,n)}\{g(r-m,c-n)+h(m,n)\} \quad (7)$$

$$\text{Erosion: } (g \ominus h)(r,c) = \min_{(m,n)}\{g(r+m,c+n)- h(m,n)\} \quad (8)$$

$$\text{Opening : } (g \circ h)(r, c) = ((g \ominus h) \oplus h)(r,c) \quad (9)$$

$$\text{Closing: } (g \bullet h)(r, c) = ((g \oplus h) \ominus h)(r,c) \quad (10)$$

where $h(r, c)$ is the structuring element and the corresponding set may be defined as $(r,c,h\ (r,c))$. After processing, the graylevel image is generated from the set of points by taking the top surface of it, i.e. in practice, by considering only the third element of the triplets.

In many applications $h(r,c)$ is zero for all (r,c). In that case, we can omit $h(r,c)$ from the definition of grayscale morphological operators as well as from the grayscale structuring element. Then the structuring element becomes a two-dimensional one, i.e., only the domain of structuring element is important. So the structuring element is degenerated to B, where $h(r,c) = B = \{(r,c)\}$ and we have

$$\text{Dilation: } (g \oplus B)(r, c) = \max\{g(r - m, c - n) \mid (m, n) \in B\} \quad (11)$$

$$\text{Erosion: } (g \ominus B)(r, c) = \min\{g(r + m, c + n) \mid (m, n) \in B\} \quad (12)$$

$$\text{Opening : } (g \circ B)(r, c) = ((g \ominus B) \oplus B)(r,c) \quad (13)$$

$$\text{Closing: } (g \bullet B)(r, c) = ((g \oplus B) \ominus B)(r,c) \quad (14)$$

This is known as function-and-set processing scheme. As the grayscale morphology is an extension of binary morphology, the corresponding grayscale morphological operators satisfy all the properties stated in section 2.2. Please note that opening clips the bright peaks and closing fills the dark pits. This observation is utili7ed in designing morphological algorithms for image processing.

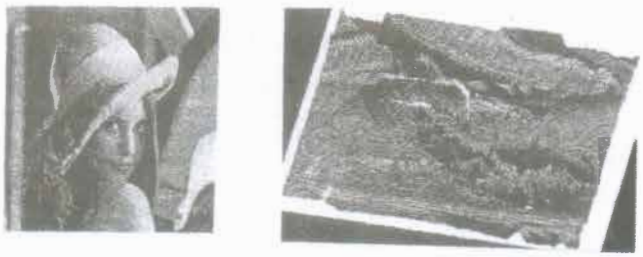


Fig 2 (*a*) Graylevel image, and (*b*) corresponding topographic surface

2.4 Multi Scale Morphology

So far we have considered only the shape property of the structuring element, say, *B*, Sometimes we need to use structuring elements of same shape but of different sizes to deal with shape features in an image at different scale. To achieve this we need to incorporate a size parameter n in the representation of structuring element. Suppose, in the continuous domain, $B = \{(r, c)\}$ is a compact point set of size one. Then

$$nB = \{nb \mid b \in B\} = \{nr,nc)\}$$

is a set of size n> 0. It may be assumed that $nB = \{(0,O)\}$ when $n = 0$. In the discrete domain, simple multiplication of coordinates leads to many holes in *nB*. So we need to define *nB* in a slightly different way as follows. If *B* is a convex compact set, then

$$nB = B \oplus B \oplus B \oplus ...(n\text{-}1) \text{ times}$$

for n = 1,2,3,... and $nB = \{(O,0)\}$ if $n = 0$. Examples of convex structuring elements of different shapes and sizes are shown in Fig 3. Morphological operators defined using structuring elements of variable sizes are termed as multi-scale morphological operators.

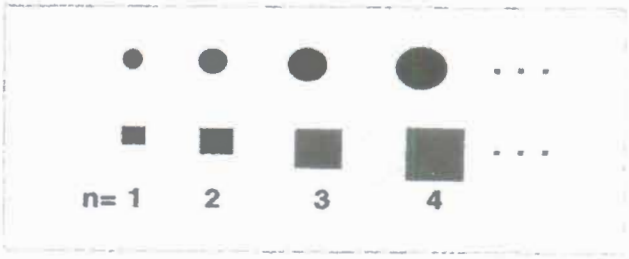


Fig 3 Family of structuring elements

Most useful operators are multi-scale opening and multi-scale closing-defined as [3]:

Multi-scale opening:

$$(g \circ nB)(r,c) = ((g \ominus nB) \oplus nB)(r,c) \quad (15)$$

Multi-scale closing:

$$(g \bullet nB)(r,c) = ((g \oplus nB) \ominus nB)(r,c) \quad (16)$$

Since opening and closing are increasing and anti-extensive (extensive, respectively), corresponding scale specific features may bk° extracted by means of hp-hat transformation Because of brightness of the extracted

features of the image, we define

Top-hat (bright) transformation: $F_i^o(r,c) = (g \circ (i-1)\,B)(r,c) - (g \circ iB)(r,c)$ (17)

Bottom-hat (bright) transformation: $F_i^c(r,c) = (g \bullet iB)(r,c) - (g \bullet (i-1)B)(r,c)$ (18)

MORPHOLOGICAL ALGORITHMS FOR IMAGE PROCESSING

A graylevel image can be decomposed into a number of feature images of different scales. Considering top-hat (bright) and bottom-hat (dark) transformations as defined above, a graylevel image can be expressed in terms of its scale specific bright and dark features as

$$g(r,c) = \frac{1}{2}\{(g \circ nB)(r,c) + (g \bullet nB)(r,c)\} + \frac{1}{2}\sum_{i=1}^{n} F_i^o - \frac{1}{2}\sum_{i=1}^{n} F_i^c \quad (19)$$

The second term of the right hand side represents the bright features and the third term represents the dark features extracted morphologically. First term may be viewed as the background (or bias or local mean level) of the image. To provide a tool to vary the importance of features at various scales, we may represent equation (19) in a more general form:

$$g(r,c) = \frac{1}{2}\{(g \circ nB)(r,c) + (g \bullet nB)(r,c)\} + \frac{1}{2}\sum_{i=1}^{n} k_i^o F_i^o - \frac{1}{2}\sum_{i=1}^{n} k_i^c F_i^c \quad (20)$$

In this section we present various image processing algorithms based on the scale specific features extracted and represented in the form of equation (20). The image processing problems we present and discuss in this paper are:

- Noise cleaning
- Local contrast enhancement
- Image fusion
- Segmentation

3.1 Noise Cleaning

Here we assume that the noise component in an image, by and large, changes the pixel value locally. A', a result noise dominates at lower scales. Hence, after extracting scale specific features (both bright and dark), if we reconstruct the image using equation (20) with less emphasis given to small scale features, i.e.,

$k_1^o < k_2^o < k_3^o < \ldots < k_n^o$ and $k_1^c < k_2^c < k_3^c < \ldots < k_n^c$

Then, the effect of noise can be reduced. In our experiment we have used [4]:

$$k_n^o = k_n^c = \frac{1}{4}, \quad k_{i-1}^o = \frac{1}{2}k_i^o, \text{ and } k_{i-1}^c = \frac{1}{2}k_i^c$$

for $i = n, n\text{-}1, \ldots$ The result of the algorithm is shown in Fig 4. Figure 4a shows the noisy image containing speckle noise and Fig *4b* shows the noise-cleaned image. Quality of the image is measured in terms of signal to noise ratio defined as

$$\text{SNR} = \frac{\sum_{(r,c)} f^2(r,c)}{\sum_{(r,c)} (f(r,c) - g(r,c))^2} \quad (21)$$

Where $f(r, c)$ and $g(, c)$ are noise-free and noisy images, respectively. Accordingly, SNR of Fig *4a* is found 17.51, while that of Fig *4b* is 101 .45. Please note that morphology based noise-cleaning algorithm, unlike mean filter, preserves the edge Information quite well.

Fig 4 Results of noise cleaning algothrim (a) Noisy image (b) Noise cleaned image

3.2 Local Contrast Enhancement

It is well known that if a small object has to draw attention of the viewer, it has to be well contrasted against its surrounding. Smaller the object, higher must be the contrast to become visible. Size of the object and the contrast has to be directly related. In other words, for better visual clarity small bright objects should be made brighter and small dark objects should be made darker. Hence, after extracting scale specific features (both bright and dark), if we reconstruct the image using equation (20) with more emphasis given to small scale features, i.e.,

$k_1^o > k_2^o > k_3^o > \ldots > k_n^o$ and $k_1^c > k_2^c > k_3^c > \ldots > k_n^c$

Then, the local contrast can be enhanced. In our experiment we have used [5]:

$$k_1^{\,o} = k_1^{\,c} = \frac{1}{4}, \quad k^{o}_{i+1} = \frac{1}{2}\, k_i^{\,o} \text{ and } \quad k^{c}_{i+1} = \frac{1}{2}\, k_i^{\,c}$$

for $i=1, 2, \ldots$ The result of the algorithm is shown in Fig 5. Figure 5a shows the original low contrasted image and Fig 5b shows the enhanced image after local contrast intensification. In this work quality of the image is measured in terms of average local contrast defined as

$$Cnt = \frac{1}{MN} \sum_r \sum_c d(r,c) \qquad (22)$$

$$\text{where } d(r,c) = \max_{(m,n)\in W(r,c)} \{g(m,n)\} - \min_{(m,n)\in W(r,c)} \{g(m,n)\} \qquad (23)$$

(a) (b)

Fig 5 Result of enhancement algorithm, (a) Original image, (b) Enhanced image

and $W(r, c)$ represents a square window around the candidate pixel (r, c) and Cnt is the desired quality measure. Accordingly, it is found that Cnt of Fig 5a is 24.63, while that of Fig 5*b* is 120.33. Visual inspection also reveals the efficacy of the method.

The above algorithm can be straightaway extended to colour image enhancement. In that case, at first RGB values at each pixel are converted to YIQ and then local contrast enhancement algorithm is applied to Y-plane, which is nothing but the brightness component of the image. Finally, enhanced colour image is reconstructed and displayed by converting back YIQ to RGB. Result is shown in Fig 6. Average contrast of Fig 6b (Y-component only, other two components remain same as they contribute to chrominance value) is much higher than that of Fig 6a.

3.3. Image fusion

Often same object or scene may be imaged through different sensors. For example, in biomedical methodologies same organs are imaged through CT and MR. It is well known that certain features are more visible in some image modality than in the others. Thus if the multi-modal images are fused then all the relevant features can be put together leading to better viewing and interpretation. The fusion algorithm described here is based on the assumption that the more visible features, either bright or dark, have higher values in the top-hat image and the bottom-hat image, respectively. Thus, images can be fused by *(i)* first, decomposing the images by top-hat transformation, *(ii)* then putting together the features of same scale but present in different images through some non-liner operation, say, max, and *(iii)* finally, integrating the combined feature images. Thus the fused image $g(r,c)$ is obtained as [6]:

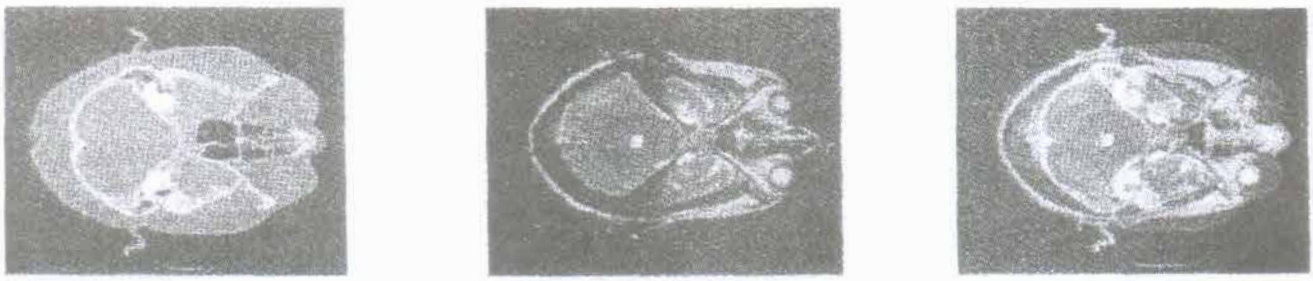
$$f_{fuse}(r,c) = \text{avg}\{\bar{g}_1(r,c),\ldots,\bar{g}_m(r,c)\} + \sum_{i=1}^{n} \max\{F^o_{i1}(r,c) \ldots, F^o_{im}(r,c)\} - \sum_{i=1}^{n} \max \{F^o_{i1}(r,c) \ldots, F^o_{im}(r,c)\} \qquad (24)$$

Result of this algorithm is shown in Fig 7. Figures 7a and *7b* show CT and MR images of brain are respectively and the fused image is shown in Fig *7c*. Performance of image fusion algorithm may be measured quantitatively in terms of cross-correlation. It is verified that correlation between Fig 7a and *7c* as well as between Fig *7b* and *7c* are much higher than that between Fig *7a* and *7b*.

Sometimes same object or scene is imaged through same sensor, say, camera but with different focusing. This is done as the depth-of-field of camera is finite and different objects in the scene lie at different distances. So in a single image all objects may not appear with equal clarity. Thus, in some application, image fusion is necessary to increase the depth-of-field of the camera artificially, i.e., putting all the sharply focused regions in the same image. It is well known that the sharply focused region contains more fine details than other regions. So sharply focused regions can easily be detected from the small-scale feature image obtained through top-hat and bottom-hat transformations. Thus, the fusion algorithm may simply be described as [7]: *(i)* detect small scale feature image from each of differently focused images, *(ii)* find the sharply focused image region by spatial clustering of the features, *(iii)* stitch the sharply focused regions (any tie may be resolved arbitrarily), and *(iv)* finally, transfer the pixel value from the corresponding image to the fused image.

(a) (b)

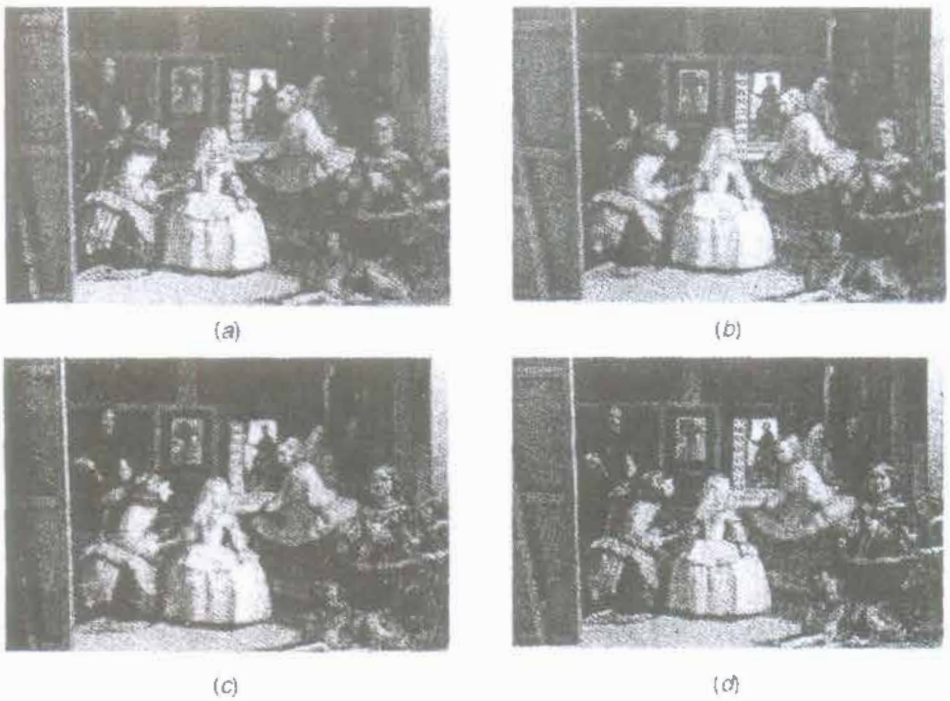
Fig 6 Result of colour image enhancement algorithm, (a) Original colour image, (b) Enhanced colour image



(a) (b) (c)

Fig 7 Result of multi-modal image fusion, (a) CT image showing hard tissues, (b) MR image showing soft tissues, and (c) Fused image showing all the features

Result is shown in Fig and Figs. 8a, 8b and 8c show the images with focus on near, middle and distant objects, respectively. The fused image is shown in Fig 8d.



(a) (b) (c) (d)

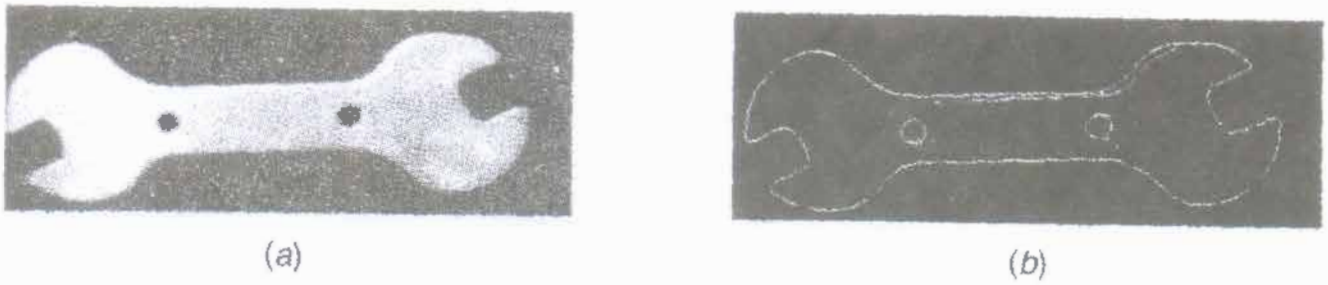
Fig 8 Result of multi-focus image fusion, (a) Center focused, (b) Rear focused, (c) Front focused, and (d) Fused image

3.4 Segmentation

Image region may be segmented in two different ways: *(i)* finding edge (or boundary) between two adjacent regions one of which may be the background and the other may be the object or region of interest, and *(ii)* extracting the entire region or feature of particular interest. In the first approach, a simple difference between dilated and eroded version of the image can produce a gradient image $g(r, c)$ between two regions. This gradient image is then thresholded to get a thick edge or may be thinned by non-maximum suppression to get the sharp boundary [8]. Detection of meaningful edges is based on the assumption that the regions are larger than the minimum feature size, say, mB. Hence

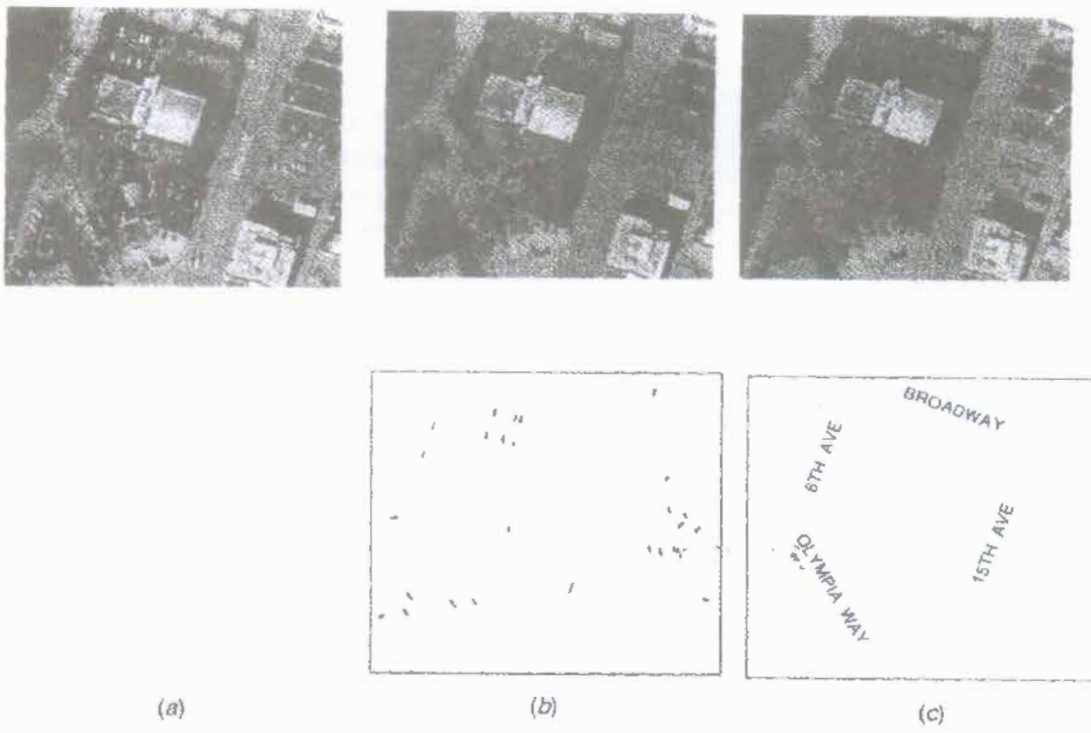
$$g_d(r,c) = ((g \circ mB) \oplus S)(r,c) - ((g \circ mB) \ominus S)(r, c) \quad (25)$$

where S is a small isotropic structuring element. Result of a simple edge detection algorithm is shown in Fig 9. Figure 9a is the original image and Fig 9b is the corresponding edge image.



(a) (b)

Fig 9 Result of edge detection algorithm (*a*) Original image (*b*) Edge image



(a) (b) (c)

Fig 10 Result of segmentation algorithm, (*a*) Original image, (*b*) Closed image with a structuring element and thresholded bottom-hat image, (*c*) Opened image with a structuring element and thresholded top-hat image

In the second approach, the feature image of a particular scale obtained through morphological top-hat (or bottom-hat) transformation may be thresholded at zero to extract desired information. That means the segmented image *g5 (r, c)* can be obtained as

$$g_s(r,c) = \begin{cases} 1 & \text{if } F_i^x(r,c) > 0 \\ 0 & \text{Otherwise} \end{cases} \qquad (26)$$

where x stand for '*o*' or '*c*' depending whether we need to extract bright or dark features, respectively. In some cases, noise may be removed by sequential filter consisting of opening and closing. Result is shown in Fig 10. Figure 10a shows the original image. Results of thresholding F ic and F j° are shown in Fig 10b and 10c, respectively. Quality of segmentation results is usually measured against the labeled ground truth. However, in this experiment we have adopted subjective evaluation strategy and the results are found quite satisfactory.

CONCLUSION

In this paper we have presented an image decomposition methodology based on top-hat and bottom-hat transformations. It has become possible because the image features of different scales are exhibited by relief of different slope and base-width in the topographic

surface representation of the image. As a result, an image is represented as a combination of scale specific features along with the background (or bias). Scale specific features are then manipulated to design various image processing algorithms. It is interesting to note that noise removal and contrast enhancement have contradicting requirements, which is managed by using different order for the parameter values. On the other hand, two different image fusion methods, one for multi-modal and the other for multi-focus, are designed based on same set of scale specific feature images but utilized in different way. Two different segmentation approaches can also be handled using similar types of operators but in different order. Results are presented to establish the usefulness of the algorithms.

ACKNOWLEDGEMENT

The author is extremely grateful to his students for experimentation and results. He also acknowledges the source of data files used in this work.

REFERENCES

1. B Chanda & D Dutta Majumder, Digital Image Processing and Analysis, Prentice Hall of India, New Delhi, 2000.
2. J Serra, Image Analysis and Mathematical Morphology, Academic Press, London, 1982.
3. P Maragos, Pattern spectrum and multiscale representation, IEEE Transaction on Pattern Analysis and Machine Intelligence, vol 1, pp 701-716, 1989.
4. S Mukhopadhyay & B Chanda, An edge preserving noise smoothing technique using multiscale morphology, Signal Processing, vol 32, pp 527-544, 2002.
5. S Mukhopadhyay & B Chanda, A multiscale morphological approach to local contrast enhancement. Signal Processing, vol 80, pp 685-696, 2000.
6. S Mukhopadhyay & B Chanda, Fusion of 2D grayscale images using multiscale morphology, Pattern Recognition vol 34, pp1939-1 949, 2001.
7. I De, B Chattopadhyay & B Chanda, Enhancing Effective Depth-of-Field by Image Fusion using Mathematical Morphology, Image and Vision Computing, vol 24, pp 278-1287,2006.
8. B Chanda, M K Kundu & V Padmaja, A multi-scale morphologic edge detector, Pattern Recognition, vol 31, pp 1469-1478, 1998.
9. S Mukhopadhyay. & B Chanda, Multiscale Morphological Segmentation of Grayscale Images, IEEE Trans on Image Processing, vol 12, pp 533-549, 2003.

Author :

E-mail : chanda:at:isical.ac.in

Prof Bhabatosh Chanda

Research Interests

- Digital Image Processing
- Pattern Recognition
- Computer Vision and Image Analysis
- Mathematical Morphology
- AI techniques in Computer Vision

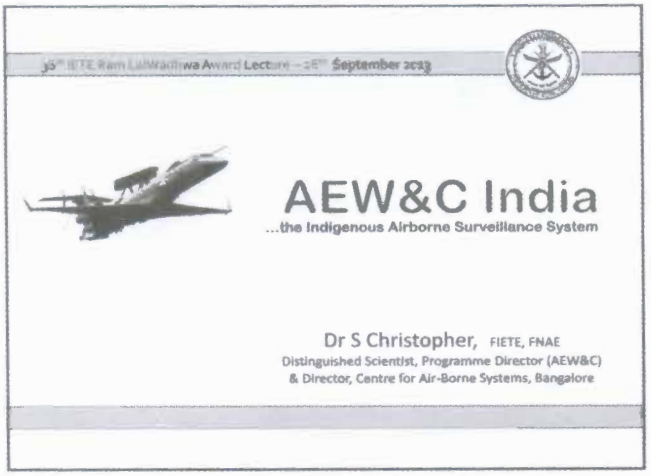
Awards / Fellowship

- Young Scientist Medal awarded by Indian National Science Academy, 1989.
- UNDP Fellowship during the period 1989-90.
- Diamond Jubilee Fellowship awarded by The National Academy of Science, India, 1992.
- Post-doctoral fellowship awarded by Univ. of Washington, Seattle, USA, 1995.
- The Computer Engineering Division Medal awarded by The Institution of Engineers (India), 1998.
- Fellow of Institute of Electronics and Telecommunication Engineers, 2000.
- Vikram Sarabhai Research Award from Physical Research Lab, 2001.
- Fellow of The National Academy of Sciences, India, 2002.
- Fellow of The Indian National Academy of Engineering, 2005.
- Best paper award} in the International Conference on Visual Information Engineering, 2006.
- IETE-Ram Lal Wadhwa Gold medal, 2007.
- 1st Prize in and international competetion on Table Detection (Page Segmentation) in 9th International Conference on Document Analysis and Recognition, Curitiba, Parana, Brazil, Sep. 23-26, 2007, (A. Antonacopoulos, B. Gatos, D. Bridson: Page Segmentation Competition, Proceedings of ICDAR 2007, Vol~2, pp. 1279-1283, 2007).
- Fellow of the International Association of Pattern Recognition, 2008.

AEW&C India the Indigenous Airborne Surveillance System

S CHRISTOPHER

Outstanding Scientist, Director Centre for Air-Borne Systems, Bangalore



AEW&C / AWACS
... the emerging new Air Power

The advent of AEW&C / AWACS surveillance systems has re-written tactics of air warfare.

The Gulf War 1990-1991 was won by AEW&C / AWACS aircraft

Gulf War 1990-1991

Northrop Grumman E-2C Hawkeye

E-2C Hawkeye squadrons played a critical role in **air operations .**
Once, a Hawkeye crew provided **air control direction** to two F/A- 18 Hornet aircrew, resulting in the shoot-down of two Iraqi MiG-21s.

US Navy Hawkeye squadrons provided **(i)battle management, (ii) close-air-support, (iii) combat search and rescue control, (iv) airspace management,** as well as **(v)data-link** and **(vi) communication relay** for both land and naval forces.

Gulf War 1990-1991

Boeing E-3 Sentry

E-3 Sentry established an **around-the-clock radar screen** to defend against Iraqi forces.

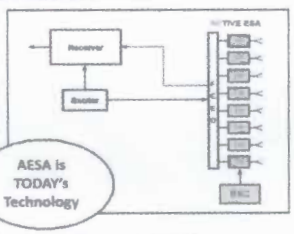
During Operation Desert Storm, E-3s flew **379 missions and logged 5,052 hours** of on-station time.

In addition to **providing time-critical information** on the actions of enemy forces, **E-3s assisted in 38 of the 41 air-to-air kills** recorded during the conflict

Arrival of the AESA Radar

Both the **E-2C *Hawkeye*** and the **E-3 *SENTRY*** carried large rotating Radomes, housing Mechanically Steered Antenna (MSA).

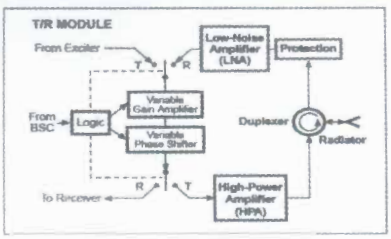
Roto-dome Technology is OUT-DATED



AESA is TODAY's Technology

With the advent of the ***Active Electronically Steered Array*** **(AESA)** antenna, it became possible to scan electronically without any mechanical rotation of the antenna.

Transmit-Receive (T/R) Module
...the crucial component of the AESA Radar

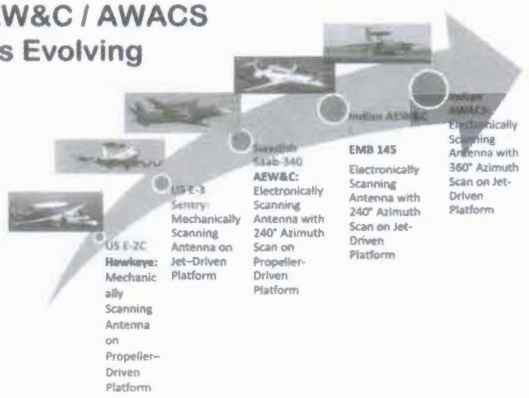


The T/R Module, which is a block of electronics with A *Transmitter, Receiver* and a *Common Phase Shifter,* is the 'Building Block' of the AESA radar.

The AESA Advantage

- AESA helps build **more agile radar** systems resulting in optimised energy management.
- AESA provides **enhanced beam agility with higher reliability** as it is not a mechanical system
- AESA **helps track air- and sea-targets simultaneously** through concurrent use of different waveforms.
- AESA provides **'graceful degradation' of performance**with cumulative failures of T/R modules.

AEW&C / AWACS ...is Evolving



Exploitation of AESA Radar Advantage is attempted through different airframe configurations for the AWACS role.

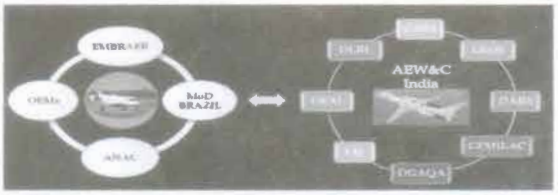
Configurations attempted are:

(i) Antennae Unit on top of Fuselage (with azimuth coverage on both sides of the aircraft)
(ii) Conformal Antennae on sides of fuselage (with azimuth coverage on both sides of the aircraft)
(iii) Additional antennae in 'Nose' and 'Tail' for fwd and aft coverage for configurations (i) and (ii).
(iv) Circular Radome on top of fuselage for 360° coverage.

Indigenous AEW&C India tailored to Operational Requirements of IAF

Compact and agile platform aircraft, **EMB-145, can operate from most of the Indian airfields and its flight endurance is enhanced with In-Flight Refuelling**

Work-centres that realisedAEW&C India



AEW&C Mission System is developed by Indian Work-centres and mounted on EMB-145 platform aircraft from M/s Embraer, Brazil

Programme is supported by a network of Academic Institutions, R&D Laboratories, S&T Centres and Industries in public and private sector

Network Centric Sensor Systems

for Joint Battle Management from Air, Land and Sea

Long-Range Identification Friend or Foe. Automatic Radar Correlation.

Surveillance over Any Terrain, in any Environment. Advanced AESA Radar detects low Radar-Cross-Section Targets at Long Ranges.

Interception and In-flight Analysis of Communication Signals.

Long Range Passive Detection and Classification of Electronic Emitters.

Radios and LoS& SATCOM Data Links network with surface stations and aircraft in the air.

AEW&C India Sub-systems

DATA LINKS:
'C' –BAND; 'Ku'-BAND SATCOM;
V/UHF COMMUNICATION & DATA

PRIMARY RADAR AND SECONDARY SURVEILLANCE RADAR (OR, IDENTIFICATION FRIEND OR FOE)

IN-FLIGHT REFUELLING

ACTIVE ANTENNA ARRAY UNIT

INTEGRATED RADAR WARNING RECEIVER, ELECTONICS SUPPORT MEASURE & SELF PROTECTION SYSTEM

COMMUNICATIONS SUPPORT MEASURE

COMMAND, CONTROL, COMMUNICATION & COMPUTER SYSTEM

Designed to Perform...

- Airborne Early Warning & Control

Search, Detect, Track, Identify, Integrate Sensor Data, Communicate *Air Situation Picture* to Ground and Air Stations

- Battle Management

Threat Evaluation, Weapon Assignment & Intercept Control

- Electronic Intelligence

Identification and Suppression of Hostile Electronic Emitters

- Communication Intelligence

Interception and Analysis of Communication Signals

- Airspace Management

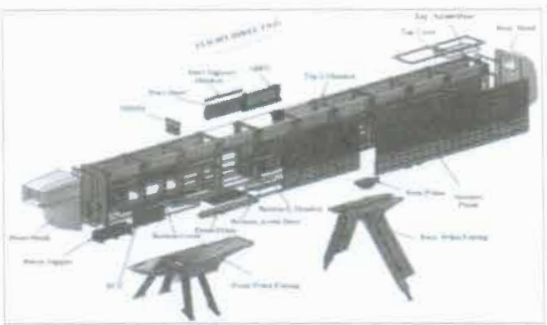
Control of Borders, Surveillance of Economic Zones

Active Antenna Array Unit (AAAU)

Design and Development of the of the AAAU involved multi-discipline Activities:

- Structural Design.
- Computational Fluid Dynamics (CFD) Analysis for Air Loads and Flow Characteristics.
- Wind Tunnel Tests for Air Loads and Flow Interference Studies.
- Lay out of Antenna Panels, Transmit-Receive Multi-Modules (TRMMs), Multi-Output Power Supply (MOPS) units, Cables & Connectors, etc.
- Ram-Air Cooling System for TRMMs and MOPs.
- Thermal Management Studies to establish adequacy of cooling air flow under extreme ambient temperature conditions.
- Lightning Strike and Bird Hit Studies.

AAAU: Structural and Lay-out Design

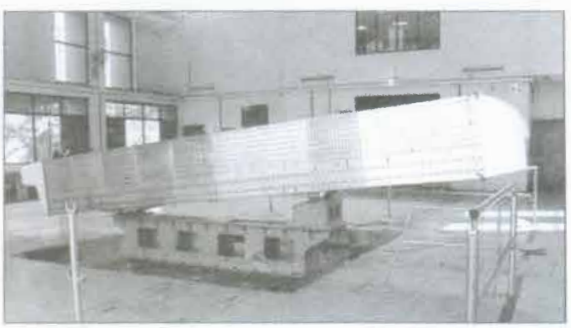


AAAU: Stress Analysis

...for Aerodynamic and Inertial Loads

AAAU Structural Integrity

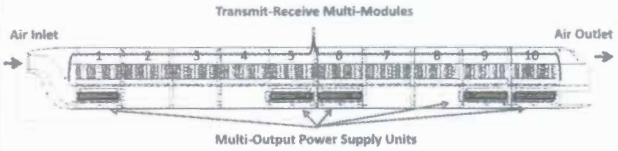
Ground Vibration and Modal Analysis Tests



AAAU: Wind Tunnel Studies

Establishing Air Loads and Checking for Interference Flow Conditions

AAAU: Thermal Management Studies



Hot Spots on TRMM

Temperature Contour on MOPS

Ram Air Cooling Flow Visualisation

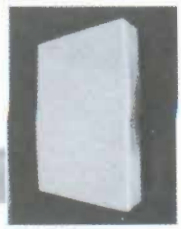
Equipping AAAU with Electronic Components

...Installation Details and Assembly Sequence

Ultra-Light Radome-clad Antenna Panels

(Ten Panels on each side of the AAAU)

Antenna Panels are designed as integral part of the AAAU structure and are designed and tested for Stresses, Vibration, Environment, Lightning and Bird Strike



Primary Radar

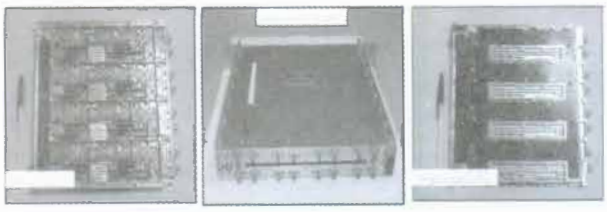
Radar Tx-Rx Pattern Measurements in PNFM Facility

Roof Top Test Rig for Radar Radiation Trials

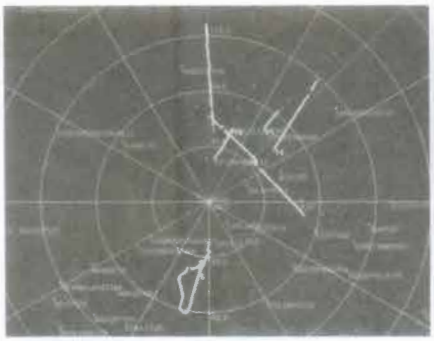
Mission System installed on platform aircraft for flight Trials

Transmit-Receive Multi-Module (TRMM) is the crucial 'Building-Block' component of the AESA Radar.

...and the TRMM was indigenously designed and developed in time for realisation of the Primary Radar.

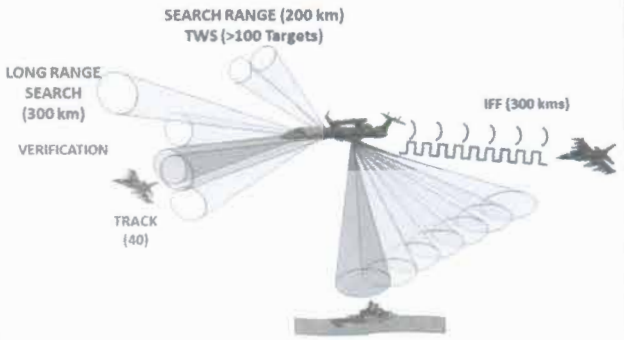


Proof of the Primary Radar



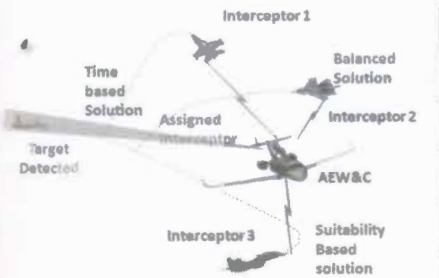
Radar performance evaluated against docile and manoeuvring air-targets

Primary Radar & IFF



Tactical Mission Software

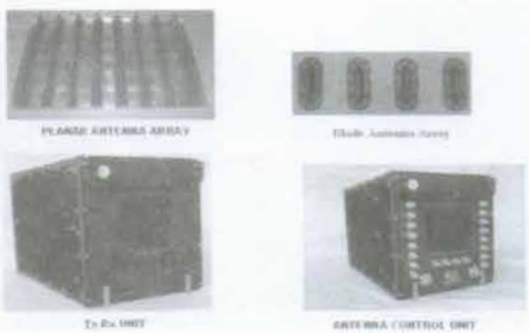
...through in-house efforts



- Mission Planning
- Human-Machine Interface
- Battle Management
- Radar Signal Processing
- Air Situation Picture
- Multi-Sensor Data Fusion
- Threat Assessment and Identification
- Mission Data Processor
- Intercept Control Processor

Secondary Surveillance Radar

...Components



Secondary Surveillance Radar

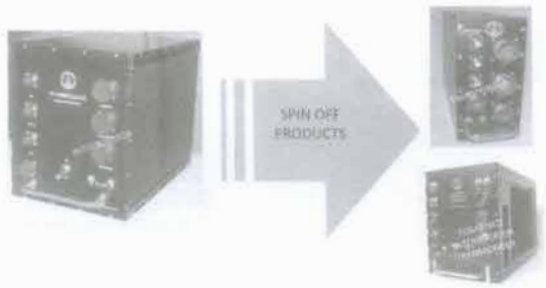
... evaluated on roof-top test-rig against opportune targets

Secondary Surveillance Radar

...Flight-tested to confirm performance

AEW&C Secondary Surveillance Radar

SSR Equipment have been sought against Tri-services Requirements for other applications



Electronic Support Measure (ESM) and Self Protection System (SPS)

ESM identifies emitter characteristics with an accuracy of 1 MHz and 2°(rms)

SPS comprises *Missile Approach Warning System* and *Counter Measures Dispensing System*

Communication Support Measures

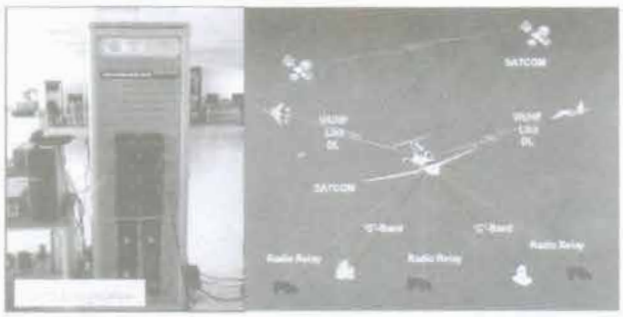
...the constituent devices

Communication Support Measure

...Accuracy and Sensitivity of Sensor established

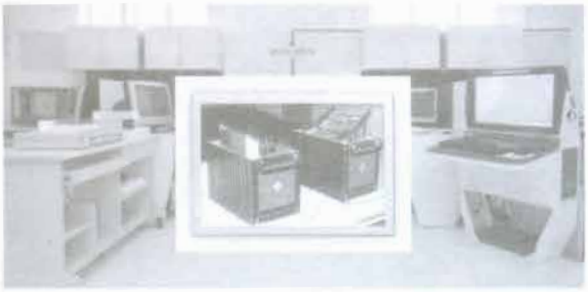
Mission Communications System

...helps inter-operate with other AEW&Cs, Airborne Fighters and Ground Air Defence Stations.



Mission System Controller

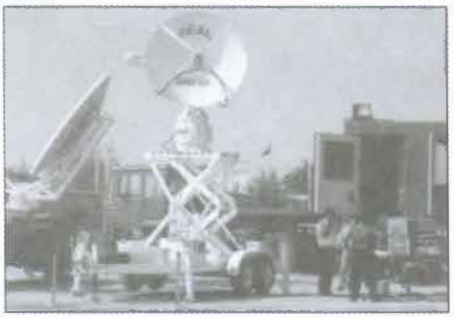
...the Heart of the AEW&C System



Data Handling & Display System

...can be configured for Air Situation Picture and Command & Control Modes

'C'-Band and 'Ku'-Band Data Links ... 'Line-of-Sight' and 'SATCOM' links found desirable for the operations.



Ground Segment Systems

Ground Exploitation Station
networking AEW&Cs with Interceptors and Air Defence stations on ground

Automatic Test System for TRMMs

Mission Planning and Analysis Station

Mission Software Support Facility

Operator Training Station

Development Infrastructure

...synchronously created on the programme timeline

System Test & Integration Rig

Sub-systems Test Labs

PNFM Facility

Radar Simulator

System Simulator

EMI/EMC Test Lab

HASS-HALT Chamber

A determined Development Team remains committed to deliver *AEW&C India* to Indian Air Force by early 2014

AEW&C India triggers a chain reaction

- *AEW&C India* is slated for induction into IAF in 2014.
- IAF have proposed a follow-on programme, *AWACS India*, with enhanced capabilities. Concept study is under way.
- M/s Embraer, Brazil, propose a joint programme to develop Export Version of *AEW&C India*. Proposal is being examined.
- Indian CG propose programme for a *Multi-Mission Maritime Aircraft*. Preliminary Studies have been initiated.

Author :

Email: director@cabs.drdo.in

Dr S Christopher, Outstanding Scientist and Director, Centre for Airborne Systems (CABS), Bengaluru,has been promoted to the grade of Distinguished Scientist wef July 2012. He obtained his BE (Hons) in Electronics & Communication Engineering from University of Madras with Distinction, securing 7th Rank at the University level. He took his M.Tech. from IIT, Kharagpur, in Microwaves and Radar Engineering, ranked 1st in the Institute. He joined IIT, Madras, as Project Associate in 1980 and carried out research in Microwave Antenna Design and Near-field Measurement Techniques. He obtained PhD in Antennae and Measurement Techniques from IIT, Madras, in 1985.

Dr S Christopher worked for M/s Bharat Electronics, Ghaziabad, as Senior Engineer, from 1985 to 1988. He worked on Design and Development of Antenna for mobile, Tropo and Line-of-Sight Communication; and Preliminary Design of Digital Beam-forming Antenna.

Dr Christopher joined Defence Research and Development Organisation (DRDO) in the year 1988 and worked in a number of capacities on various projects at Electronics and Radar Development Establishment (LRDE), Bangalore. He joined CABS as Scientist-'G' on June 18, 2004 and assumed charge as Programme Director for the Airborne Early Warning and Control (AEW&C) system, when the task was assigned to CABS in October 2004 taking over the complete responsibility for Design, Development, Fabrication and Qualification of the AEW&C System to specific Operational Requirements of the Indian Air Force through the many work-centres within DRDO. On January 01, 2007, Dr S Christopher was appointed Director, CABS, in addition to his responsibilities as Programme Director (AEW&C) and was elevated to the rank of Outstanding Scientist / Scientist-'H' on July 25, 2008.

ACKNOWLEDGEMENTS

Dr S Pal, President IETE; Shri R K Gupta, Chairman, Diamond Jubilee Celebrations Committee; Shri Harsh Vardhan, Chairman, IETE Publications Committee, take pleasure to acknowledge the dedicated efforts of the Members of the Diamond Jubilee Celebrations Committee and the following Officers and Staff of the IETE HQ in preparing this Diamond Jubilee Compendium of Memorial Lectures for release on 7th November, 2013 on the occasion of 60th Foundation Day.

- Shri S R Aggarwal, Secretary General, IETE
- Mrs Sandeep Kaur Mangat, Asstt Secy(ARP)
- Shri Sanjay Setia
- Shri Sanjay Chawla
- Shri Prakash Singh

About IETE

Founded in 1953, The Institution of Electronics and Telecommunication Engineers(IETE) is a leading professional society devoted to the advancement of Science & Technology in Electronics, Telecommunication, Information Technology, Computer Science and other related disciplines. IETE serves its more than 1,25,000 members both individual and industries/ organizations through its 65 Centres spread all over India including one at Kathmandu(Nepal).

The Government of India, Ministry of Science and Technology, Department of Scientific &Industrial Research has recognized IETE as a Scientific and Industrial Research Organisation (SIRO) and the Institution has also been notified as an Educational Institution of National Eminence by the Government of India. The broad objectives of IETE are given below:-

- To promote and conduct basic engineering and continuing technical education programmes for human resource development.
- To provide forum for discussion on national policies and to provide suitable inputs to policy makers.
- To organise conferences, symposia and workshops involving all concerned professionals, students and industry associations for the advancement of the discipline.
- To stimulate research and development in the discipline.
- To bring out quality publications for all levels of readership.
- To honour outstanding professionals.
- To facilitate Inter-disciplinary interaction with other organizations and individuals within and outside the Country for the promotion of the discipline.
- To undertake socially relevant programmes with Electronics, Telecommunication and IT as tools.