WHITHER SPACE
&
ASTRONAUTICS

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CONTENTS

Abstract

Man's future in Space will be determined more by Socio-Cultural imperatives rather than Science & Technology alone. Individual Liberty & Democracy along with deep and active concern for all living beings on Earth are essential features of a Civilized Society - Space programmes will have to pay attention to this. Two illustrations are sketched: NEWARS - an Early Warning & Response System for INDIA and Research on Planetary Engineering for the long term. The present troubles of the World are by-products of probably the greatest of revolutions in history involving Ethics, Science & Politics. This revolution has created powers of appalling destructiveness but it has also sown the seeds of how they may be conquered & used constructively.

WHITHER SPACE & ASTRONAUTICS

1.0 INTRODUCTION:

Astronautics is the Science of Travel in Space & except for the imagination of Philosophers & writers, in real terms, Astronautics is only about 40 years old. However Astronomers, Astrophysicists and Cosmologists (also Astrologers) among them Aryabhata & the Bhaskara's have been at work since many centuries. Observing the motions of the planets, the Sun and the Stars they have tried to understand & relate these to the activities of man. The evolution of Civilized Society on Earth is closely linked with man's quest for understanding the unknown, seeking answers to the questions & problems of existence.

1.1 The culture of a people embodies their basic outlook and assumptions about the natural world as well as the patterns of behaviour of living beings including humans. Science & Religion have thus played a vital part from the beginning in helping communities to arrive at collective answers to the organisation & functioning of society and their moral outlook as well as socio-economic & political activities.

2.0 THE INHERITANCE:

During the last 100 years or so, the tempo of scientific & technological developments and their inevitable interactions with society, have resulted in an explosive growth of knowledge - much of which has still to be digested. Since World War II science has come to dominate human activities everywhere. It is however useful to remember that the same events which spurred the growth of science also re-drew the Political Map of the World. The Colonial Era ended and 150 new Nations came into being - many of them still struggling to find an equitable place in the Comity of Nations. Much of what is known about the UNIVERSE - The Big Bang - the discovery of the existence of Millions of Galaxies other than the Milky way - the birth & death of Stars & the composition & distribution of matter in the Universe and the origin, structure & development of living beings - all this and more is the result of relatively recent discoveries.

2.1 During the same period mankind has also witnessed societal turmoil on an unprecedented scale. The great ideas & concepts of human freedom & liberty, of reverence for life in all its forms now vie with the great discoveries of Science and there is a growing urge everywhere to review & establish a way of life in which mankind instead of threatening the future evolves a civilization which would sustain & preserve all life forms on the only planet where it is known to exist.

2.2 Fig.1 and Fig.2 graphically depicts the events since the Universe came into existence. A harmonious Culture & Civilization implies flourishing of the Arts and Science, Music & Architecture, Philosophy & Religion. It also presupposes that to a lesser or greater degree everyone participates in and understands the basis of community life and upholds certain values & ethics - even though many may often fail to observe them.

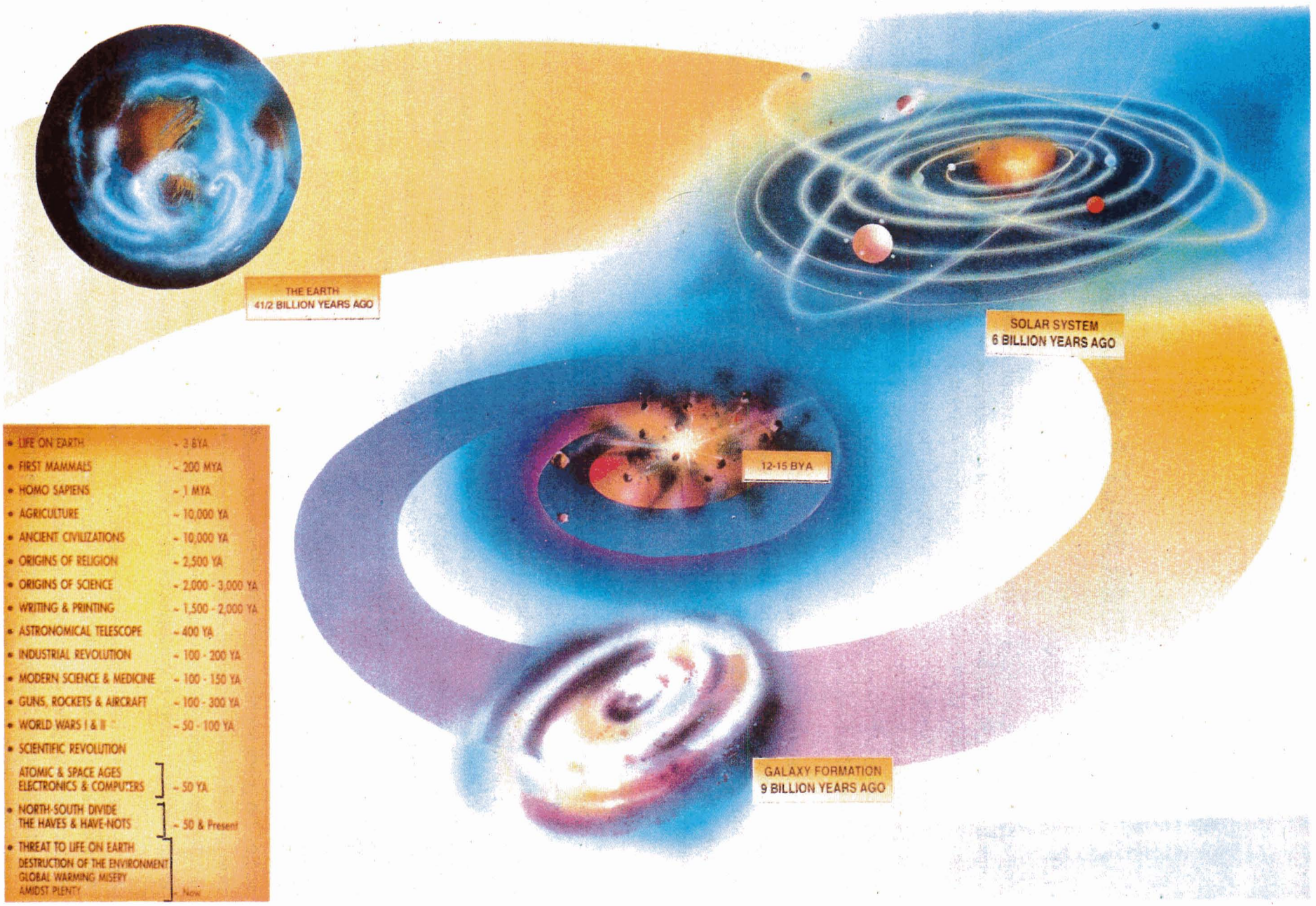

THE EARTH
41/2 BILLION YEARS AGO
SOLAR SYSTEM
6 BILLION YEARS AGO
12-15 BYA
GALAXY FORMATION
9 BILLION YEARS AGO
• LIFE ON EARTH ~ 3 BYA
• FIRST MAMMALS ~ 200 MYA
• HOMO SAPIENS ~ 1 MYA
• AGRICULTURE ~ 10,000 YA
• ANCIENT CIVILIZATIONS ~ 10,000 YA
• ORIGINS OF RELIGION ~ 2,500 YA
• ORIGINS OF SCIENCE ~ 2,000 - 3,000 YA
• WRITING & PRINTING ~ 1,500 - 2,000 YA
• ASTRONOMICAL TELESCOPE ~ 400 YA
• INDUSTRIAL REVOLUTION ~ 100 - 200 YA
• MODERN SCIENCE & MEDICINE ~ 100 - 150 YA
• GUNS, ROCKETS & AIRCRAFT ~ 100 - 300 YA
• WORLD WARS I & II ~ 50 - 100 YA
• SCIENTIFIC REVOLUTION
ATOMIC & SPACE AGES
ELECTRONICS & COMPUTERS ~ 50 YA
• NORTH-SOUTH DIVIDE
THE HAVES & HAVE-NOTS ~ 50 & Present
• THREAT TO LIFE ON EARTH
DESTRUCTION OF THE ENVIRONMENT
GLOBAL WARMING MISERY
AMIDST PLENTY ~ Now

Fig. 1

CHRONOLOGY OF THE UNIVERSE

* "BIG BANG"	—	15 BILLION YEARS AGO
* MILKY WAY GALAXY	—	9 B.Y.A.
* SOLAR SYSTEM	—	5 B.Y.A.
* PLANET EARTH FORMED	—	4-1/2 B.Y.A.
* LIFE ON EARTH	—	3 B.Y.A.
* FIRST MAMMALS	—	200 M.Y.A.
* HOMO SAPIENS	—	1 M.Y.A.
* CIVILIZATIONS	—	10,000 TO 2,500 Y.A.
* AGRICULTURE	—	10,000 Y.A.
* ALPHABET	—	3,500 Y.A.
* ORIGINS OF SCIENCE / RELIGION	—	2 - 3,000 Y.A.
* ASTRONOMICAL TELESCOPE	—	400 Y.A.
* CARVE-UP OF ASIA	—	300 Y.A.
* INDUSTRIAL REVOLUTION	—	200 - 100 Y.A.
* MODERN SCIENCE	—	100 Y.A.
* WORLD WARS I & II	—	80 - 50 Y.A.
* SCIENTIFIC REVOLUTION ATOMIC / SPACE	—	50 Y.A.
• MAN'S DESTRUCTION OF THE ENVIRONMENT • GLOBAL WARMING • THREAT TO LIFE	—	NOW!

Fig. 2

3.0 CHALLENGE & OPPORTUNITY:

The challenge & the task is well recognized - among Scientists, Philosophers, Politicians as well as common people everywhere. Many problems in the evolution of the new culture still remain. How will the new culture, which we seek, amalgamate Science with Aesthetics & Ethics. Can the two cultures of C.P. Snow *fuse into one? Aspiring Astronauts & Space Technologists need to be aware of this turmoil engaging mankind and at least keep it at the back of their minds when thinking of the future of Space.

3.1 India has now a well developed Space programme. Over the last 30 years much has been accomplished and more is in the pipeline. Internationally the ending of the Cold War & the socio-political events that followed, have some what shaken the ambitions and aspirations

* Ref. 1

of many Space Agencies. Declining budgets and the disillusionment of people at large with the changed patterns of employment, rising prices and social & moral dilemmas of drug abuse, alienation of young people, race caste & sex discrimination etc. have moved the attention of large sections of society away from Space. After many twists & turns the Space Station is being pursued internationally with US in the (somewhat diminished) lead & Russia, Europe & Japan uneasily cooperating and wishing for Space Stations of their own. Space Science projects have also shrunk in number & size inspite of the belated success of the Hubble Telescope, Galileo & a few other missions. Satellite Communications & Television have enveloped the world. Developments in computer technology are pushing the establishment of Information Highways across the Globe - but the people of the world still to have watch out for 'highway robbers & bandits'! - often supported surreptitiously by the very governments who publicly proclaim adherence to principles of freedom & law but are quick to seek devious political & economic advantages.

3.2 The dreams of Colonies in Space - of man exploring the planets & beyond are not dead. Even a cursory glance at the professional literature and popular journals shows that Scientists, Engineers, Writers and also many lay people, are still stirred by the vision of human beings sojourning in the vastness of the Universe among the twinkling stars. Budgets are at an all time low but some enthusiasts are still searching & keeping the vigil for Extra-Terrestrial Intelligence. We may pause and ask what does this signify? Are people disillusioned & seek an escape from the earth **OR** despite the problems it is a display of courage and faith in humanity ?

3.3 In the world of today the lessons of the Space Age are that large scale complex & expensive endeavours must have:

(a) the psychological, political & economic support of the nation as a whole &

(b) International Cooperation & not active hostility.

3.4 As an example one can note the programme called "Mission to Planet Earth"*. Prompted essentially by the alarms sounded by ecologists & supported by the scientists findings of the reasons for the rapidly deteriorating conditions of life on earth and prodded by the need to appear concerned & progressive, International Scientific & other organizations have responded positively (not without politics!) to the US lead & an ICSU supported Geosphere Biosphere Programme@directed towards a study of Global change has emerged. India too has a National Committee for IGBP and a widely dispersed programme since 1989 with a number of National Scientific Organizations & individual scientists studying various aspects of global change of relevance to India. This passing reference to the IGBP is only to draw attention to the complexity & the scale of the effort. The Science inevitably intermingles with Geo-Politics. This was so in the 1950's when the IGY programme calling for artificial Earth Satellites got intertwined with the US-USSR cold war rivalry.

3.5 It is sobering to note the relative budgets - for IGP & SPACE - The annual CIVILIAN Space Expenditure of the world is currently around $100 BILLION - The budget for the Mission to Planet Earth is less than a tiny fraction of this. This proportion is also reflected in INDIA's outlay for IGP and the national annual space expenditure of approx. $200 million. The dreams and aspirations

* Ref. 2
@ Ref. 3

of Space Exploration & Colonization and Astronautics Highways in Outer Space get tempered by the ground realities on earth. No doubt pioneers have to dream & advocate adventures into the unknown - some times even embark on some of them. Even if nothing concrete comes of these, the ideas fire the imagination of people and there is always hope of a net gain in human knowledge and ingenuity.

4.0 ELEMENTS FOR ACTION:

What should the Indian Astronautics community set up as possible goals? I suggest that it may be worthwhile to conceive of a programme with two components. One which India & Indians can attempt on their own and the other larger in scope, scale & time frame requiring participation in international multi-disciplinary research with the inevitable Geopolitics & uncertainties. This is not the only approach to consider the future in Space, but one possible path. Let us take a brief look at two areas : First considering the needs of India as a whole & the current status of Indian Space Systems, attention could be directed to the implementation of a **National Early Warning & Response System** (NEWARS). The second effort - longer in time & broader in scope - could be in, what has come to be called "Planetary Engineering" *During the last decade scientists have been examining the possibilities of creating an environment in Space - on the Moon or one of the Planets - in which life, as we know it on the earth, may be able to survive and eventually flourish on its own. Such an effort may also contribute to the understanding of urgent large scale problems faced by mankind on earth itself - in fact the IGBP can be viewed as a small initial attempt at Terraforming or rather Terra-Reforming!

4.1 Before briefly sketching the suggested projects it is useful to recall some background facts relating to India and the World.

Fig.3 and Fig.4 summarize the situation.

4.2 If we take an unbiased sounding, the scene in India, as well as the world, does not appear very promising. The humans on the Indian subcontinent as well as the Globe seems to have embarked on an uncoordinated but nevertheless vicious activity of discord, destruction & demolition - all in the name of Progress & Post Industrial Society! - can we call this Civilization? Hopefully there are signs that more & more people in India from all walks of life, and all over the world are seeking a different form of Civilization in which knowledge is openly accessible and used for society as a whole including all living creatures.

5.0 THE PRESENT SPACE SYSTEMS: INSAT & NNRMS/IRS

Before outlining the concepts of **NEWARS** and Planetary Engineering, it is useful to take a brief overview of the existing Indian Space Systems - INSAT & NNRMS. These operational Systems are the result of a two decade effort and each embodies elements adapted to serve Indian needs. @

5.1 The INSAT & NNRMS have served their purpose well and brought Indian use of Operational Space Systems to a very respectable status nationally & internationally. In the fast changing world & national scene both systems are due for changes & modifications. These changes must focus on worthwhile objectives.

* Ref. 4(a).4(b)
@ Ref. 5

INDIA - SOME FACTS

- TRAUMA
- HAVOC
- LOSSES

CAUSED BY → NATURAL & MAN MADE DISASTERS → NO FAMINE - BUT MILLIONS SUFFER ACUTELY

* ANNUAL CROPS LOSS DUE TO
- PESTS/DISEASE
- FLOODS
- DROUGHT

→ Rs.3000 TO 4000 CRORES
OVER 100 MILLION AFFECTED

* OF THE 15 AGRO CLIMATIC ZONES 3 ARE MAJOR LAND DEGRADATION AREAS
- POPULATION DENSITY
- RESULT

→ EXCEEDS CAPACITY OF LOCAL AGRICULTURE

ACIDIFICATION & DESERTIFICATION

* WATER SCARCITY → DETERIORATION OF MAJOR RIVER BASINS → 66% OF CROPPED AREA IS RAIN FED
34% IRRIGATED

* LARGE DISASTER ZONES → ANNUAL LOSS
- 1500 LIVES
- 8 MILLION HECTARES
- Rs.250 CRORES LOSS IN CROPS & PROPERTY
- DISRUPTION OF TRANSPORT SYSTEM
- POWER GRIDS

* URBAN CENTRES GROWING AT ALARMING RATES (More than 1/2 Million Population)
- URBAN GHETTOS -
- TONS OF GARBAGE
- CONGESTION
- ILL-HEALTH

→ NO UP-TO-DATE MAPS/DATA ON EXTENT & RATES OF CHANGE

* NATIONAL SECURITY → BORDER+10 LOCATIONS IN INDIA

WHAT IS HAPPENING TO THE WORLD BY-PRODUCTS OF MAN'S ACTIONS

* 5 & 1/2 BILLION PEOPLE ON EARTH → WILL INCREASE TO 10 BILLION BY 2050

* MAN USES UPTO 40% OF ORGANIC MATERIAL FIXED BY PHOTO SYNTHESIS ON LAND

* THE RICHEST 15% CONSUMES → >50% OF ENERGY, 30% OF ALL FERTILISER → MORE THAN 1 BILLION GO HUNGRY

* WHILE MILLIONS STARVE → SOME COUNTRIES PAY FARMERS NOT TO GROW FOOD

*THE COLD WAR HAS ENDED → BUT THERE ARE OVER 30 MURDEROUS CONFLICTS ALL OVER THE EARTH KILLING AND MIAMING MEN, WOMEN & CHILDREN

* IN THE LAST 250 YEARS

- 6 MILLION SQ.KM. OF FOREST DISAPPEARED → AREA GREATER THAN EUROPE
- 3600 CUBIC KM/YEAR WATER WITHDRAWN FROM THE HYDROLOGICAL CYCLE → EXTINCTION OF MANY LIFE FORMS
- METHANE DOUBLED
- CO_2 INCREASED BY 25%
- ATMOSPHERIC POLLUTANTS
- HOLES IN OZONE LAYER

→ INCREASE OF DISEASE & ILL-HEALTH FOR HUMANS &

Fig. 4

INSAT System : Operates 4S/c, carrying between them 66C-band, 15S-band Transp.3 VHRR's - Data Relay-Search & Rescue Transp. A mobile Comm. package.

- On the ground are: 200 Earth Stns. for Telecom. All major Cities, Towns, Rural & Remote Areas connected.

Programme: 750 TV Transmitters

Distribution: 275 Radio Stations. entirely via S/c

More than 2500 VSATS in use by Business operators.

Search & Rescue Payload : Only one in the region

Education Services used by Univ., Schools & the Public

NNRMS System : Closely coupled with the Plan. Com. Principal means for assessing and monitoring the NATURAL RESOURCES of India.

- 4 IRS S/c provide high resolution, multi-spectral imagery over the whole subcontinent.

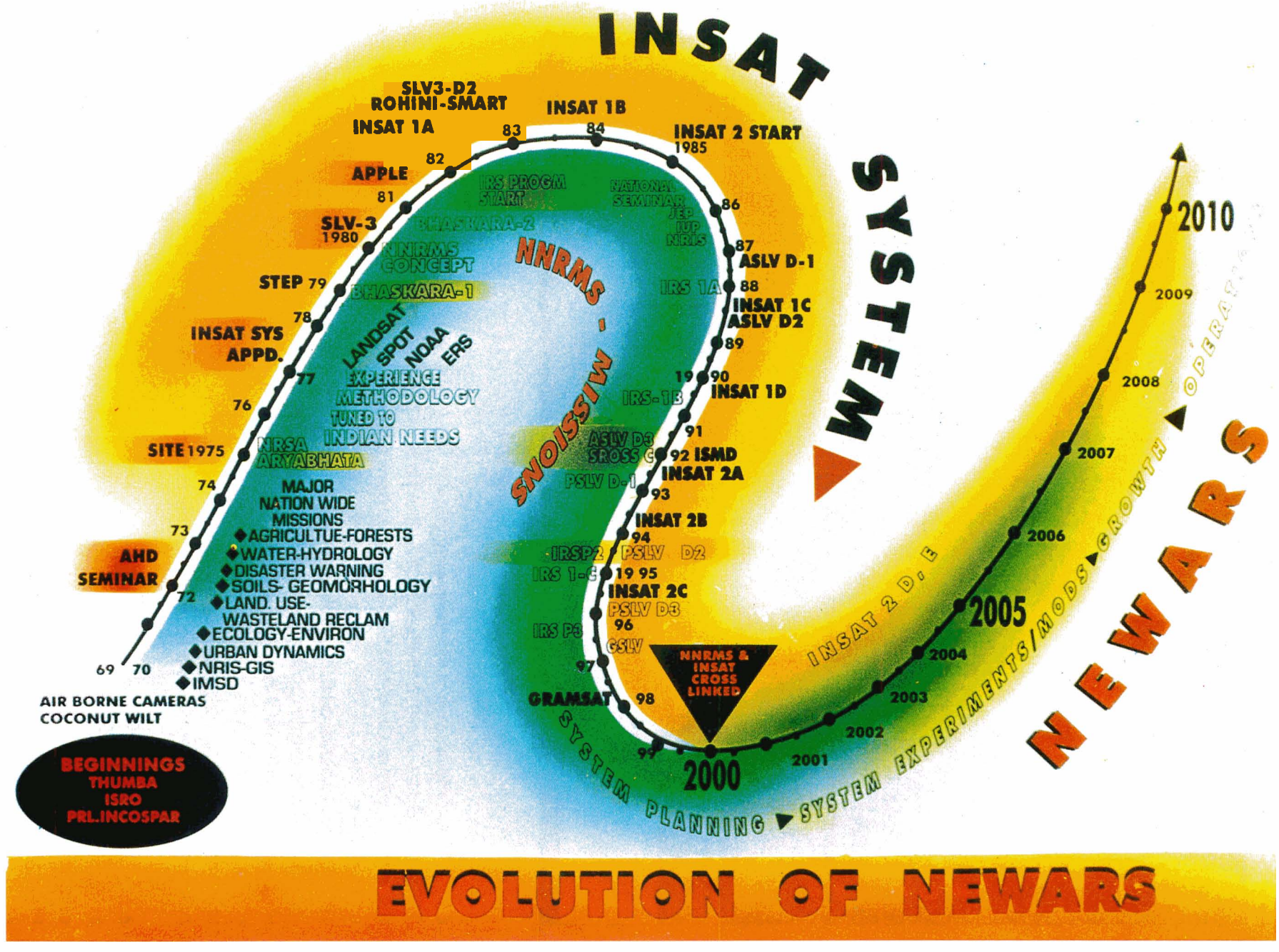
Primary attention is focussed on:
- Agriculture & Forests
- Water Resources
- Geomorphology & Soils
- Ecology & Environment
- Coastal regions

- 15 nation wide NNRMS missions are in progress in cooperation with a large number of departments, agencies & institutions. A National Resource Info. System is nearing completion. The Integrated Mission for Sustainable Development (IMSD) seeks to provide active support to all the 450 taluks in India to put into practice concepts of Sustainable Development.

Fig.5 gives a snapshot of the evolution of the Space Systems & Fig.6 summarizes their status.

6.0 THE NATIONAL EARLY WARNING AND RESPONSE SYSTEM (NEWARS):

Consolidation, Extension and Systematic utilization of what has been accomplished in the last 15 years of NNRMS & INSAT logically leads to NEWARS - a Space based Early Warning & Response System which would collect timely information on all major aspects of national life which have a strong coupling with and depend upon protection and effective use of natural and organized human resources. The system goes well beyond information collection & dissemination and seeks to feed and nurture not only organized sectors of public life but also create awareness, initiative and action among wide sections of rural and urban India. Fig.7 gives a sketch of the NEWARS concept.



EVOLUTION OF NEWARS

Fig. 5

Fig. 6

6.1 The scale, scope and complexity of NEWARS (NATIONAL EARLY WARNING & RESPONSE SYSTEM) would be significantly greater than the present NNRMS & INSAT Systems - EVEN more than the scale - several QUALITATIVE elements in concept would set NEWARS apart. It would be a unique space based system using 3 classes of S/c i.e. Sun Sync, LEO and GEO with ground to S/c, S/c to Ground data transfer enhanced through S/c on-board processing, data & communications links in real time. A great deal of system definition & system management effort will be necessary to evolve a cost effective operable & viable overall system. The design would allow growth with time as the ground user & assets expand from the present largely departmental units into widely dispersed professional as well as community & individual entities - eventually becoming familiar to & used routinely by the public at large.

6.2 The evolving NEWARS would not seek to displace existing components but essentially integrate and tune them into a comprehensive network - each element performing its task efficiently & remaining aware of other elements. Strong user orientation and the ability to execute/ receive/analyze/transmit functions within well defined accuracy & time limits would form key elements. When the early warnings/alerts can reach the village groupings (panchayats), the urban areas, the specialised agencies dealing with the major seasonal crops etc and the many

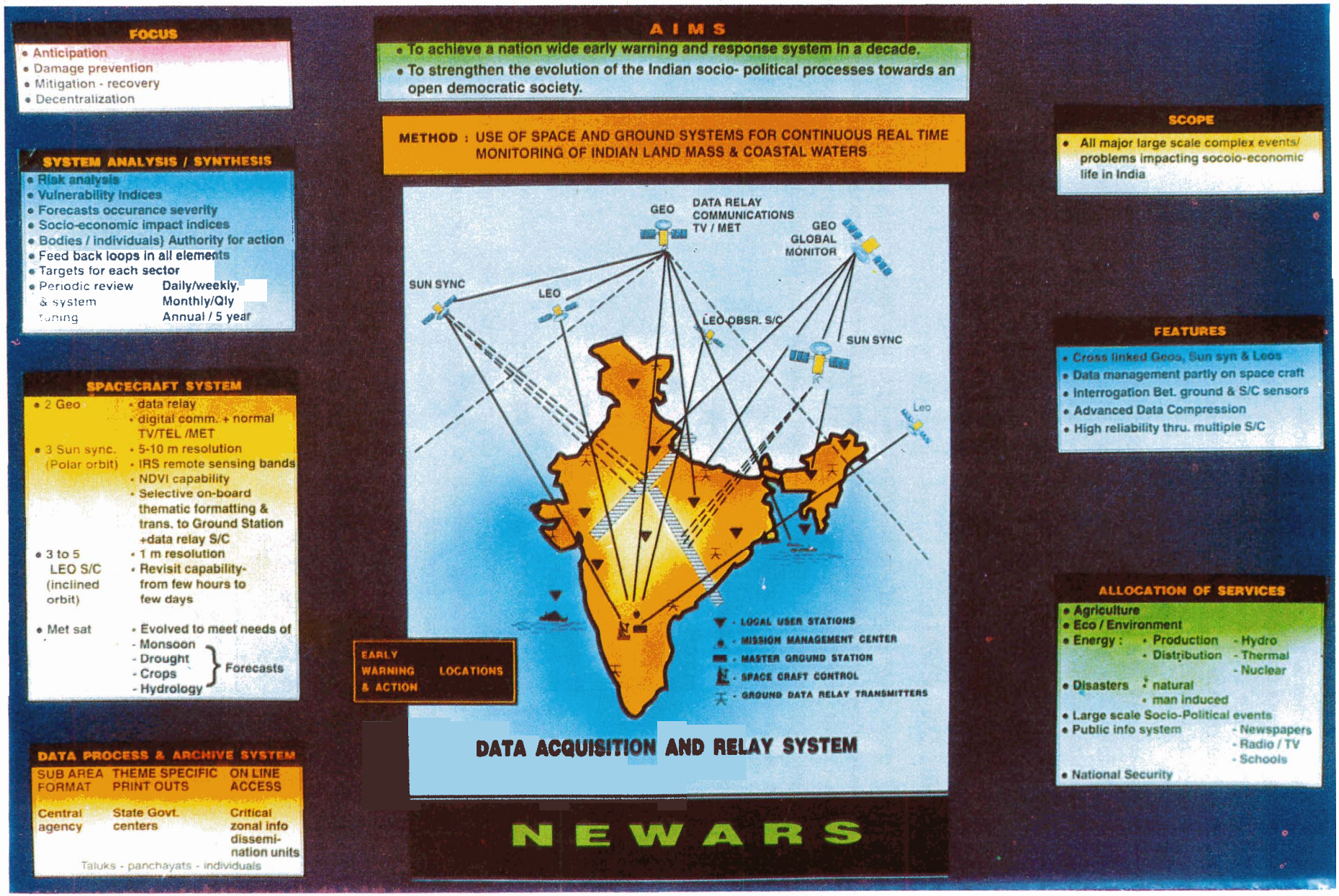

FOCUS
• Anticipation
• Damage prevention
• Mitigation - recovery
• Decentralization
AIMS
• To achieve a nation wide early warning and response system in a decade.
• To strengthen the evolution of the Indian socio- political processes towards an open democratic society.
METHOD : USE OF SPACE AND GROUND SYSTEMS FOR CONTINUOUS REAL TIME MONITORING OF INDIAN LAND MASS & COASTAL WATERS
SCOPE
• All major large scale complex events/ problems impacting socio-economic life in India
SYSTEM ANALYSIS / SYNTHESIS
• Risk analysis
• Vulnerability indices
• Forecasts occurance severity
• Socio-economic impact indices
• Bodies / individuals} Authority for action
• Feed back loops in all elements
• Targets for each sector
• Periodic review & system tuning
Daily/weekly, Monthly/Qly Annual / 5 year
GEO
DATA RELAY COMMUNICATIONS TV / MET
GEO GLOBAL MONITOR
SUN SYNC
LEO
LEO OBSR. S/C
SUN SYNC
Leo
FEATURES
• Cross linked Geos, Sun syn & Leos
• Data management partly on space craft
• Interrogation Bet. ground & S/C sensors
• Advanced Data Compression
• High reliability thru. multiple S/C
SPACECRAFT SYSTEM
• 2 Geo
• data relay
• digital comm. + normal TV/TEL /MET
• 3 Sun sync. (Polar orbit)
• 5-10 m resolution
• IRS remote sensing bands
• NDVI capability
• Selective on-board thematic formatting & trans. to Ground Station +data relay S/C
• 3 to 5 LEO S/C (inclined orbit)
• 1 m resolution
• Revisit capability- from few hours to few days
• Met sat
• Evolved to meet needs of
- Monsoon
- Drought
- Crops
- Hydrology
} Forecasts
EARLY WARNING & ACTION LOCATIONS
• LOCAL USER STATIONS
• MISSION MANAGEMENT CENTER
• MASTER GROUND STATION
• SPACE CRAFT CONTROL
• GROUND DATA RELAY TRANSMITTERS
DATA ACQUISITION AND RELAY SYSTEM
ALLOCATION OF SERVICES
• Agriculture
• Eco / Environment
• Energy : • Production - Hydro
• Distribution - Thermal
- Nuclear
• Disasters : • natural
• man induced
• Large scale Socio-Political events
• Public info system - Newspapers
- Radio / TV
- Schools
• National Security
DATA PROCESS & ARCHIVE SYSTEM
SUB AREA FORMAT
THEME SPECIFIC PRINT OUTS
ON LINE ACCESS
Central agency
State Govt. centers
Critical zonal info dissemi-nation units
Taluks - panchayats - individuals
NEWARS

Fig. 7

other identified bodies with assigned responsibilities a state of preparedness would come into being across the country without provoking alarm or crisis. As the days, weeks, months go by, each element of the system would compare their forecast information with the 'reality' and proceed to take already identified protective, ameliorative or normal actions. Integrated across the country as a whole one can visualize INDIA at work!

6.3 As the state of readiness & effective countermeasures evolve, the benefits across the country down to taluk level & urban & rural groups & individuals would be in real socio-economic terms & of well being and a spirit of confidence - a sadly missing component in the dismal picture usually built up by the prophets of doom & not dispelled by the 'air dashes' of ministers or the announcements of relief to the victims with red tape worms nibbling away at each step - recall the tragedy of Bhopal, a decade after the horror!

7.0 NOTES ON NEWARS:

Fig. 7 gives a synopsis of the NEWARS concept. The AIMS-FOCUS-SCOPE-FEATURES and the Services are shown in summary form. The System is based on the concept of Risk Analysis & Vulnerability Indices. In virtually all areas/aspects historical records would be extensively used supplemented by more recent information & data produced by the NNRMS & INSAT Systems in cooperation with major national agencies.

THE MAIN AREAS to be covered include:-

- Agriculture
  Geology
  Plants & Forests
  Soils
  Industry & Mining
  Ecology & environment
  Urbanization
  Transport & Energy Sectors, etc. etc.,

The System Analysis & Synthesis would use modern modeling techniques incorporating past information & use forecasting methods to anticipate events & occurrences, through an understanding of the principles involved.

7.1 A quick glance at the complex components brings out the challenge & complexity.

Fig.8 to 12 illustrate the Scale & Nature of the components which must be addressed.

Fig.8 ... depicts the 15 Agro climatic zones covering India
- each zone has its own specific elements to be monitored, collated and forecast.

Fig.9 ... illustrates 3 major crops: Wheat, Rice & Sugarcane.
- the zones overlap & are subject to various hazards & vital to the nations food supply.

Fig.10 ... shows the land degradation zones & the severe limitations they impose on Agricultural productivity - causes need to be identified and solutions found.

Fig.11 ... shows the zones subject to natural disasters.

Fig.12 ... shows in summary form, the National Transport, Irrigation & Urban network which is subject to severe strain by disasters. Along with the Communications network this forms the backbone of the Response System.

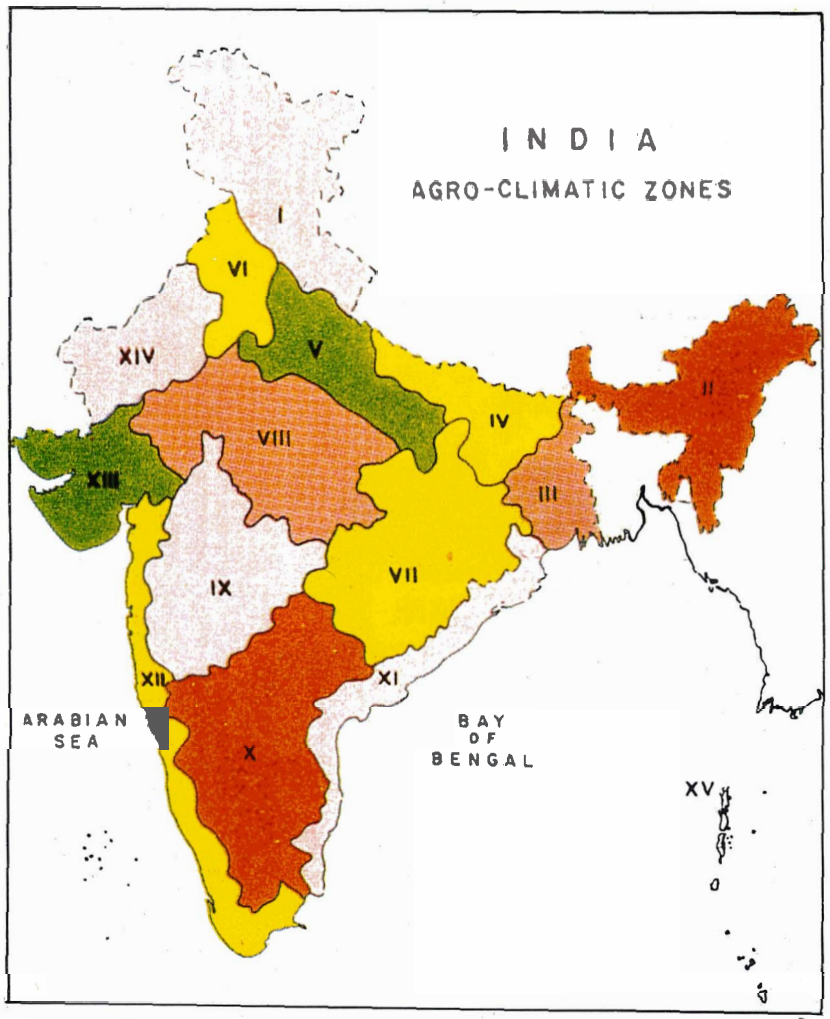


Fig. 8

ZONE – I	:	The Western Himalayan Region
ZONE – II	:	The Eastern Himalayan Region
ZONE – III	:	The Lower Gangetic Plain Region
ZONE – IV	:	The Middle Gangetic Plain Region
ZONE – V	:	The Upper Gangetic Plain Region
ZONE – VI	:	The Trans-Gangetic Plain Region
ZONE – VII	:	The Eastern Plateau & Hill Region
ZONE – VIII	:	The Central Plateau & Hill Region
ZONE – IX	:	The Western Plateau & Hill Region
ZONE – X	:	The Southern Plateau & Hill Region
ZONE – XI	:	The East Coast Plain & Hill Region
ZONE – XII	:	The West Coast Plain & Ghat Region
ZONE – XIII	:	The Gujarat Plain & Hill Region
ZONE – XIV	:	The Western Dry Region
ZONE – XV	:	The Island Region – Andaman & Nicobar

AGRO-CLIMATIC ZONES

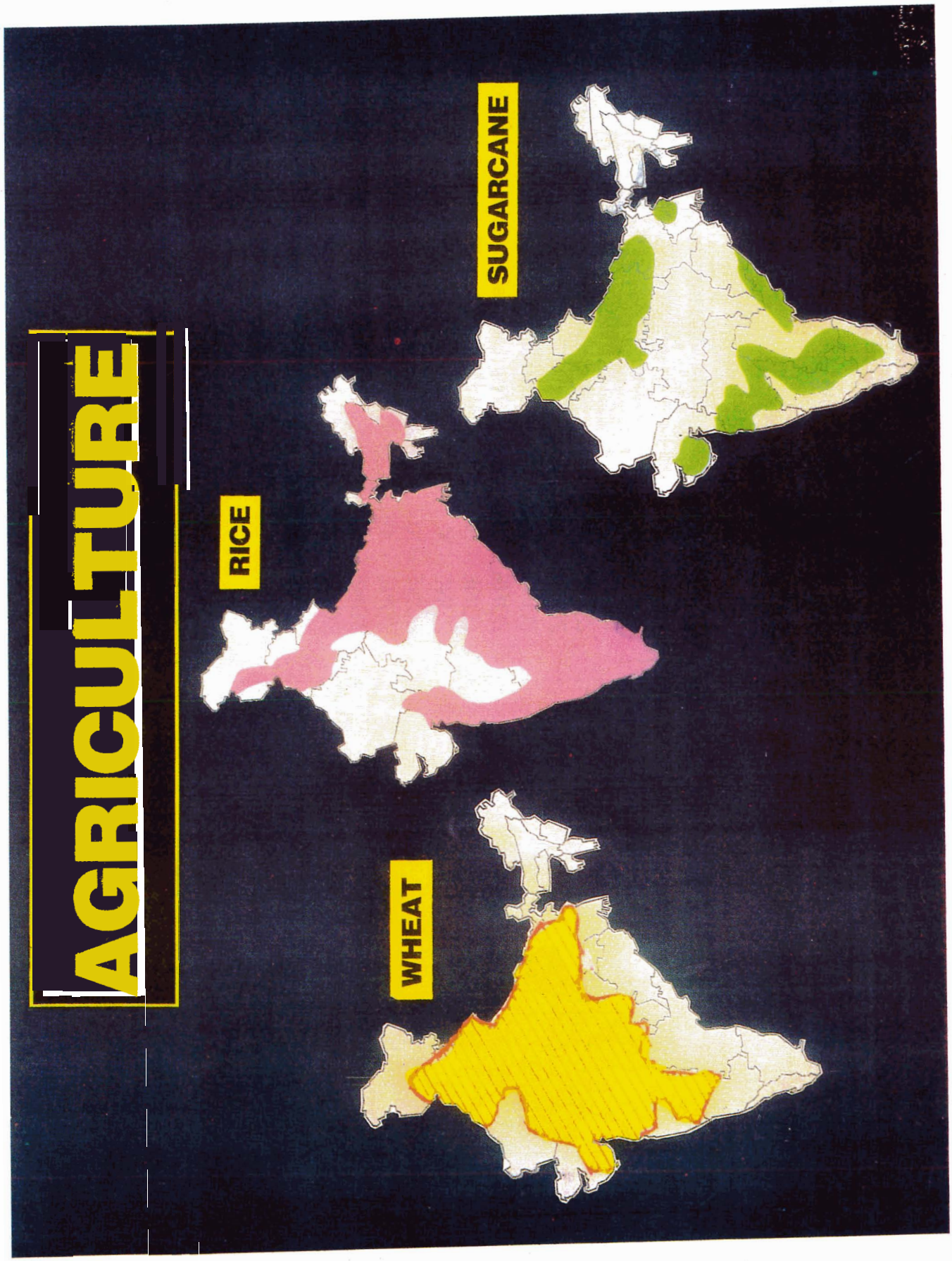
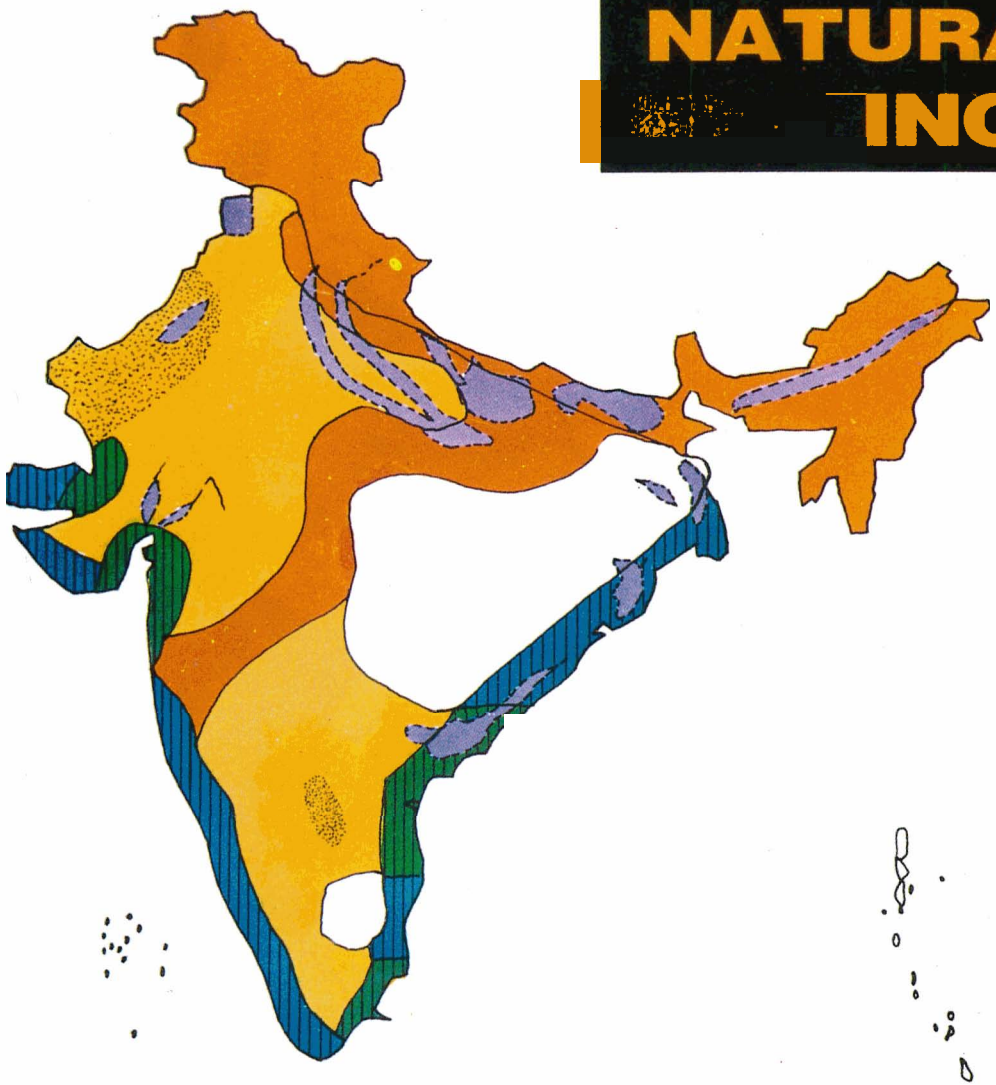


Fig. 9

LAND DEGRADATION
STRESS FROM ACIDIFICATION AND SCARCITY OF FIRE WOOD
POPULATION EXCEEDS CARRYING CAPACITY OF LOCAL AGRICULTURE
HIGH RISK OF DESERTIFICATION

Fig. 10

NATURAL DISASTER INCIDENCE



☐ DEFICIENT SOIL

CYCLONE PRONE

DROUGHT PRONE AREAS

EARTH QUAKE PRONE

FLOOD PRONE AREAS

Fig. 11

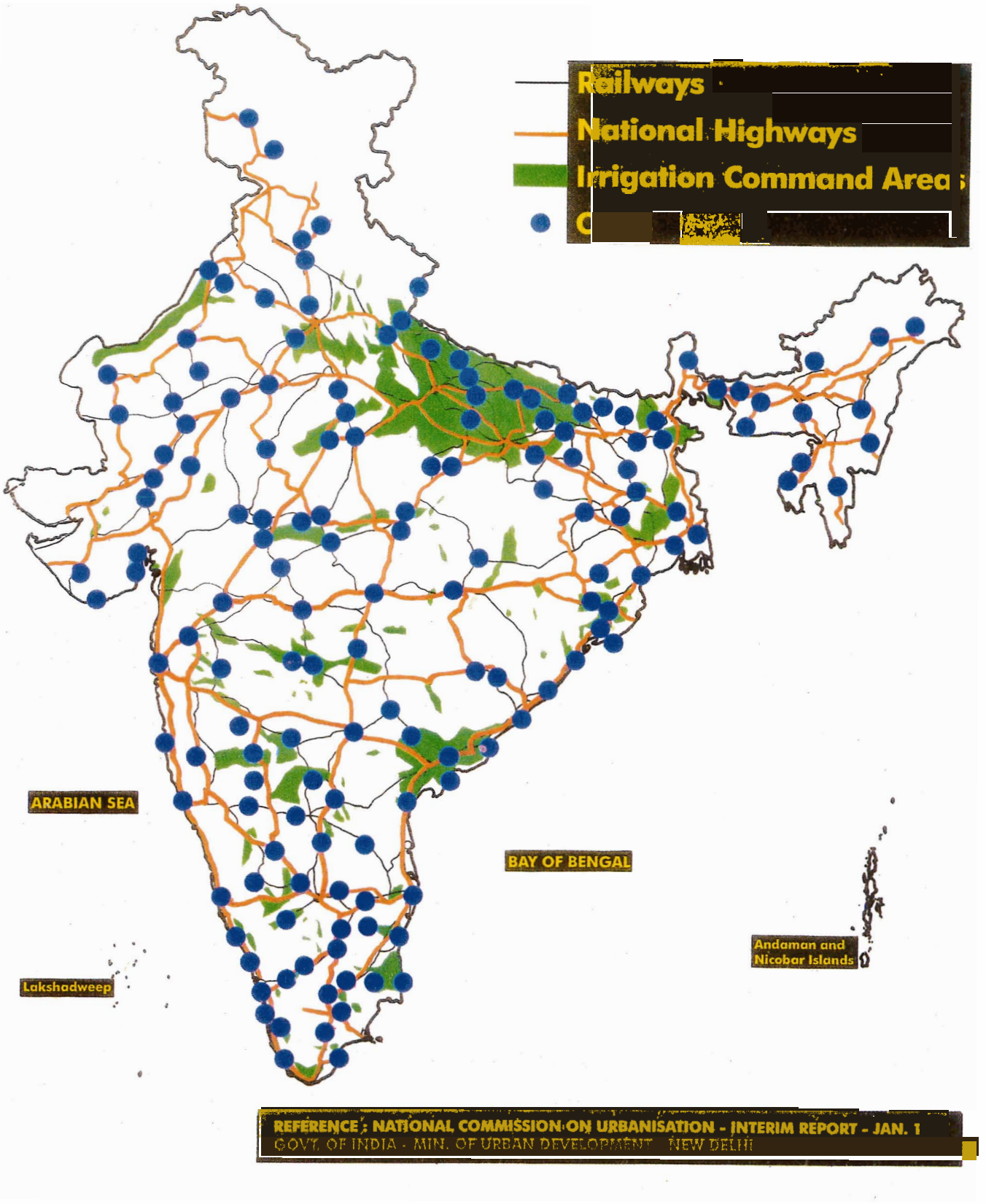

Railways
National Highways
Irrigation Command Area
ARABIAN SEA
BAY OF BENGAL
Andaman and Nicobar Islands
Lakshadweep
REFERENCE : NATIONAL COMMISSION ON URBANISATION - INTERIM REPORT - JAN. 1
GOVT. OF INDIA - MIN. OF URBAN DEVELOPMENT NEW DELHI

Fig. 12

NEWARS encompass all the above elements and one can envisage in addition during the course of growth:

*	Smuggling - Land & Sea	Loss to the economy Distress to fisher & farm folk Illegal intrusions into Indian Territory
*	Large Scale community gatherings - Amarnath-Sabarimalai-Kurukshetra - Sravanabelagola Holy fairs at Sangams	Pilgrimage Areas (Oct. 29, 1995) 10 lakh persons Holy Dip) A million visit Sabarimalai Accidents, Illness etc.
	Population migrations	Bangladesh displaced. Biharis driven towards Delhi
	Large scale Epidemics -	Induced by Natural/Man made disasters/ spread of VIRUS etc.
	Insurgency & Terrorists & National Security	Disruptive of Civil life India's borders and within the country.

7.2 Obviously the predictive component and the time scales & formats for data transfer would vary. It is in the transformation of the acquired data/information into a variety of practically useful forms that the challenge lies. Geographic information systems are already showing how effective multiple uses emerge from a basic set.* The planning & execution of such a system would need detailed system analyses, studies & experimental pilot phases. Particular attention would need to be paid to the content & means of transmission of Information Advanced digital data compression techniques will be called for. The basis of the requisite information would be ground stations plus space based sensing & monitoring. The information transfer would require ground satellite links to central receiving & formatting facilities from which periodic (daily, weekly, monthly) output in multi-forms would go to designated focal points & the public. Fig.7 gives a view of the concept: The basis is already in place waiting to be harnessed to its logical purpose - The well being of the Indian Sub-continent. Within the ambit of such an Early Warning & Response System would come, step by step, all kinds of natural disasters as well as man made ones Figs.8, 9, 10, 11 and 12.

8.0 SPACE COLONIES - A second avenue for Astronauts ?

Science Fiction writers and imaginative scientists have for many years written and dreamt about colonizing & creating an Earth-like environment on the Moon or another planet like Mars. Others have speculated about extended journeys in the vastness of the Universe. In recent years serious attention is being paid to what has been termed "ECOPOIESIS", PLANETARY ENGG & TERRA FORMING: (13). - The fabrication of a self sustaining ecosystem on an hitherto lifeless planet. Before we briefly look at the technical aspects it is necessary to note some broader issues.

8.1 The future of Cosmic Exploration cannot be bereft of the destiny of humans as a vital &

* Ref. 12(a)/12(b)

unique part of living beings. If we blew up the earth or make it uninhabitable for all life forms which have evolved over millions of years who will explore the Cosmos and for whom ? Modern civilization is still beset with acute problems - some a legacy of the past and many more generated by the often mindless exploitation of the natural resources of the Earth. The further evolution of modern human society will depend not only on Scientific & Technological advances but even more on the socio-political framework and interests of not only the present but also the future generations must be included. Hopefully the approach would veer away from the rather authoritarian, centralized manner of the past and be more open. Informed & serious discussion, democratically & openly conducted, is the only sane way toward achieving civilized ends. Wishful thinking? Perhaps! But is there an alternative?

8.2 The way Space programs have been usually planned and evolved in the past holds several lessons. The decision making process has generally been charted by 'internal' choices - internal to a group or faction; by the Ruling Elite - the Science & Technology elite - the Cold Warriors and now in a Unipolar World by the Globe Dominators who talk about 'Global Villages' but imply a nicely controlled arena with invisible walls! The planning & decision making process for large scale complex enterprises has been by special interest groups - Science & Technology driven, OR Political Prestige & Power driven - all under the banner of PROGRESS. Thus the alternatives posed: Robots in Space or Earth Sciences -

Space Stations & or Space Ferries, Colonies on the Moon, Planets or the Asteroids - all leave out the inhabitants of the earth who pay for all of it - No matter which alternative wins, the process & therefore the result, emerges through an esoteric procedure which ends up in a pyramidal system - in Space & on the ground. It should be obvious that large & complex enterprises operating in a high risk environment for long periods do tend to create very strong tendencies for centralized control & decision making - not only in the technical but also in the human management aspects. Such tendencies can have dangerous socio-political implications unless the planners build in checks & antidotes from the start.

8.3 Monolithical organizational structures get shaped after Military hierarchies & the Socio-Political equivalents follow - however subtly disguised by twists & turns in vocabulary - If you ponder over the rise & fall of the great Civilizations of the past, you can see the tendencies & pitfalls of centralization in a historical perspective - Egypt,Mesopotomia, the Indus Valley - even the Greeks did not escape. Witness the fate of Socrates! Historically somewhere along the line there also evolved the spirit of scientific enquiry and the flame of individual liberty and democratic processes was lit.

8.4 If large scale ventures into Space are not consciously & firmly rooted in the Values & Ethics evolved over centuries on Earth, then the projects & programmes and their results are likely to give rise to de-humanized systems & in the final analysis, these are likely to be diametrically opposed to and unmindfully intolerant of the subtler & gentler but more difficult traits for which humanity today yearns. Karl Popper has set the philosophical issue out in his discourses on the OPEN SOCIETY & ITS ENEMIES.* Leaders & Pioneers of Science and Thought have in the past often risen to the occasion – Buddha & Mahavira, Ashoka, Gandhi & Nehru – Aryabhata & Bhaskara,

* Ref. 14

Galileo & Gutenberg, Bertrand Russell, Neils Bohr & Einstein. They were not only great intellectuals but also champions of liberty & democratic values - surely it is time that Space visionaries of today move from their confined adulation of pioneers of Rocketry & Voyages to the Moon to the adoption of value systems through which the civilization of tomorrow may be reached.

8.5 The Indian Space Programme was fortunate at its beginning to have in Vikram Sarabhai a visionary aware of values & ethics in using Science but it is not likely to escape the tendencies & vissicitudes of centralization & dehumanization. Without serious & conscious effort from the Astronautics community & support by people at large this is likely to happen. SITE was a vision but how are the INSAT spacecraft used? How will Gramsat be saved to give effect to the Directive Principles of the Constitution asking for free & compulsory education of the millions? In spite of serious efforts to reach the taluks, the NNRMS is largely a centralized system with a large component of bureaucracies - public & otherwise. No doubt it takes years to build up the wherewithal for going into space and existing political & other structures cannot be easily bypassed. But it is important to realize that the nature of the means used can overshadow the ends and Space is not a trivial means! All in all, India has a programme which in many features differs from those of other Space Faring Nations - it is relatively open, not unmindful of the real needs of the people of India and enjoys support from large sections of the population. It is sensitive to the problems of the degrading environment and the urgency to move towards sustainable ways of living. But also inherent are the tendencies to "keep up with the Jones's, 'High Technology' and Higher Jargon of "Conquering Heavens"! "Space for Mankind" may conceal the drift toward projects like those of the other SPACE POWERS. It will need inspiration, conviction & hard work to steer the ASTROSHIP towards the lowly beings inhabiting the earth.

9.0 PLANETARY ENGINEERING:

To get back to Planetary Engineering etc & what ethics minded Astronautics Professionals might do. Here we can only sketch the principal elements (Fig. 13).

ECOPOIESES	**FABRICATION OF AN ECOSYSTEM ON A LIFELESS PLANET**
PLANETARY ENGG.	**APPLICATION OF ENGG. & SC. TO CHANGE PLANETS FOR HUMAN USE**
TERRA FORMING	**CREATION OF AN AEROBIC BIOSPHERE ON ANOTHER PLANET A SECOND INHABITABLE EARTH**

Fig. 13

First some definitions:

- Ecopoieses — A term coined by R.Haynes from the Greek (The words' Greek root means the making of a home) it implies the fabrication of an ecosystem or biosphere on a lifeless planet.
- Planetary Engineering — Implies application of Engineering & Scientific principles to planets to change them to suit human purposes.
- Terra Forming — Implies creation of an Aerobic Biosphere on another planet,suitable for humans & higher animals - in effect a second inhabitable Earth.

People have also been proposing & discussing PANBIOTIC MISSIONS, by which they imply the propagation in the Universe of the basic DNA based units of life found on Earth.

9.1 Before briefly seeing what would be involved in Planetary Engineering we note that serious ethical questions have been raised :

(a) Is it morally justified for Man to change the climate & environment of another planet?

(b) If life exists on the planet has Man the right to modify the ecosystem to suit humans? - this may harm the life forms there - a problem man has encountered on Earth & is yet to fully understand & solve.

(c) If no life exists on the planet is it right to change the conditions to suit earth based life?

Future space missions cannot escape facing such issues.

9.2 We can now take a brief look at what would be involved in Terra-forming a planet. The cases which have been studied include the Moon,Venus,Mars as well as the moons of Jupiter and also the planets of Stars other than the Sun. We will take Mars as an example. Mars contains all the raw materials to support life and humans - see Fig.14, Fig.15 and Fig.16. Terra-forming MARS would involve warming the planet and altering its chemical state. The aim would be to change the atmosphere so that eventually it becomes Oxygen rich with Carbon,H_2 ,N_2 & some rare elements to support life. The atmosphere must recycle indefinitely as organisms need the elements for life processes. Carbon Dioxide pressure must be high enough for photosynthesis (on earth it is 0.35 millibar). Micro-organisms do the bulk of the recycling on Earth - so this could be the agent of change. The average temperature must be raised to above 0° C so that liquid water can exist.

9.3 As experience on the Earth has shown, if "greenhouse gases" - CO_2, Methane & CFC's can be introduced in sufficient quantities into the Martian atmosphere the process of warming could be speeded up. The problems of transporting sufficient quantities from the Earth and attaining equilibrium would have to be solved. Sending Spaceships with the gases would be prohibitively expensive as millions of tons would be involved. Setting up industrial factories on Mars

would need large scale use of Nuclear Power, producing the machinery etc with humans in enclosed habitats. Technically these are assessed to be feasible but the time scales stretch from hundreds to thousands of years.

MARS		
MEAN DISTANCE FROM EARTH	.....	78 MILLION KM
GRAVITY LEVEL	.....	0.38 G
SUN LIGHT	.....	43% OF SUNLIGHT ON EARTH
SURFACE TEMPERATURE	.....	-60°C
ATMOSPHERE	.....	95% CO_2, PERMAFROST NO RECYCLING 3% N_2 2% ARGON
WATER	.....	NO LIQUID WATER FROZEN CO_2 + H_2O ICE ON POLES
LIFE FORMS	.....	DO NOT EXIST
RAW MATERIALS	.....	CARBON NITROGEN HYDROGEN OXYGEN

Fig.14

9.4 Fig.17 shows a Terraforming scheme for MARS studied by M.J.FOGG (13). The aim is to create a Bio-generative life support system - i.e. an environment that :

- Produces Food
- Purifies Air & Water
- Recycles Wastes

The essential Dynamics are ENERGY FLOW & MATTER CYCLING.

The Thermo Dynamics is such that the BIOSPHERE is:

(a) A FAR FROM EQUILIBRIUM SYSTEM

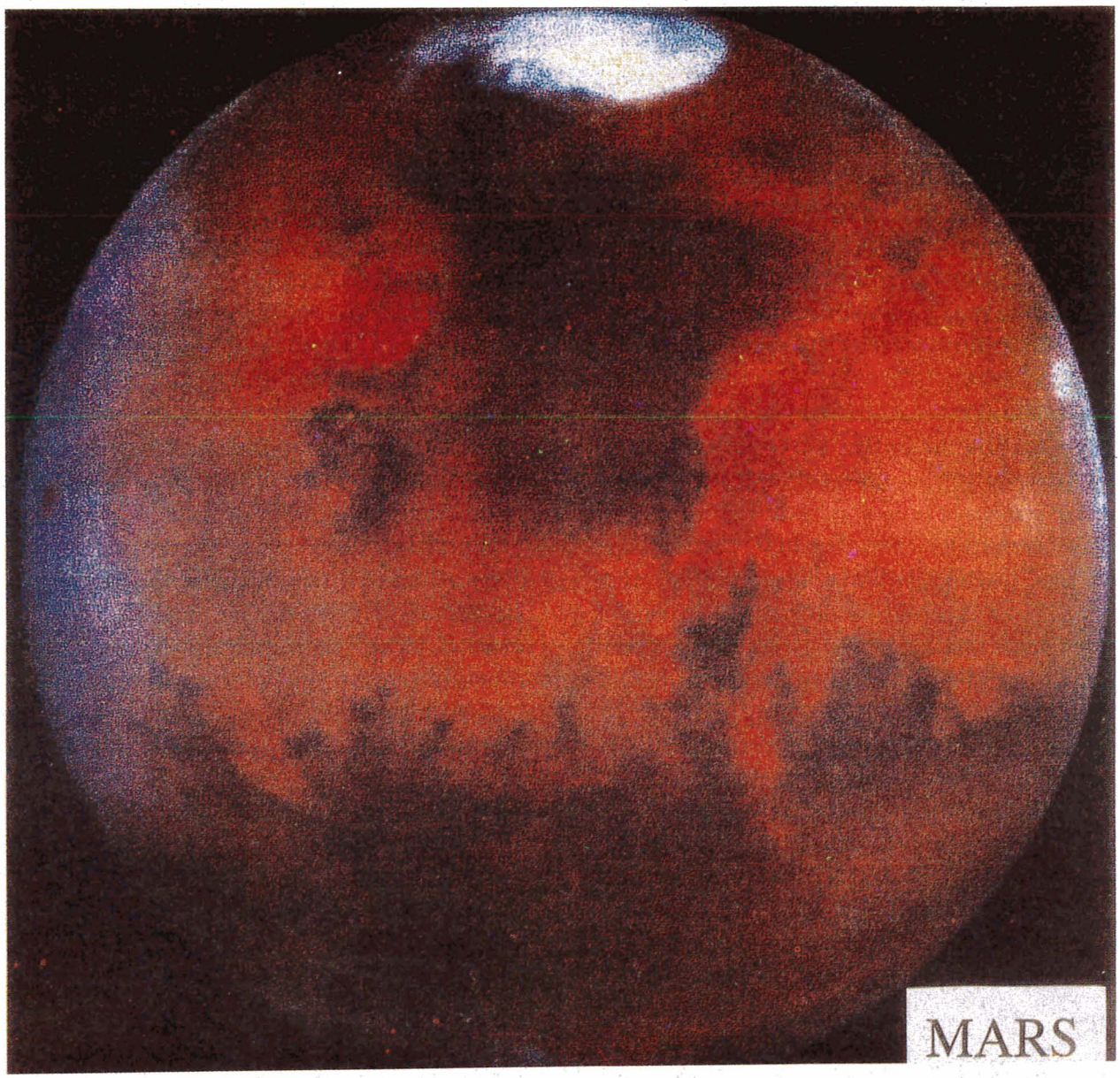


Fig. 15

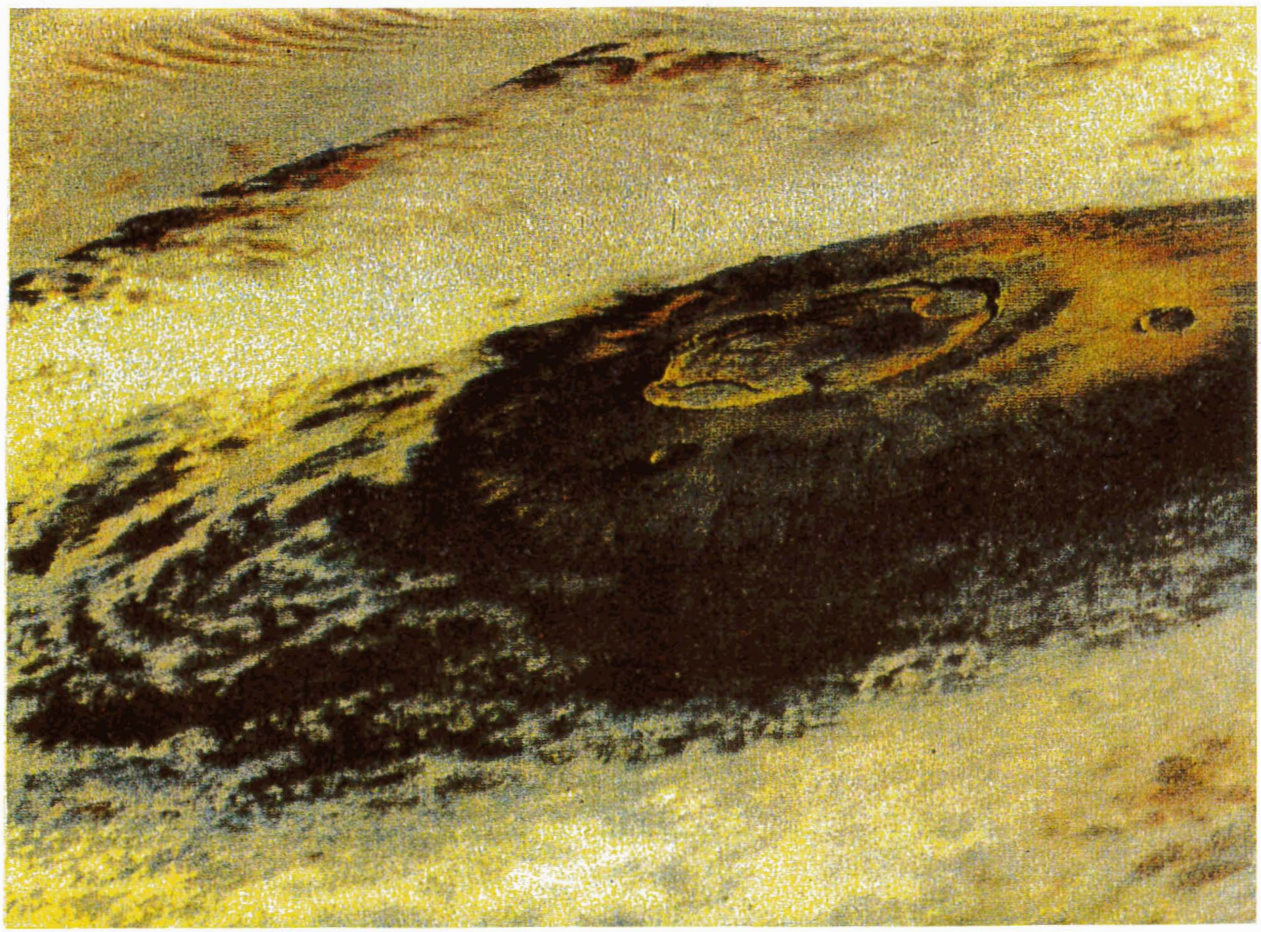


Fig. 16: (Top) Mars as seen from the Viking 2 Lander;
(Bottom) Olympus Mons, the largest Martian volcano (NASA)

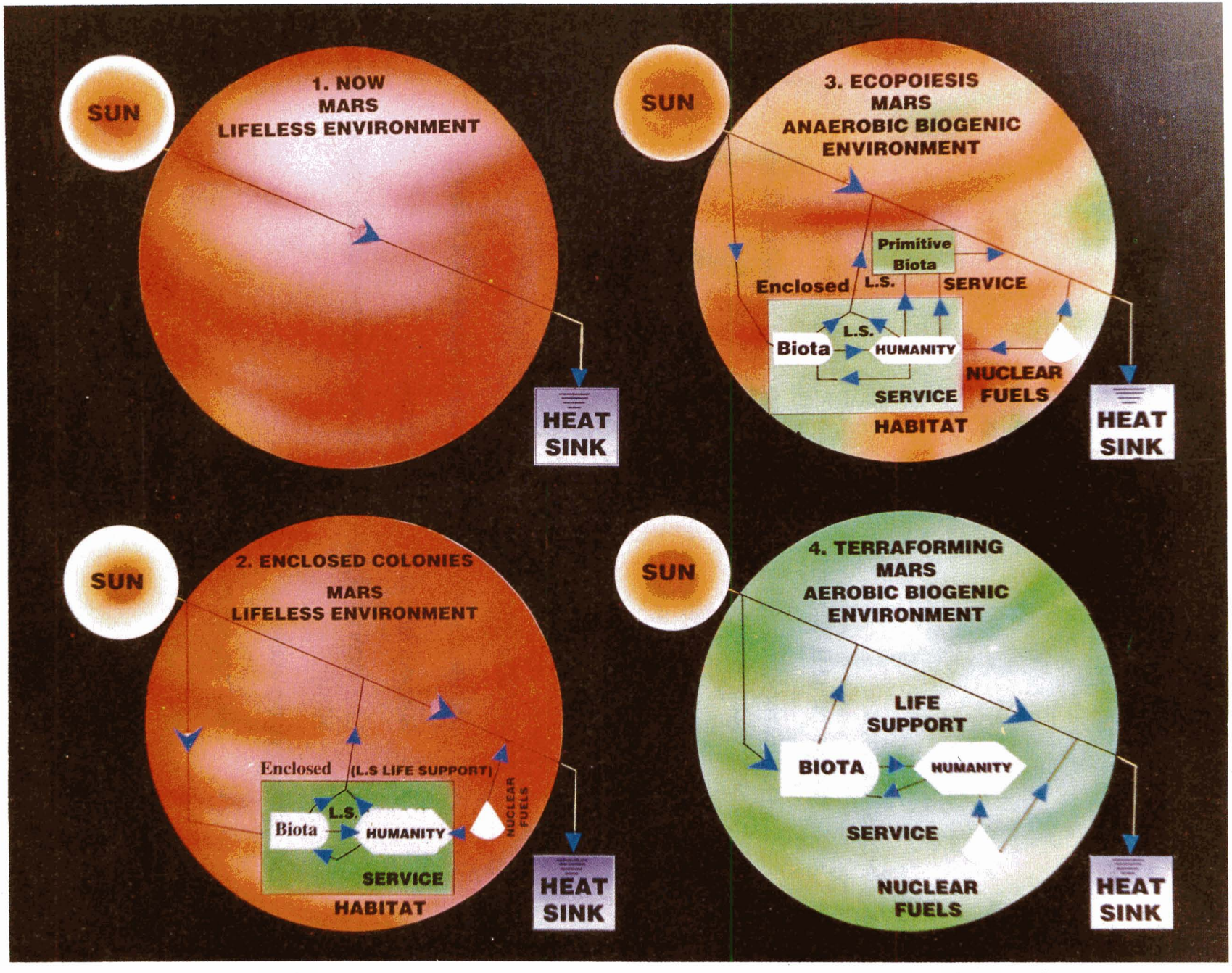

SUN
1. NOW
MARS
LIFELESS ENVIRONMENT
HEAT SINK
SUN
3. ECOPOIESIS
MARS
ANAEROBIC BIOGENIC
ENVIRONMENT
Primitive Biota
Enclosed
L.S.
SERVICE
Biota
L.S.
HUMANITY
SERVICE
HABITAT
NUCLEAR FUELS
HEAT SINK
SUN
2. ENCLOSED COLONIES
MARS
LIFELESS ENVIRONMENT
Enclosed
(L.S LIFE SUPPORT)
Biota
L.S.
HUMANITY
SERVICE
HABITAT
NUCLEAR FUELS
HEAT SINK
SUN
4. TERRAFORMING
MARS
AEROBIC BIOGENIC
ENVIRONMENT
LIFE SUPPORT
BIOTA
HUMANITY
SERVICE
NUCLEAR FUELS
HEAT SINK

Fig. 17

(b) IT IS MAINTAINED IN A HIGHLY ORDERED STATE BY ENERGY TRANSFORMED FROM LOW TO HIGH ENTROPY STATES. Thus:

SOLAR ENERGY MATTER	STORED IN CHEMICAL COMPOUNDS REPROCESSED BY RESPIRATORY PROCESSES & ORGANISMS	PROVIDE POWER THRU FOOD CHAIN

9.5 NOTES ON FIG.17 :

1 SHOWS THE LIFELESS MARS

ENERGY FROM THE SUN FLOWS THROUGH MARS & IS DISSIPATED AS HEAT - RADIATED INTO SPACE AS INFRARED.

2. INITIAL SETTLEMENT OF HUMANS IN ENCLOSED HABITATS – MOST OF THE SOLAR ENERGY STILL DISSIPATED.

3. SMALL SCALE PLANETARY ENGG. HAS PRODUCED AN ANAEROBIC BIOSPHERE

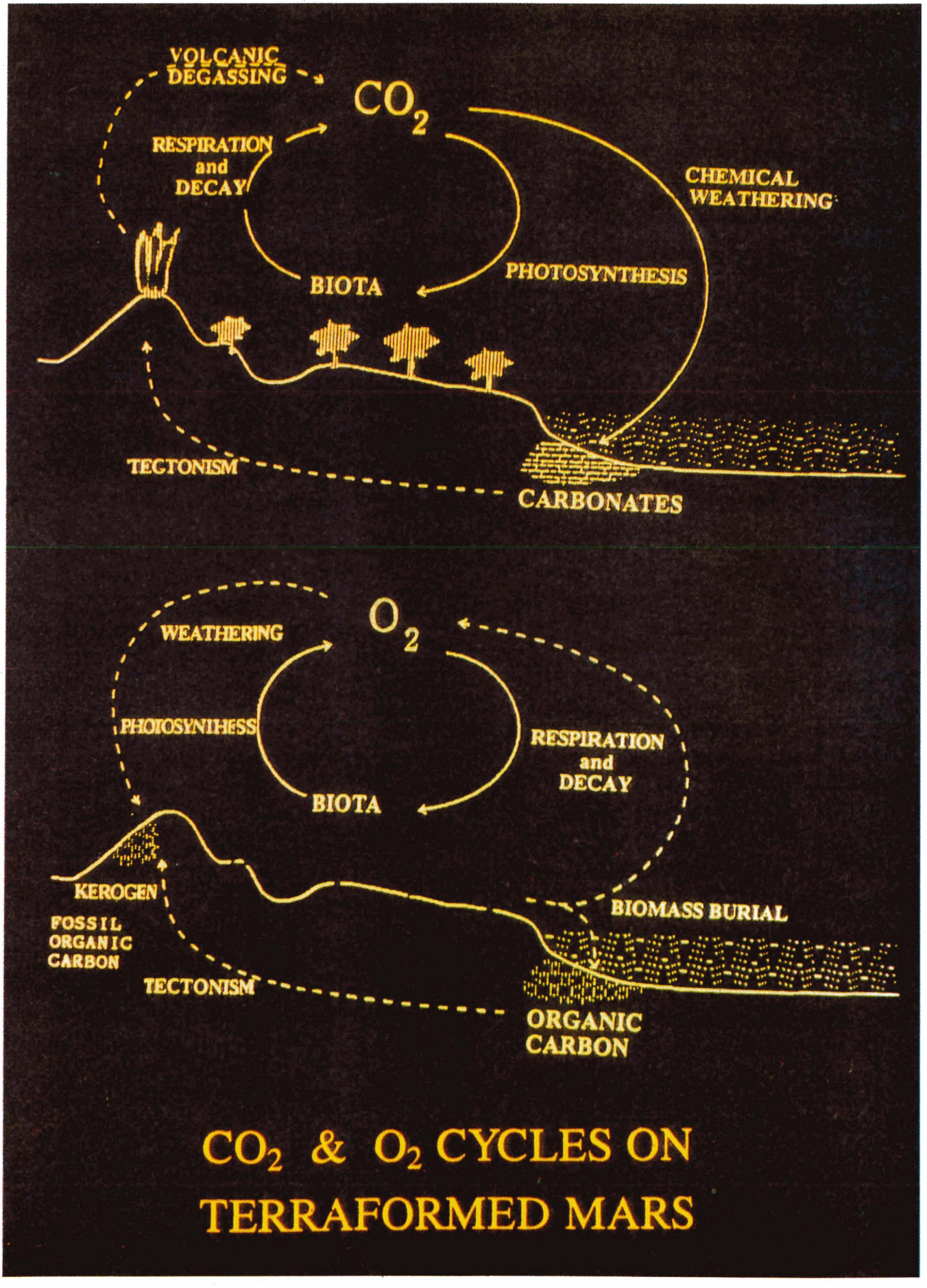
- ATMOSPHERIC CO_2 PRESSURE HAS RISEN
- MARS SLOWLY THAWING
- BACTERIA & PRIMITIVE PLANTS ON THE PLANET CAN SURVIVE
- HUMANS STILL IN ENCLOSED HABITATS
- DIVERSION OF SOLAR ENERGY FOR BIO PURPOSES BEGUN ON FAIRLY LARGE SCALE

4. TERRA-FORMED MARS :

- AEROBIC BIOSPHERE
- RECYCLING OF WATER-ATMOSPHERE- EARTH WASTES
- SUPPLY OF FOOD

FIG.18 DEPICTS the APPROXIMATE CARBON & WATER CYCLES ON THE TERRAFORMED MARS.

THE EFFICIENCY and long term SUSTAINABILITY is still an open question requiring more research.



CO_2 & O_2 CYCLES ON TERRAFORMED MARS

9.6 There are many other questions, ideas & schemes under discussion & research. Essentially these focus on :

- How to speed up the processes
- How to reduce cost & effort
- How to foresee problems & pitfalls etc,etc.

There are schemes to change the speed of Rotation, modify the ORBIT of planets - all to hasten or improve Terra-forming.

One interesting scheme suggests introducing Genetically Engineered Micro-Organisms - The Mars BUG - this has traits which help it survive and release CO_2 & N_2 faster from Carbonate & Nitrate deposits - such micro-organisms have been given the name GEMOS:- Genetically Engineered Micro Organisms.

9.7 At this stage it is useful to remind ourselves of the TIME SCALES : From 1000 TO A MILLION YEARS!

ON EARTH
- a few 100 million years to form single cell bacteria
- 2 billion years to form complex cells with nuclei
- 100 million years to form multi-cellular organisms

All subsequent developments 600 million years – Can Earth Systems – Scientific, Economic, Socio-Political sustain support for the long periods involved? Will ISRO still exist?

9.8 Some people regard Planetary Engg. as one of the most extra-ordinary & worthwhile creative ideas of all time. Through its realization our civilization may be able to achieve major benefits. It is a prospect which we can only dimly perceive. If Scientists along with the general public can sustain active interest in the idea, it may help mankind to move towards a better world. Can the Astronautical Society help? One may ask : Can the advent into Space provide a moral and practical substitute for WAR? War between peoples & also Man's war on the ECO SYSTEMS? Can exploring the Solar System fulfill a psychological need & also unify Mankind?

10.0 CONCLUDING REMARKS:

Civilizations have for long sought answers to problems of existence. In the last half a century it has slowly dawned on Mankind that of the great variety of Life Forms on the Earth, one of them - Homosapiens - has reached a stage when its actions are endangering the Globe. The Sceptic asks : "What is the moral justification for exploring the Planets & Stars when there is so much Hunger, Misery, Poverty & Strife on Earth? The Optimist says: Programmes which focus on Space & encounter complex issues of survival in a hostile environment, facing unexpected dangers & situations & overcoming them - enhance Man's capability to face the Unknown & Survive as a truly civilized being.

10.1 Collectively can Mankind enhance its capabilities to evolve a Civilization on Earth which is more humane, sensitive & harmonious not only to humans but to all forms of life? If yes, then we go into Space to Understand & Resolve problems of Life on Earth -

* JOURNEYS IN SPACE & TIME are SYMBIOTIC with MATTER, MIND & VALUES

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