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DESIGN CARE NEEDS FOR THE TRANSFER OF REMOTE SENSING TECHNOLOGY CONCEPTS TO THEMATIC PROFESSIONALS

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Abstract. Space based technology has been providing precise data sets on natural resources such as agriculture, forest, soil, geomorphological and geological features useful for narrowing down the area of search for minerals, hydrocarbon and ground water resources besides providing information on drought, snow-melt run-off and flood inundation. The coarse resolution of meteorological satellite data is used for monsoon forecasting, cyclone and disaster forecasting, and forecasting of potential fishing zones in oceanic region. The geographers are looking for human interventions to nature by studying landuse / landcover patterns which has been resulting in identification of wastelands, urban sprawl etc. Such wide scenario of social, natural and earth scientists form the user spectrum for remote sensing technology.

Complex interactions of all these disciplines are now threatening the future of planet Earth through climate change and its enlarged scope given by global change which includes the human dimension of climate change. This involves modelling of Earth systems science when we are still struggling to forecast weather (one component of Earth System) using super computer.

Remote sensing technology is driven by engineering, physics and computer sciences. The image processing, pattern recognition (both statistical and artificial neural network based) with additional complexity - handling tools emerging from fuzzy logic and chaos theories are opening new areas of information mining from vast data sets provided by space based measurements of earth and its environment.

Thus imparting training and education in remote sensing technology to mix-up of social-natural sciences (with few engineers and physics background persons) resource persons poses challenge as technological concepts have to be transferred graphically without involving the language of mathematics. To achieve the hand-in-hand transfer of knowledge as well as analysis skills, the emphasis has to be on **Experiental Learning** through **Productive Tasks** rather than **Reception Learning** through **Reproductive Tasks** which has to be achieved by clearly defining **Enabling, Training** and **Performance** objectives.

To cater to wider and heterogeneous entry behaviour of trainees, trainer has to tune the delivery by using the principles of **must, should** and **could.** Normally trainer has to practice **must** (core learning) and **should (**the possible content which helps to put the learning in

context). To satisfy the inquistiveness of trainees with engineering and physics background, trainer could sometime venture into **could** (providing of interesting background information).

Trainer has to use facts, procedures, concepts and principles for transferring knowledge; and thinking, acting, reacting and interacting mechanisms for transferring skills. Here trainer has to practice following modalities: (1) Start from what is **Known** to what is **Unknown,** (2) Start from something **Concrete** to one that is **Abstract**, (3) Start from the **General** and move on to the **Particular**, (4) Start from **Observation** and move to **Theory**, (5) Start with something **Simple** before making it **Complex** and (6) Start with an **Overview** before introducing **Details**.

The fast emerging technology makes us reach the upper part of sigmoid curve very fast and how to draw another sigmoid curve above the previous one is the continuous challenge for remote sensing oriented peer organisations.

1. Introduction

When the entry behaviour of trainees having different backgrounds was examined in the past, it was found that they come expecting that remote sensing, Geographic Information System (GIS) and Global Positioning System (GPS) technology would enable them to make decision not only precise but also accurate so that their error of analysis gets minimized. Thus, the training programmes need to be geared up so that these converge to such training objectives. The enabling objectives for such a need would cross the boundaries among different disciplines which will cover causative or forcing parameters related to weather and climate, biotic and abiotic pressures besides integrating the multiple resource themes. The step size for integration in GIS needs to be decided by the fastest changing variable (or set of variables). Hierarchical approach may be adopted wherein a process at ‘N’ level needs to have zero and first order continuity with reference to parameterized outputs at ‘N-1’ level and with the boundary conditions set by ‘N+1’ level. GIS platform could help in precisely defining the response functions and realistic linearizations of these at implementation level. Thus, Geomatics (Conventional Surveying, Remote Sensing, GIS and GPS) could lead to a Solution Providing Engine (SPE).

To achieve growth in intransitive and step function mode it is necessary that characteristics of training system are changed to training-cum-research system to ensure minimization of trainer’s entropy (Gupta and Rao, 1992). Before coming to application oriented solutions the research phase has to go through Basic Research for Knowledge Development, Basic Research for Mission Oriented goals and Applied Research.

Most of the trainees have professional expertise in their own field but are not conscious of error of analysis in the products delivered by their organisations. Any tool needs to provide 10 times better measurements as compared to error of analysis. It is necessary that second step of training program covers discussion mode of learning (as per principles of **Andragogy**) where trainees work in group to find out the error of analysis in currently practised mode of product delivery.

2. Training Methodology

Performance objectives of sponsoring organisations include incorporation of remote sensing technology in the currently practised methodology to achieve consistent and faster execution of task(s), identification of zones for intensive exploration from large area and achieving convergence in decision making by using ancillary and conventional information together with remote sensing based information.

Learning is the process whereby individuals acquire knowledge, skills and attitudes through experience, reflection, study or instruction. Training is a planned process to modify attitude, knowledge, skill and behaviour through learning experience to achieve effective performance in an activity or range of activities. Its purpose, in the work situation, is to develop the abilities of the individual and to satisfy the current and future manpower needs of the organisation. People learn as individuals, each with a unique and highly personal learning process ***while*** training is the process of organising an individual's learning to meet performance requirements. Thus for the success of training, each trainee should be able to achieve satisfactory performance with reference to performance objectives which is known as **Mastery Learning**. Figure 1 illustrates the typical learning curve and conveys that post-training motivation could only enable trainee to achieve the performance objective in an asymptotic manner. The learning event is tobe created to suit the **Entry Behaviour** of learner -- a challenging task for the designer of training programme. Entry behaviour refers to the existing behaviours of a learner in terms of knowledge, skills and attitudes previously learned which a learner brings-in while coming to training programme.

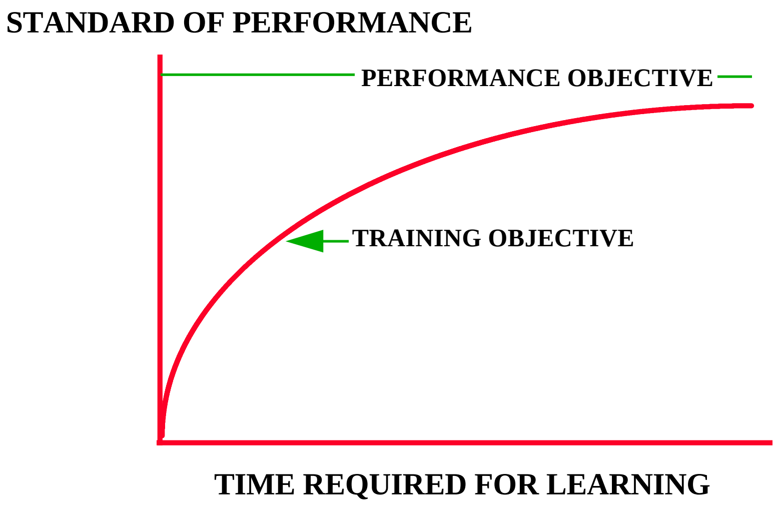

Figure 1: A typical learning curve

As the remote sensing and GIS technology is evolutionary in nature it is necessary to transfer knowledge and skills in generic manner, e.g., with reference to response of different objects in all the wavelengths instead of spectral bands of a given sensing system and thereafter integrate the response in wavelength range for a given band. Starting (even on the first day, just to inspire) with demonstration during image interpretation exercise, the trainee needs to explore the remaining segments of image (taking help of toposheet only; as toposheet is based on old information, the trainee is bound to see the variations in image - with reference to toposheet, which could be taken to advantage in developing the thought process) to develop productive (rather than reproductive) knowledge and skills in discovery mode, so that trainee could handle variety of situations while handling tasks in his organization in a discovery-learning mode. Figure 2 gives geometrical explanation of productive and reproductive skills.

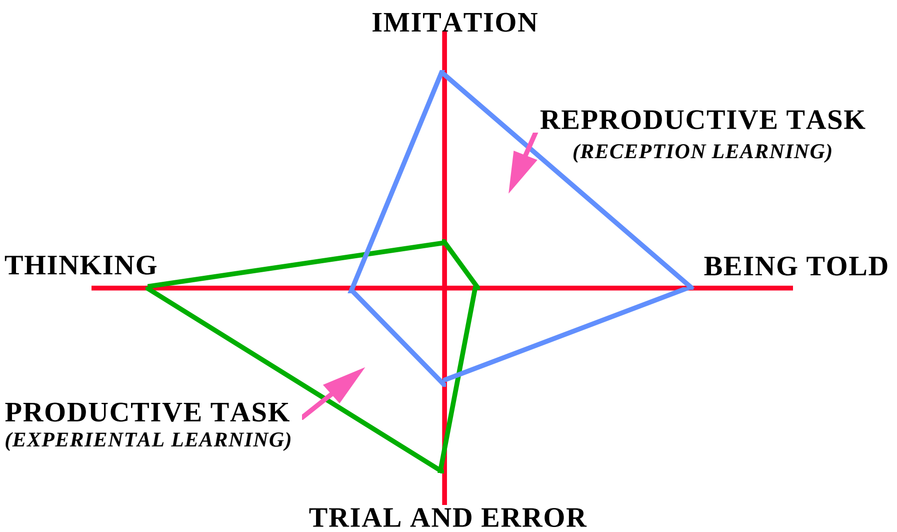

Figure 2: Comparison between reproductive and productive learning

As the trainees come from wider academic backgrounds (Natural Sciences, Geography, Social Sciences and rarely from Physical Sciences and Engineering) and from different type of organisations (Govt. Survey Organisations, Voluntary Developmental Organisations, Research Institutions, Universities etc.) with different magnitude of experience base, the entry behaviour becomes heterogeneous and thus complicates the design task for the training programme. To take care of this the training and enabling objectives have to be designed around **Must-Should-Could** syndrome (Figure 3).

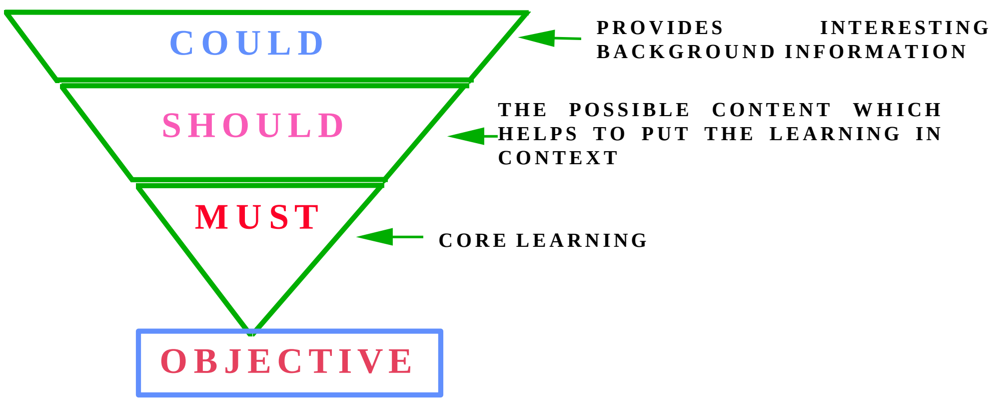

Figure 3: Flexibility needs during delivery by trainer to cope up with heterogeneous entry behaviour

As the trainees have very little background in physics and engineering, the transfer of knowledge (Facts, Procedures, Concepts and Principles) and Skills (Thinking, Acting, Reacting and Interacting) to trainees has to be achieved by practising the modalities given in Table 1.

Gupta et al. (1995) have given examples to communicate fundamentals of remote sensing following the above mentioned basis.

Table 1: Modalities for transferring new concept

KNOWLEDGE • **FACTS** • **PROCEDURES** • **CONCEPTS** • **PRINCIPLES** **SKILLS** • **THINKING** • **ACTING** • **REACTING** • **INTERACTING**	• Start from what is **Known** to what is **Unknown** • Start from something **Concrete** then to one that is **Abstract** • Start from the **General** and move on to the **Particular** • Start from **Observation** and move to **Theory** • Start with something **Simple** before making it **Complex** • Start with an **Overview** before introducing **Details**

Being adult and mature, trainees see themselves less as a dependent personality and more as a self-directing human beings and possess growing reservoir of experience and increasingly relate new learning to that experience. Their readiness to learn becomes increasingly oriented towards dealing with real situations they will be involved in and the time perspective changes from one of postponed application of learning towards its immediate needs. Thus the principles of *Andragogy* (a technology for adult learning) have to be practised. Even changing attitude to accept new technology not as replacement but as an additional tool needs to be inculcated through exploring, self-learning and discussion modes in trainee-centered approach. E.g. to convince about satellite multispectral and far beyond visible region capabilities one need to compare with human eye (as it is limited to visible band). To explain about limitation with reference to pixel dimension again one need to compare with human eye capabilities by conceptually shifting it to satellite altitude. To justify the need for multispectral measurements one need to create the visualisation about number of parameters that affect the state of feature on Earth's surface (e.g. crop yield estimation would need genetic, meteorology, soil moisture, soil type, soil nutrients etc. related parameters say, 50 to 60 parameters). To study a process which depends on 'N' parameters one at least needs 'N+1' independent measurements to describe the process. By having much more than 'N+1' independent measurements the error of analysis can be minimised by using the concept of overspecification / overestimation.

Thereafter, the discussion on the range of subjectivity errors of human beings when different parts of a large survey areas are handled by different persons could be used to describe the preciseness of satellite data again by using a known example illustrated in figure 4. Here, once all the arrows get within the bull's eye of the target, the shooter is precise as well as accurate (fig.4 'a'). In figure 4 (b) the arrows are around the bull's eye and neither accurate

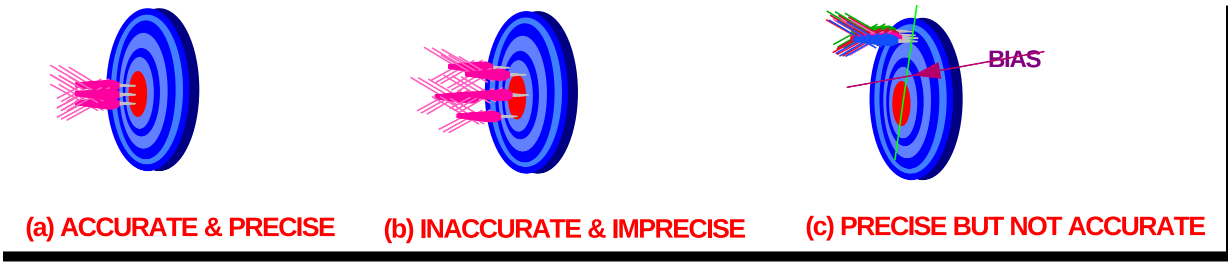

Figure 4: Concept of precision and accuracy

nor precise. The arrows in figure 4 (c) are in a narrow distribution, the envelope of which is smaller or equal in diameter of bull's eye, but are away from bull's eye. Such a shooter is precise but not accurate and his squint while shooting (bias) could be corrected by giving a shift to bow just prior to shooting. Thus, preciseness of remote sensing can be taken to advantage by working out the offset with reference to currently practised methodologies.

Further, trainees could be put to discussion to work out the error of analysis of the outputs, inferences and decisions arrived at using the currently practiced methods. This would create the receptiveness for new remote sensing and GIS technology once they feel that their error of analysis could be reduced by using remote sensing data. Requirement of accuracy could be demonstrated by doctor's thermometer example. Though technology has advanced a lot yet doctor's thermometer has only 0.1° F accuracy. As doctor is going to prescribe same medicine once human temperature equals or exceeds 100° F and is within 101±1° F range (means doctor's error of analysis is 1° F) he needs temperature measurement which is 10 times better i.e. 1÷10 = 0.1° F. With this one can ask trainees to examine whether the precision provided by remote sensing data is 10 times better than the error of analysis of the task(s) undertaken by them. Table 2 (Gupta, 1996) lists a sample of learning unit. For a given set of performance objectives, there would be many *Learning Units*. In the design of objectives (*Performance, Training and Enabling objectives*) one need to use active verbs to achieve definite goals. Through this approach, coupled with exploratory analysis of the satellite image as discussed earlier, the receptive attitude could be inculcated among the trainees. Seminar by the trainee through guided reading using library resources and interactions during delivery of seminar could bring-in confidence besides becoming aware of the state of the art of application aspects of remote sensing technology in trainee's discipline. As the trainees are from different disciplines and the satellite provides image which can be used for variety of disciplines, it becomes advantageous in getting vertical as well as horizontal perceptions during discussions and seminars.

TAB. 2

The communication process in the lecture makes use of the trainee's sense of sight and hearing. This information is then stored in the trainee's short-term memory, which has a limited capacity and can retain information for 5-30 seconds. Some of the information will be passed to the long-term memory, although most of it will be forgotten. By emphasising key points, repeating where possible and by using visual aids to provide the second medium of communication for the same key points one could improve the recall rate for the trainees.

Table 2: A sample design for the Learning Unit

Title	Training Objective(s)	Enabling Objective(s)
	At the End of Learning Unit participants will be able to	
Initiation to Remote Sensing and its broad conceptual comparison with conventional ground based information system	1. Explain Advantages of Remotely Sensed Image (RSI)	1.1 Define Precision 1.2 Describe benefits of image mode vs. Text / Tabular Mode information during analysis and assimilation by human beings 1.3 List 5 advantages of Satellite based Remote Sensing
	2. Define Accuracy need criteria for input data towards identification of different types of land cover	2.1 Distinguish Accuracy from Precision 2.2 Discuss and Estimate Error of Analysis in the identification of different types of land cover by conventional methods
	3. Estimate the error in analysis of RSI	3.1 Describe error as a function of size of contiguous area under a feature 3.2 Describe error as a function of size of spatial resolution of Remote Sensing Data.

To ensure a dynamic, stimulating and effective trainer-lead discussion, the sequence of questions, to be followed after a brief introduction, need to be well planned and timed. The effectiveness would be a function of quality of questions and group behaviour. Questions are categorized as *Learning* and *Control* questions. Learning questions are perceptive, challenging and appropriate, help members of the discussion group to gain a deeper insight and understanding of the topic under discussion. Control of discussion is achieved through tactical questions to obtain maximum value from a discussion and to provide opportunities for all members of the group to participate. Use of Socratic approach i.e. challenging assumptions, comparing opinions etc. would enable development of deeper understanding of the topic under discussion. Low order questions would test existing knowledge, check understanding and enable the gathering of facts and information. High order questions would provoke discussion because there is no clear-cut answer and could be categorized as *Analysis, Synthesis* and *Evaluation* type questions. Analysis type questions, meant to arrive at deductions, encourage organisation of thoughts and to look for evidence in order to interpret and to make generalisations. Synthesis type questions, needed to stimulate the group's creative potential, require member to reflect and work together as team, taking ideas and suggestions about the topic and the question, and developing them. Evaluation type questions address to the highest level of thinking obtained from a discussion group and this helps in modifying or developing attitudes. Tactical questions are for directing group behaviour for focussing on high-order learning questions.

Training programmes can be partitioned in class-room-cum-practicals and project mode learning modules. During first module after discovery-learning of image interpretation, the trainees need to be given an image to interpret for broad land-use / land-cover classes to bring out a pre-field visit interpreted map. Thereafter, the trainees go for field check and identify the pitfalls of pre-field interpretation and analyse the need to enhance their understanding of interpretation key and create an individual oriented supplementary performance aid. The understanding can be further enhanced through group discussion wherein experiences get shared and trainer assumes the role of validating the inferences arrived through discussion. The project-work (second module) permits trainees to do the job in an end-to-end mode and get it verified by an expert. This generates confidence to work independently at their host organisation.

3. Trainer's and Training Tools Development Needs

In general, growth in any discipline is governed by *Sigmoid* curve as illustrated in figure 5.

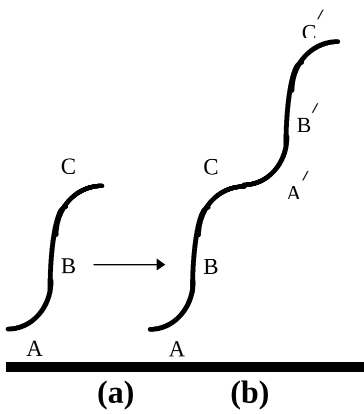

Figure 5: Graphical representation of growth process in science and technology

The areas of remote sensing, image processing and pattern recognition has more or less reached the stage C of figure 5(a). Synergistic use of new type of measurements, GIS and GPS tools coupled with mechanistics oriented thought models development could only enable enhanced rate of growth as shown by B′ segment of figure 5(b). The A′ stage in remote sensing is being created by higher spatial resolution. The launch of new sensing systems (*for studying Earth Systems Science*) on-board Earth Observation System (EOS) scheduled for launch in the year 1998 is expected to initiate B′ stage (Figure 5 'b'). In GPS and GIS we are somewhere in between stage A and B of figure 5(a). With the forceful marketing of GIS and GPS tools we shall very soon land up near the C stage. The spatial modelling in GIS taking into account the variables besides quasi-static parameters and development of spatial statistics would enable development of B′ stage of figure 5(b) in the area of GIS.

3.1 Remote Sensing

Remote sensing provides precise information at different spatial scales covering from resources management scale of around 10-30 m spatial resolution to process studies scale of 1-10 km. Further, the remote sensing data from these scales have to be integrated in two different manners i.e. (1) with the process study scale of 100 km to drive the General Circulation Models with realistic surface boundary conditions for estimating climate forcing towards development of renewable natural resources and (2) with the varying spatial and temporal scales of different earth resources (thunderstorm to monsoon type rain; soil erosion, soil development, soil type; watershed size as a function of climate zone, agriculture, forest etc.) and socio-economic variability. If remote sensing has to provide solution then interlinking of different spatial and temporal scale phenomena with due understanding of error of analysis at intra-theme and inter - theme levels is *a priori* need.

The interfaces at different interacting disciplines could be defined once the error budget of the measurements is known in definite terms. Under current methodologies atmospheric corrections are applied by using models but atmospheric correction could be better applied by using measurements made in relevant absorption bands. Thus, the existing atmospheric windows based remote sensing needs fortification from absorption bands remote sensing which is also well developed and used in environmental satellites. The Moderate Resolution Imaging Spectroradiometer (MODIS) on-board Earth Observation System (Asrar and Greenstone, 1995) would provide capabilities for such atmospheric corrections.

Usefulness of different spectral bands and bandwidth requirement for different earth surface features at sub-class level (e.g. crop species, forest species, etc.) require thorough understanding of spectral behaviour of objects in narrow bandwidth measurements. Hence, training programme need to give more thrust, in practical mode, on ground based observations and their understanding through hyper-spectral analysis. The exercises for plotting reflectance characteristics curves as a function of wavelength, to identify the spectral regions that would provide maximum separability between objects of interest, need to be carried out for finding optimal bandwidth that would provide maximum separability among different thematic classes. Digital satellite data (2 dimensional array of digital values) in a given spectral band could be used to reinforce the separability concept (among trainees) for broad earth’s surface cover types using histogram technique. The number of modes in the histogram communicates about the broad earth’s surface cover types in the image while the spread around the particular histogram mode conveys about the variability in the spectral signatures within the same very broad earth’s surface cover type. By studying histograms for different bands it can be demonstrated that a single band alone could not provide the discrimination of all the surface features. Thus the necessity of multispectral approach in analysis of satellite image could be emphasized. The difference between minimum and maximum values of pixel in the single band image could explain the image contrast and amount of information available in raw data. Hence, a graphical analysis of an individual spectral band data would help in attaining the conceptual understanding of the behaviour of a feature on the earth’s surface in that spectral band.

Scatterogram is a graphical representation of pixel relationship in two spectral bands. The distribution of pixels in scatterogram can give idea about correlation between these two bands. The scatterogram can also be helpful in locating features like water, vegetation, soil etc. in this two dimensional graph to work out the spectral separabilities.

At this point, the decrease in error in the remote sensing data based analysis in estimating area under a given land cover type (e.g. forest, water body etc.) as area increases could be conveyed geometrically by assuming that area is circular (for simplicity in analytical treatment) and radius of the circle is ‘r’. At the periphery of this circle one expects that picture element (pixel) of the image could have mix-up of the classes within and outside the circle. Thus error would be a function of (i.e. related to) $2\pi r$ in an area of πr^2 which is being estimated. Thus error per unit area would be a function of $(2\pi r/\pi r^2)$ i.e. $2/r$. Thus as ‘r’ increases the error per unit area decreases. Further, the probability of mixed pixel at periphery decreases as the size of the pixel decreases.

Beside resources management through mapping and monitoring the natural resources, the remote sensing technology (by virtue of its capabilities to provide simultaneous, consistent and continuous data over decades for lithosphere, biosphere, atmosphere and cryosphere) is assuming crucial role in studying the inter-play among the various processes of the Earth Systems Science (Gupta and Sesha Sai, 1994). Space based observations are able to provide multispectral measurements over visible, short-wave IR and thermal IR spectral regions over a variety of spatial (20 m to 1 Km) and temporal (once in 16 to 22 days to daily basis) scales. The Global Circulation Models which are used for visualising climate in future need surface information at 100 Km scale while the surface changes take place at decimeters scale. To represent these surface changes at 100 Km scale, the integrity of information available at finer resolution need to be preserved during upscaling. In upscaling, the random errors get reduced by a factor $\sqrt{N}$, N being the number of data sets aggregated while bias does not get reduced. Upscaling of 36.25 m IRS LISS-II data to 72.5 m and studying its correlation with 72.5 m IRS LISS-I data provides a research opportunity to test upscaling algorithms. The observations made for atmospheric corrections at 500 m to 1000 m spatial scales from MODIS (Moderate Resolution Imaging Spectroradiometer on-board EOS) and AVHRR (Advanced Very High Resolution Radiometer on-board US-NOAA meteorological satellites) are to be used for incorporating atmospheric corrections in the remote sensing observations at 5 to 30 m spatial scale. To appreciate such downscaling problem one could learn from diagnostics oriented upscaling studies. Thus, there is a need to work out the error budget in applying atmospheric corrections through down-scaling procedures.

The spectral signature from an object is a mix up of various sub-components. Further, separability of the spectral signatures for different thematic classes is ill-defined. Thus, getting back the information about objects from the spectral signatures resembles the inversion problem wherein finding unique solution is not possible. This is the basic reason for embedding ground truth during analysis of remote sensing image. This idea could be communicated in a graphical mode by showing inter-band scatterograms. By making trainees do these exercises at computer and thereafter conducting group discussions for developing inferences could result in development of lasting, innovative and productive type skills even among those trainees who come from natural sciences and humanities background. Towards gearing up for ‘solution-oriented approach in rajor-sharp focus mode’, the narrow spectral bandwidth data sets and data sets becoming available from multi angle looks need to be researched-in by trainers.

Thus the graphic orientation based performance aids and research based new sigmoid curves need to be established by trainers.

3.2 Image Processing and Pattern Recognition

Today the image enhancements are applied by trial and error method. Here, experience becomes the guiding force. There is a need to develop ability in the trainers to abstract the generic from the specific which will mean creating concepts from experience. Trainers need to work out criteria or say, decision tree, to match the user requirements with the satellite image by appropriately choosing a particular enhancement. Even a software package or say an inference engine could be developed to replace the decision tree concept. This will minimize the subjectivity in analysis and will make the output precise -- a driving goal of remote sensing.

It needs to be told that the geometric corrections applied to satellite image to take care of errors caused by curvature and rotation of earth are primarily the manipulations to achieve convenience in analysis. This further demands that the error budget of such manipulation is made known to trainees. This would enable them to appreciate the concept of measurement needs versus error of analysis and would make them cautious in deriving too finely cut solution/prescription. These pre- and post-processing aspects in geometric correction, radiometric corrections, image enhancement etc. need to be demonstrated by taking outputs at in-between stages of any image processing exercise/activity.

Pattern recognition is primarily going in statistical mode. There is a need to generate a set of demonstrable, with emphasis on diagnostic insights, classification outputs using various classification methods (Maximum Likelihood; Clustering; Artificial Neural Networks using pixel, mean, context and fractal dimension; and fuzzy logic) in a tutorial package mode. This mode will also generate a variety of investigation and development oriented ideas.

3.3 Geographic Information System (GIS)

Presently GIS is being used as a data base and retrieval system with the flexibility of analytical transformations to match data sets generated under different projections, standards and formats.

The modelling concept is empirical in nature and handles the problem in linear manner while the real life situation, for which prescription is being prepared, is nonlinear. The concept of integration is not based on the calculus criteria but is more a high sounding word for the logical operations. The step size for the integration need to be decided by the fastest changing variable among the variables and parameters describing the process. The GIS modelling is currently growing around quasi-static parameters while the useful outputs would emerge when variables are included in the modelling. In nature, adjacent data are interrelated in spatial domain and thus cannot be considered as a set of random data sets. Point Spread

Function increases this interrelationship. The statistical operations performed in GIS do not take care of spatial interrelationship. Thus, there is a need to generate a new “Spatial Statistics” package and to make the trainees aware of error caused by the assumptions made in statistical package currently used in GIS.

3.4 Global Positioning System (GPS)

Today GPS is used for getting location of an object of interest in three dimensional space. Using the built-in Ground Control Points (GCPs) library and GPS based information one could geometrically correct the fine spatial resolution satellite data which would enable cadastral level mapping. Exercises need to be developed to demonstrate use of GPS in the evaluation of altitude information estimated from satellite data based stereo pairs.

The temperature and humidity profiles in the troposphere would change the GPS signal path length (due to change in refractive index) thereby causing error in the estimation of positional accuracy. Thus, there is a need to work out correction mechanism for GPS data using temperature and humidity profiles obtainable from meteorological satellite data.

4. Conclusions

The areas of remote sensing, image processing, pattern recognition and GIS now need to be handled in soul-searching diagnostic mode to enable the synergism to provide the sought-for solutions by Natural Resources Managers and Earth Systems Scientists. Enunciation of research (knowledge oriented to mission oriented basic research passing through applied research stage before reaching application stage) as the responsibility of trainers in the training organisations is needed to develop human resources at trainer as well as trainee levels. Forthcoming technology-oriented developments need to be handled by physical sciences and engineering background persons. Here, thematic scientists need to collaborate as consultants.

References

1. Asrar, G. and R. Greenstone (Editors), (1995): MTPE EOS Reference Handbook , NASA-Goddard Space Flight Centre, Greenbelt, Maryland, USA, 277 pp.

2. Gupta, R.K. and M.V.R.Sesha Sai (1994): The Potential of Satellite-Based Systems for IGBP Studies and the Facilities Available in India, Asian-Pacific Remote Sensing Journal, 7(1), 81-90.

3. Gupta, R.K., R.K.Swamy, D.Vijayan and K.V.S. Badarinath (1995): Physics of Remote Sensing, Atmospheric Effects and Remote Sensing Sensors, In Remote Sensing for Earth Resources (Editor: D.P.Rao), Association of Exploration Geophysicists, Hyderabad, 19-53.

4. Gupta, R.K. (1996): Assessment of Spatial Distribution of Wasteland using Remote Sensing Technology, Project Report towards Partial Fulfilment of Training Requiements under **Design of Training** course conducted at Institute of Secretariat Training and Management, New Delhi, 33 pp.