Major Research Initiatives (2012-13 to 2015-16) by Prof. Dharmendra Singh , Microwave Imaging and Space Technology Application Lab, Dept. of Electronics and Communication Engineering, IIT Roorkee, Roorkee-247667

- **Development of Hand Held Cavity Detector (Ground Penetrating Radar) – Sponsored By Army Technology Board, Pune, India**

The Cavity/Caches detector is a project to assist troops/govt. agencies to help for identification of caches/voids in the ground which act as hideouts. The developed device has a capability to detect and classify various targets till one meter depth. The principle involved is similar to that employed in ground penetrating radars wherein use of electromagnetic waves of a particular frequency is employed to penetrate the surface and the reflected wave form received is analysed to provide an image.

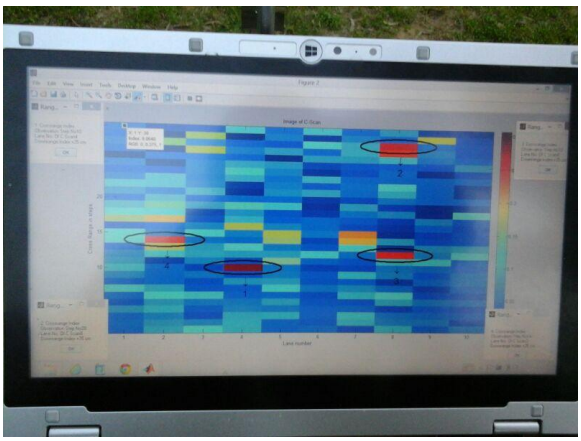
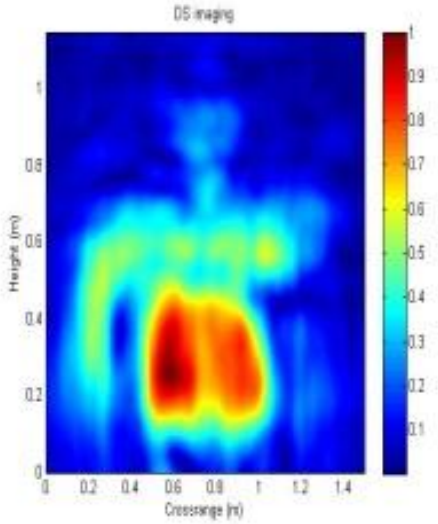


Fig.: Developed Hand Held cavity Detector (Ground Penetrating Radar) with the type of display of results

- **Through Wall Imaging System- Sponsored By LRDE, DRDO- Bangalore, India**

Developed suitable signal and Image processing algorithm for simulation of the process of image formation to improve the signal to interference ratio (interferences include indoor multipath, coupling noise, thermal noise and clutter reflections) for detection and identification of the different objects (human being, metallic guns etc.) behind the wall taking into consideration wall thickness, variations of transmission and reflection coefficients of the wall .



Results of TWI Imaging System

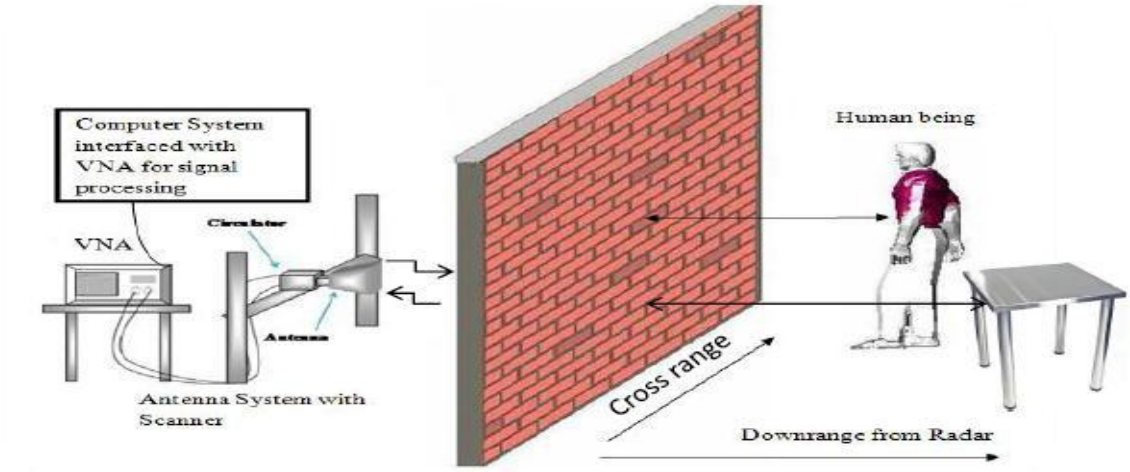
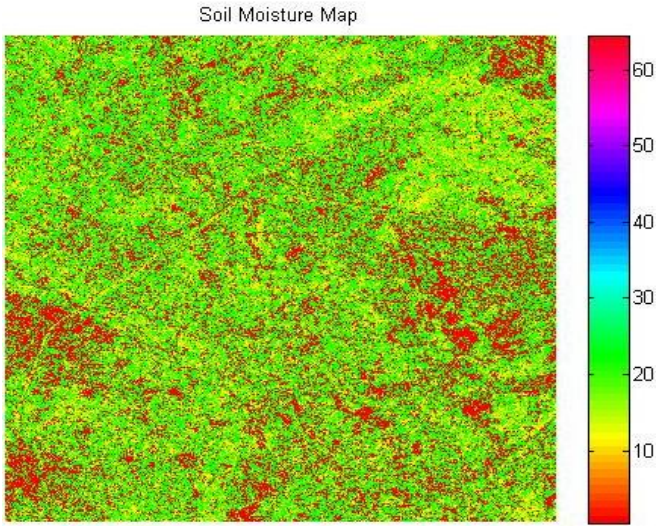


Fig: Ingeniously developed TWI system

- **Soil Moisture Monitoring with Satellite Images –Sponsored by Dept. of Earth Sciences, Delhi, India**

Monitoring soil moisture with satellite data on regional and global scale is of paramount importance for understanding and protecting environment as well as for natural resource management. Thus, it is necessary to develop a satellite based system for monitoring and predicting the soil moisture. The project has developed three main components: **1) "A**pplication of Radar data for estimating the soil moisture and 2) minimize the effect of roughness and vegetation while retrieving soil moisture. (3) Specification to develop the "automatic soil moisture monitoring system" with satellite data. Since **satellite (radar) sensors** offer a potential means of determining the spatial distribution of various types of landscape and soil condition (i.e., moisture and roughness) over large areas within a short time and reasonable cost. An automated system has been developed for Radar Data to retrieve the soil moisture with Synthetic Aperture Radar data.



Fig,: Developed Soil Moisture Retrieval System with generated soil moisture map of Roorkee region (April 9, 2011), India (Data Used: PALSAR-1, provided by JAXA, Japan)

- **Agriculture Information System for ICT- Sponsored by RailTel, Delhi, India**

Basically this project deals with two major objectives in which first objective is to use of satellite data for development of agriculture information system and second objective is to develop a system for real-time data capture via imaging of diseased plants in the field, on the field disease diagnosis and transmission of data for use by agricultural administrators to support operational decisions such as pesticide application. Accurate and timely information of agricultural field is very much required, as it can be used to evolve strategies for sustainable management of agricultural resources. Nowadays, satellite data, computer advances and communication technology may offer great scope for efficient planning and monitoring of agricultural resources in more efficient ways. Monitoring of agricultural system generally depends upon actual information of cultivated area, crop type, crop condition and region wise knowledge of agricultural system and effect on meteorological conditions. To provide these valuable information to various users like, satellite data may play a major role. Another important challenge is the definition of a cost effective solution, so end users like farmers can use these information with minimum cost. In this project we propose to develop methods for fusing the information of various satellite data in order to monitor crop area, crop type, crop health condition and soil moisture and this information can be timely send to end users by Information Communication Technology. The ICT system will consist of agricultural statistics for providing information about trends and changes in crops and meteorological conditions. A WEB/SMS information diffusion system will be experimented. **Please visit URL: www.aisiitr.in/modis/**

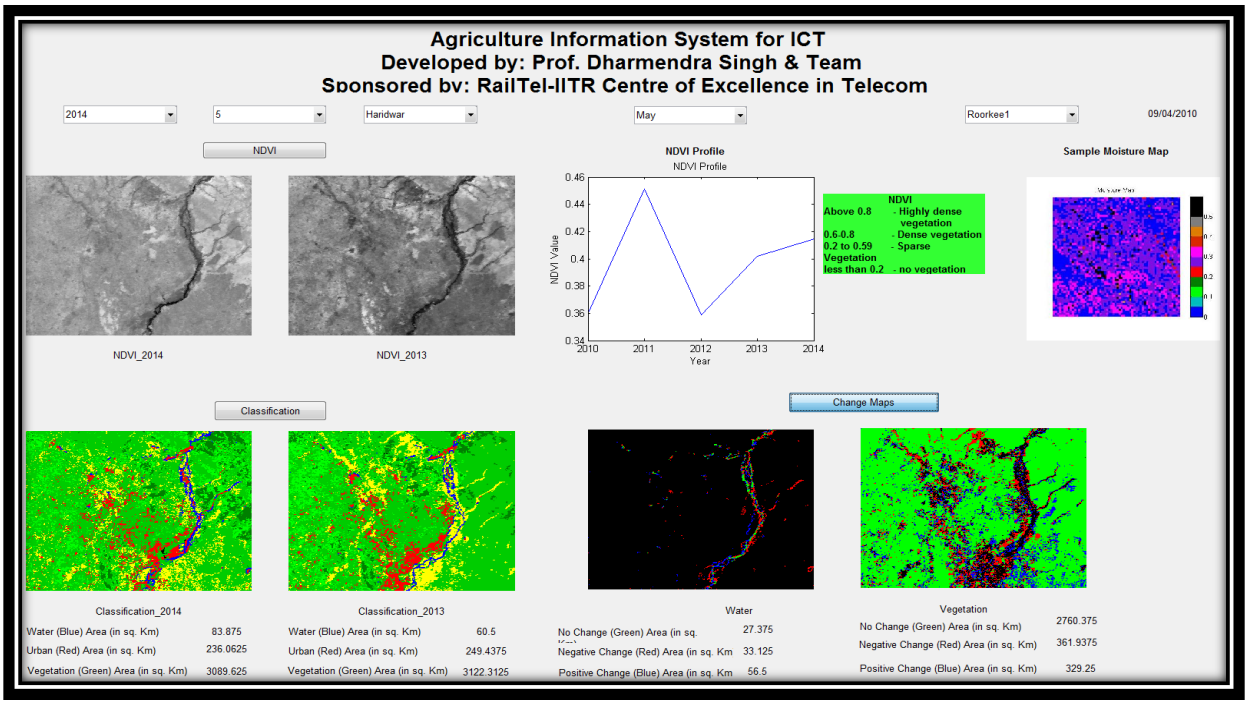


Fig: Agriculture Information System

- **Radar Absorbing Materials with Frequency Selective Surfaces- Sponsored by DRDO-Extra Mural Research, Delhi, India**

Technology on the microwave absorbers in GHz frequency band is a great topic in the military field to reduce the radar cross section (RCS), as well as in the telecommunication engineering fields. The microwave absorber is a specially designed material to suppress the reflected electromagnetic energy incident on the surface of the absorber by dissipating the magnetic and/or electrical fields of the wave into heat and although most absorbers do not dissipate enough energy to become even detectably warm when illuminated by a radar, this is nevertheless the mechanism by which they operate. Underlying the operation of RAM is the fact that substances either exist or can be fabricated whose indices of refraction are complex numbers. In the index of refraction which includes magnetic as well as electric effects, the imaginary part accounts for loss. At microwave frequencies, the loss is due to the finite conductivity of the material, as well as energy expended by molecules in attempting to follow the oscillating fields of an impressed wave. It is customary to lump the effects of all loss mechanisms into the permittivity and permeability of the material, both of which can be complex. . It is important to explore the some computational and electromagnetic techniques by which RAM as well as structure of the FSS can be optimized for a broad band of frequency spectrum. A technology for the optimizing the various thickness of multilayer is developed that will be avoiding the commonly used method of trial and error. An electromagnetic based approach is developed/under developed to achieve the proper FSS for different frequencies.

- **Obtained -10 dB RL bandwidth approx. 4.2 GHz (From 8 GHZ to 12.2 GHz) with coating thickness 1.4 mm**

Fig. Experimental measurement setup (a) transmission-reflection waveguide setup with measured sample and, (b) ATD setup with fractal FSS embedded sample.

- **Possibility of Water Ice on Lunar Surface- Chandryaan-1- Sponsored by SAC, ISRO, Ahmedabad, India**

The major components of the project include; polarimetric application of radar data for interpreting classification of moon surface on the basis of roughness and dielectric properties. The general objectives were as following: - Research on **classification of moon surface** and possibility of existence of water ice on lunar surface. Possibility of water ice existence on lunar surface has been investigated by using polarimetric approach with Fractal application on Chandrayaan-1 data.

Fig. S_1 image representing selected ROIs on the floor of Rozhdestvenskiey crater Using Mini-SAR1 data of Chandrayaan -1

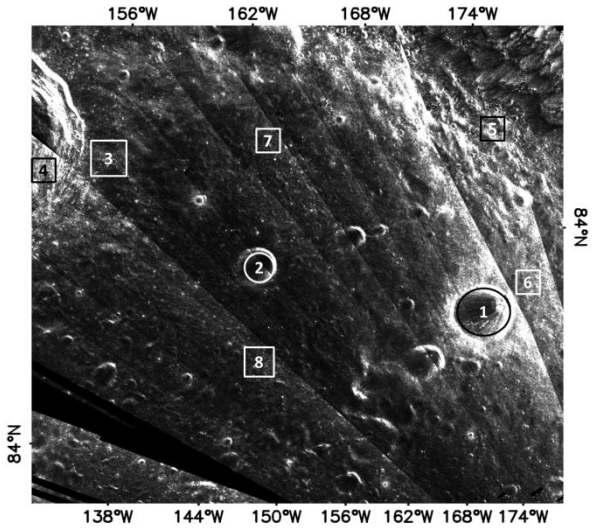


Table- Results for possibility of water ice on Lunar Surface

ROI	Pixel % : Possibility of dielectric mixing due to water ice
1	Yes
2	Yes
3	Negligible
4	Negligible
5	Negligible
6	Negligible
7	No
8	Negligible

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- **Millimeter Wave Imaging**

MMW imaging is one of the fascinating and rapidly expanding area; for object identification for security applications and for quality monitoring for industrial applications. Henceforth, critical investigation of digital image processing techniques in context to MMW imaging is currently becoming a new focused area of research. Various research works are carried out and going on for stand-off target detection and identification using different imaging techniques. An efficient MMW imaging methodology has been developed for accurate, non-invasive target detection, identification (especially crack detection) and material classification.

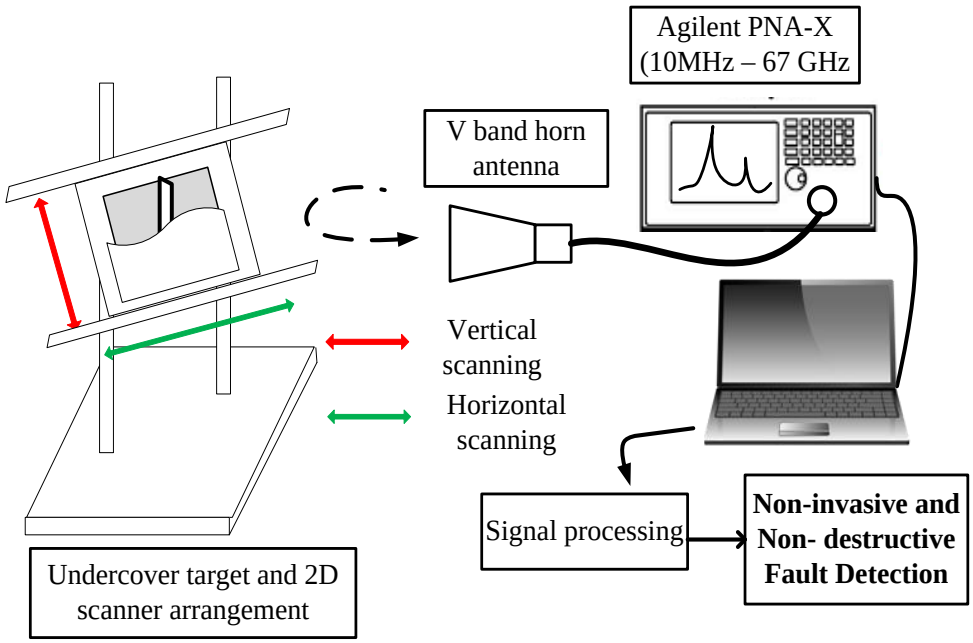

Fig. Ingeniously configured MMW imaging radar system

Results: Non-destructive undercover crack detection and Shape detection using MMW imaging system

Actual tile targets	Undercover target's crack detection output	Test Targets	Shape identified