Hyperspectral Remote Sensing in Acquisition of Geospatial Information for the Modern Warfare

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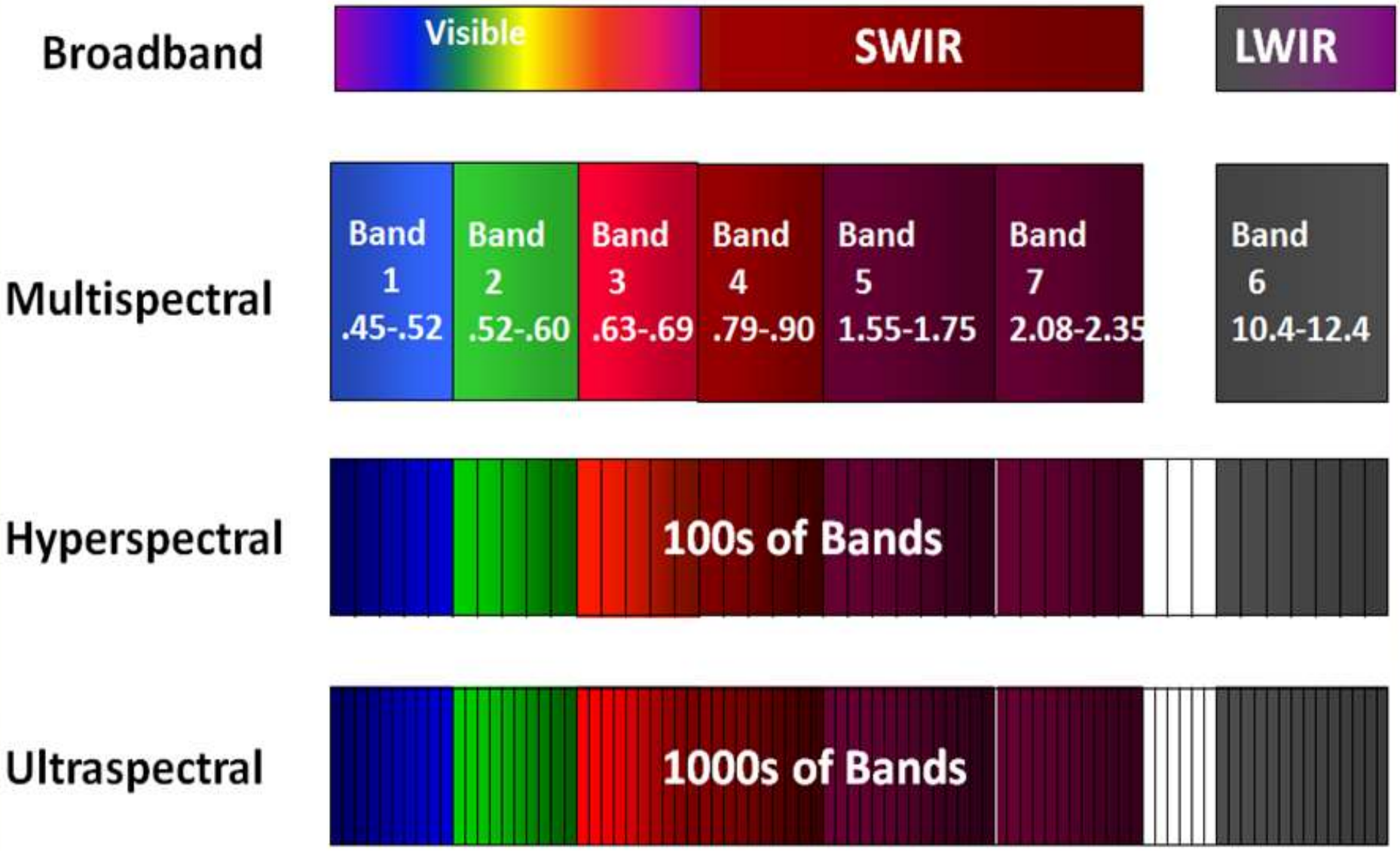
Air photo-interpretation

Multi-spectral Remote Sensing

Hyper-spectral Remote Sensing

Ultra-spectral Remote Sensing

Difference Between Multispectral and Hyper-spectral Data



METHODS OF INTERPRETATION

Air photo-interpretation (Air-photo elements & image characteristics)

Qualitative Spatial pattern recognition

Satellite imageries (Multispectral – Many bands)

Analog + digital data (Visual and computer aided analytical methods)

Qualitative and quantitative Spatial and spectral pattern recognition

Satellite data (Hyperspectral – 100s of continuous bands)

Hyperspectral remote sensing provides a continuous, essentially complete record of spectral responses of materials over the wavelengths considered.

Spectral imaging and Automated target recognition techniques using various algorithms for Image cubes

Automated Quantitative Spatial and spectral pattern recognition

Ultra-spectral (1000s of continuous bands)

Current and Recent Hyperspectral Sensors & data providers

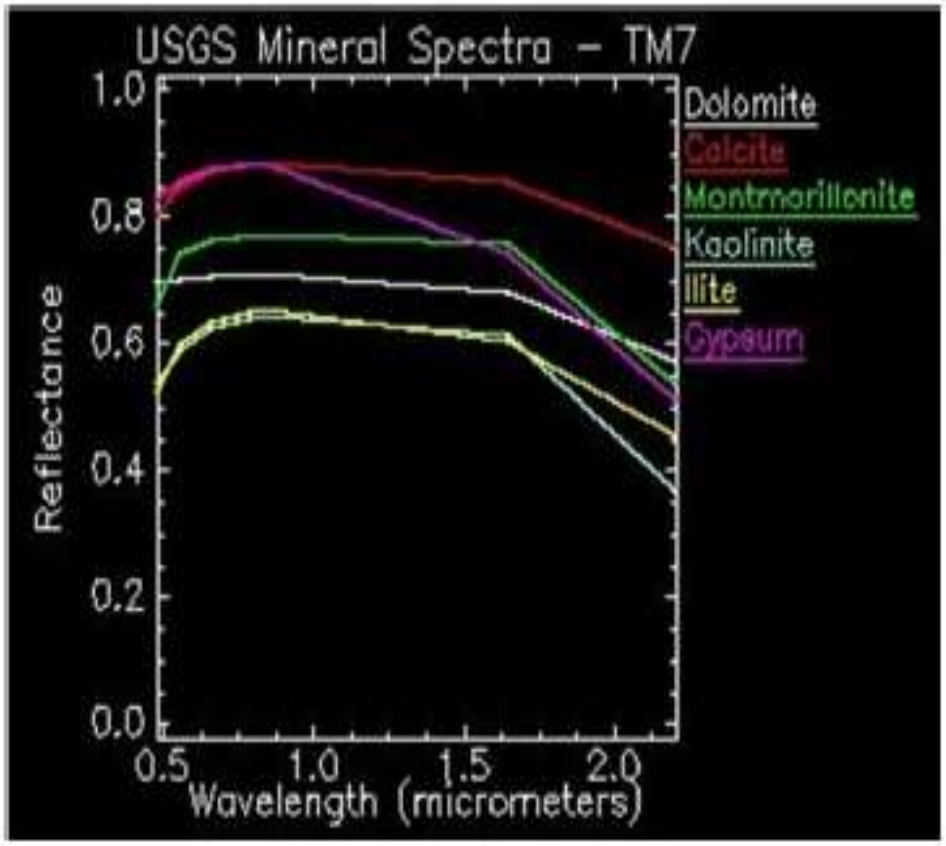
Satellite Sensors	Manufact-urer	Number of Bands	Spectral Range in µm
FTHSI on MightySat II	Air force Research Lab	256	0.35 to 1.05
Hyperion on EO-1	NASA Goddard Space Flight Center	220	0.4 to 2.5
Airborne Sensors	Manufact-urer	Number of Bands	Spectral Range
AVIRIS	NASA Jet Propulsion Lab	224	0.4 to 2.4
HYDICE	Naval Research Lab	210	0.4 to 2.5
PROBE-1	Earth Search Sciences Inc.	128	0.4 to 2.5
CASI	ITRES Research Limited	228	0.4 to 1.0
HyMap 00 to 200 Visible to thermal Infrared	Integrated Spectronics	100 to 200	Visible to thermal infrared
AISA	Spectral Imaging	Up to 288	3 to 1.0 um

Jadhav, 2014

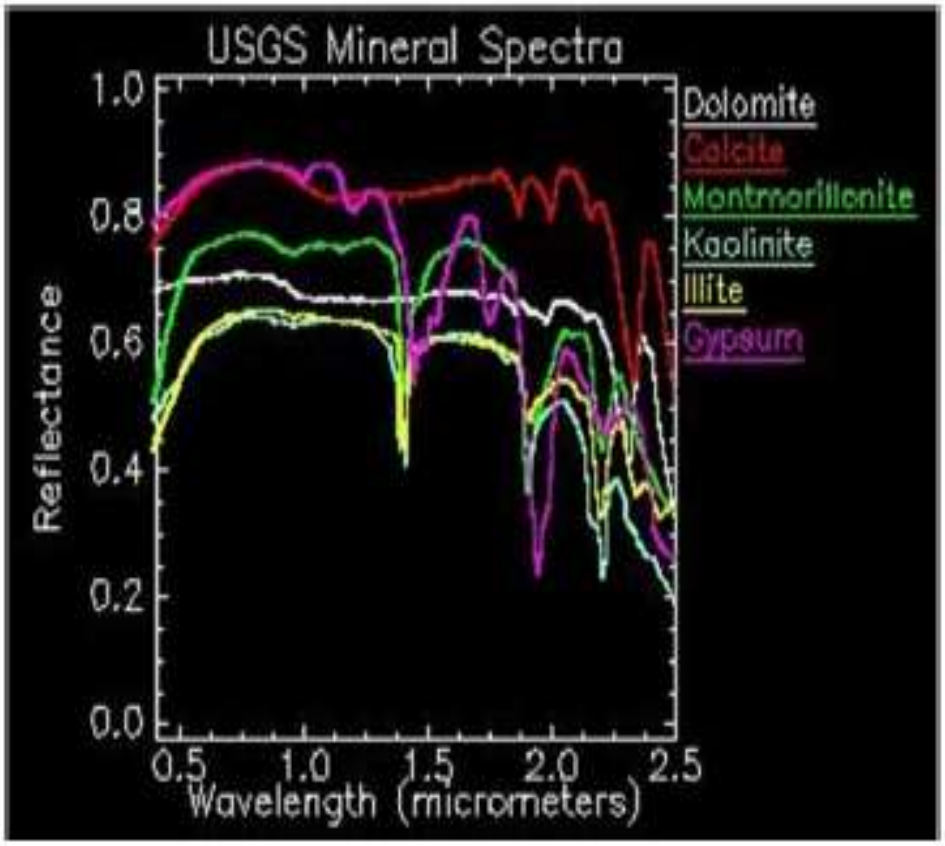
International Journal of Computer Applications. 106 (7); 38-42

Multispectral - Hyperspectral Signature Comparison

Multispectral



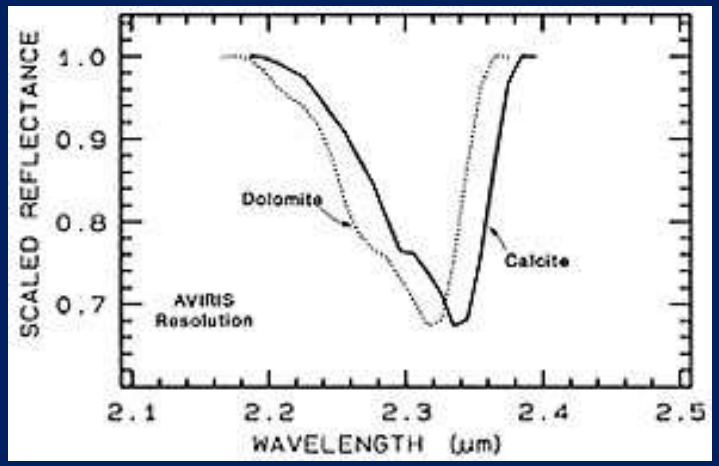
Hyperspectral



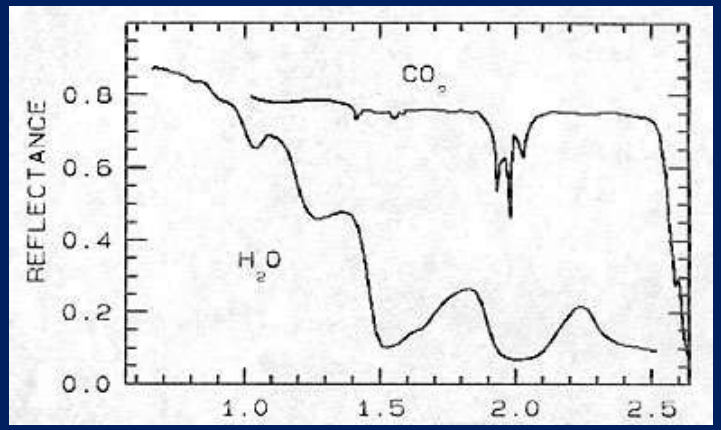
Resampled to Landsat TM7 Bands

Hyperspectral Remote Sensing

Hyperspectral images can be analyzed in ways that multispectral images cannot

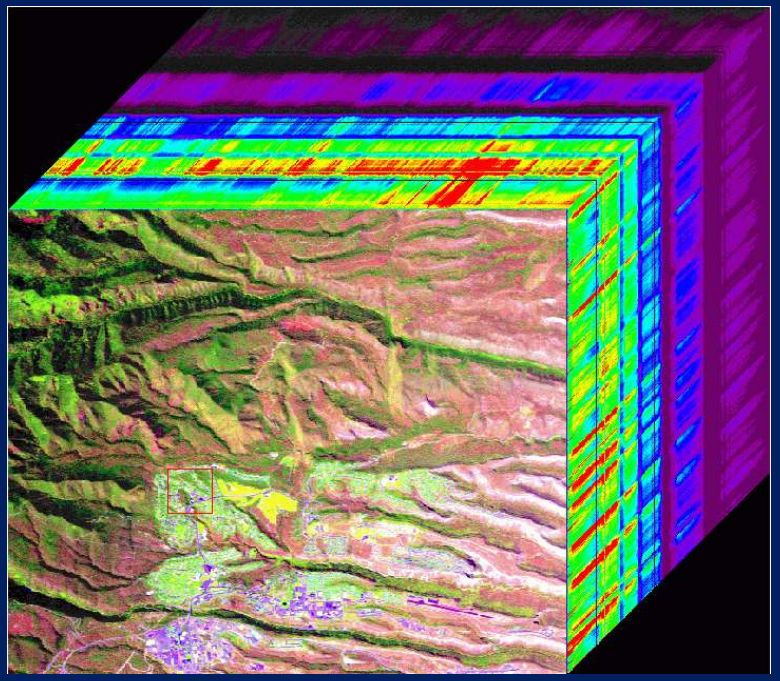


In the Visible-NIR range, water ice and dry ice give characteristic spectral curves, as shown here:



Hyperspectral Problems

- Data volume
- Cost
- Difficulty of analysis
  - Spectral Libraries
  - More complex



Hyperspectral Data Analysis

General Approach:

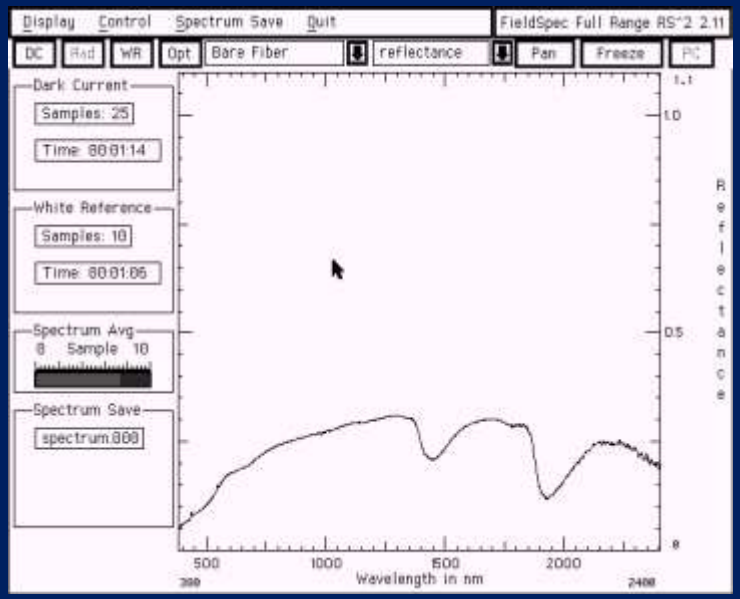
- **Develop Spectral Library**
- **Construct spectral curve for relatively "pure" materials**
- **Specific reflectance peaks and absorption troughs are read from these curves.**
- **Compare to lab spectra (mixture analysis)**
- **Mixtures of two or even three different materials can be identified as the components of the compound spectral curve.**

Hyperspectral Remote Sensing

Non-Imaging Instruments

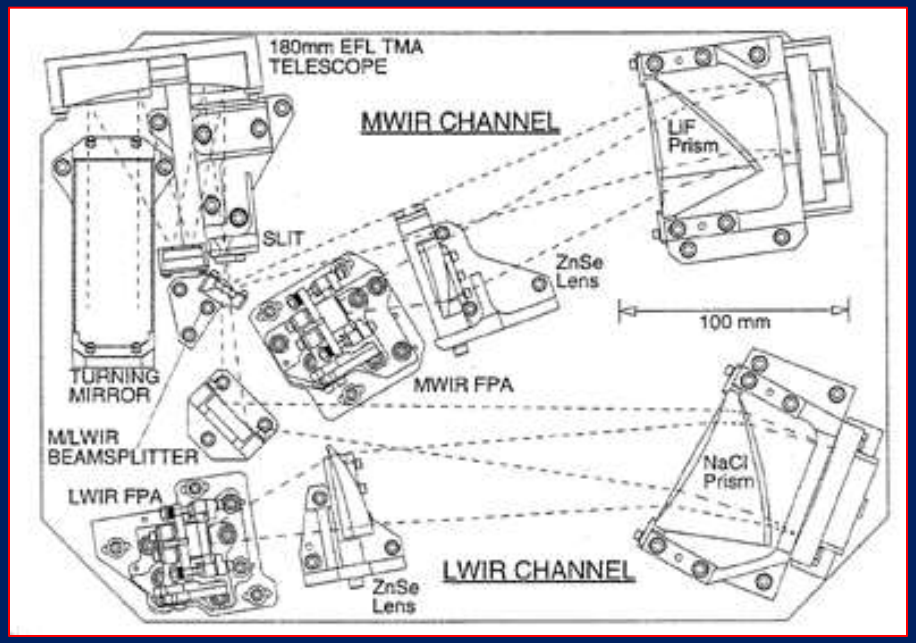
(example: Field Spec Hand Held Spectroradiometer)

- **sensor obtains data (amount of light per wavelength)**
- **computer software displays recorded spectrum**
- **analyze spectral signature**



Low Altitude Remote Sensing

Hyperspectral camera embedded on an UAV


180mm EFL TMA
TELESCOPE
MWIR CHANNEL
LiF
Prism
SLIT
ZnSe
Lens
100 mm
TURNING
MIRROR
MWIR FPA
M/LWIR
BEAMSPLITTER
NaCl
Prism
LWIR FPA
ZnSe
Lens
LWIR CHANNEL

Applications of Hyperspectral Remote sensing : DST Sponsored Research Project

Atmosphere	water vapor, cloud properties, aerosols
Ecology	chlorophyll, leaf water, cellulose, pigments, lignin
Geology	mineral and soil types
Coastal Waters	chlorophyll, phytoplankton, dissolved organic materials, suspended sediments
Snow/Ice	snow cover fraction, grainsize, melting
Biomass Burning	subpixel temperatures, smoke
Commercial	mineral (oil) exploration, agriculture and forest production

Military Applications

Development of satellite and ancillary systems - RCI

Design & Development of Hyperspectral sensor (Project Anvesha) – DEAL

Applications Development (Project Himmant) - DTRL

Military Applications

MILITARY GEOSPATIAL REQUIREMENTS

- Topographic/Terrain Mapping
- Visualization- Strategic Planning
- Terrain (scene) Matching for cruise missile guidance
- War Gaming- Tactical operations, inter-visibility for optimal positioning
- X-country trafficability Assessment
- Training Simulators for mission planning & rehearsal
- Cover & Concealment planning
- Natural (Geological) hazards result in changed surface topography

Terrain Potential

Inputs to Battlefield Management, Military Planning and Operations

Off-road mobility for A & B vehicles

Underground shelters

Target recognition

Bridging Site identification

Camping sites, dropping zones and landing sites

Artillery positioning & Line of Sight

Movement of men and animals

Ground water potential

Artificial Triggering of landmass

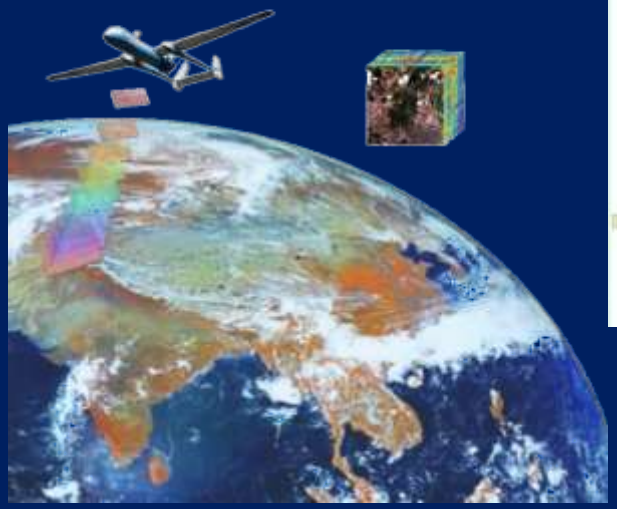
Artificial flooding

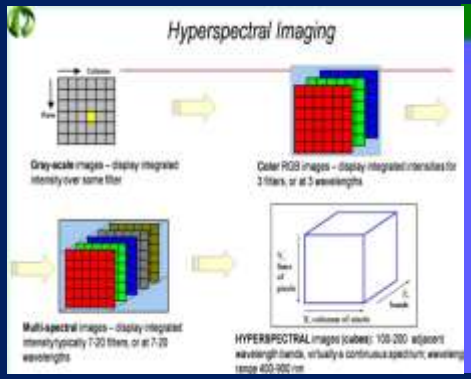
Terrain Profile for Guided Missile Navigation - Target Guidance

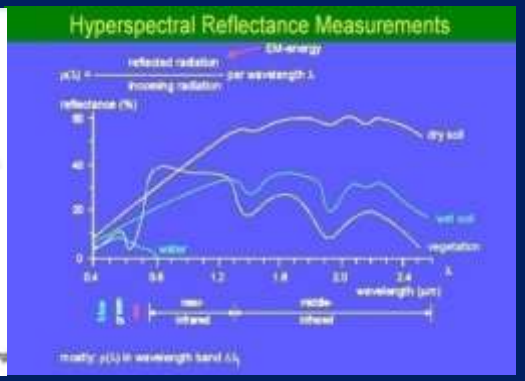
Camouflage and Concealment

3-D terrain models for simulators

Hyperspectral Imaging for Terrain Diagnosis (HIMANT)

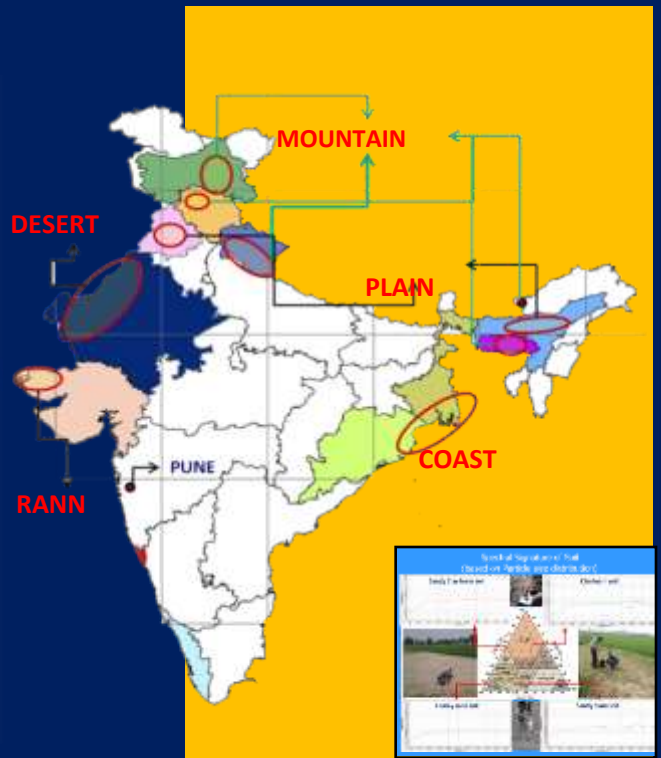




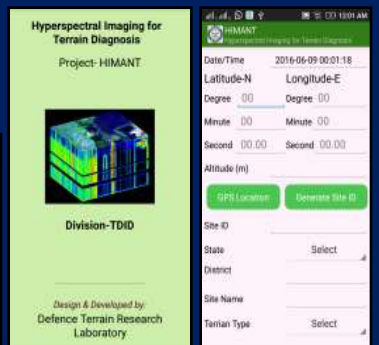


Enhance terrain intelligence to facilitate tactical operations

- ❖ Soil texture classification for off road mobility
- ❖ Composite material identification for various constructions / Built-up area
- ❖ Creation of Signature Library for the aforementioned applications covering all five terrain types



Portable tool for field data collection



Collection of Spectral signature in field

Field Investigation at Plain terrain in Amritsar : Spectra collection using Spectroradiometer April 2016

Field Investigation at Plain terrain in Fazilka & Ferozpur : Spectra collection using Spectroradiometer May 2016









Spectral signature collection

MOONLAND CLAY SOIL

ROCK- KARU

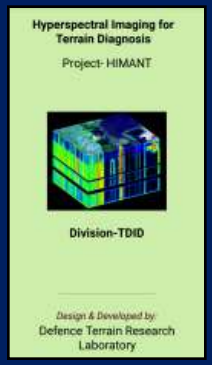
GLACIO FLUVIAL SOIL

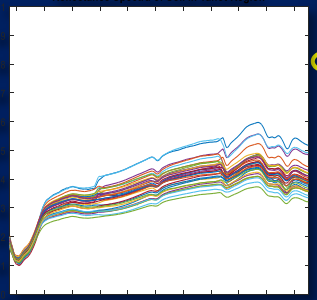
SOIL AT DIHAR

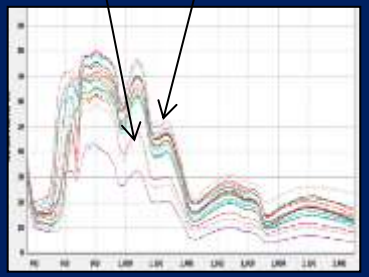
FRESH SNOW

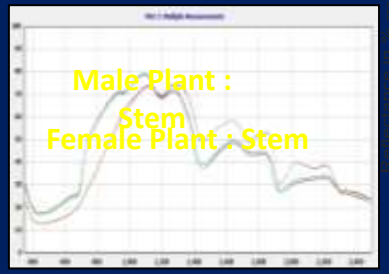
Plant Species Identification

Portable tool for field data collection



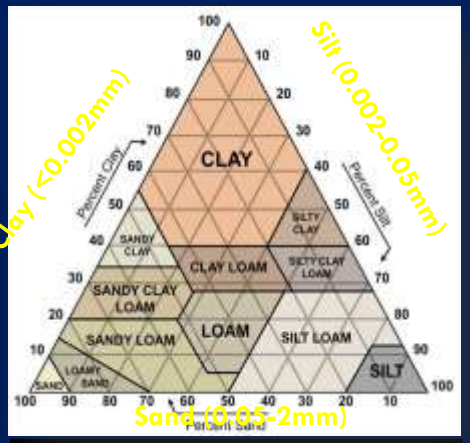


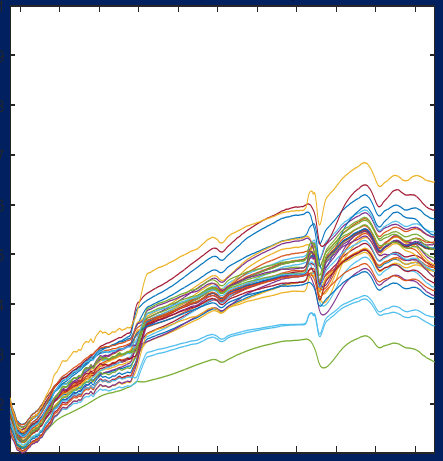




Sea Buckthorn

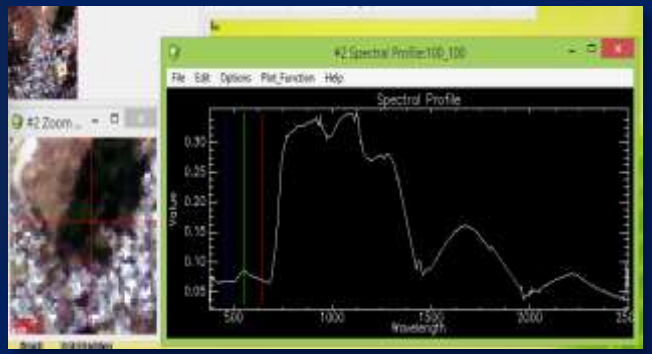
Soil Texture Identification

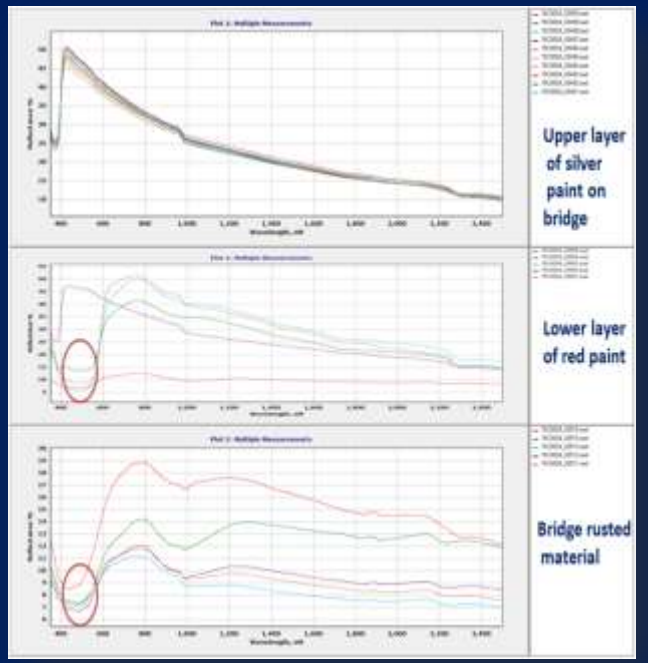




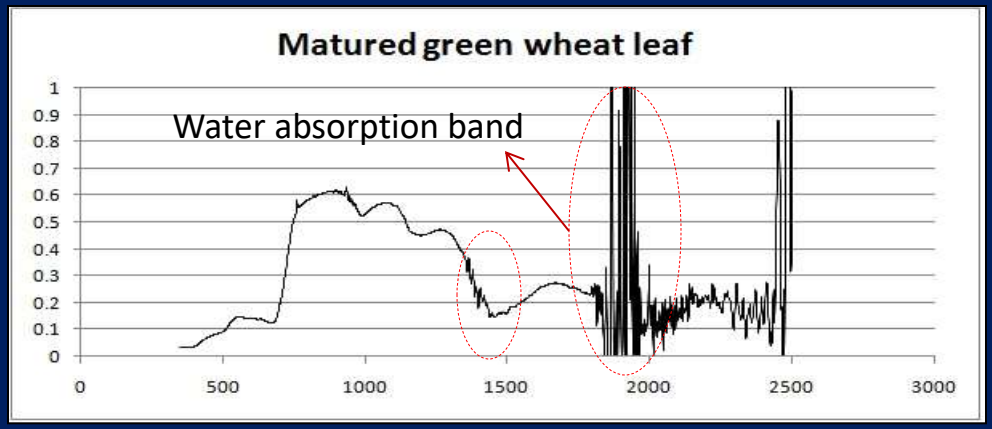
Fruit Apricot : Spectra

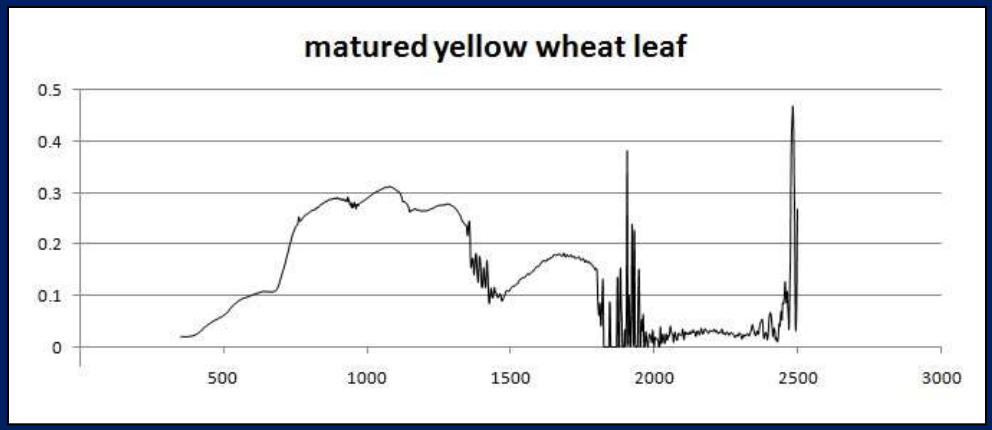
Composite Material Identification

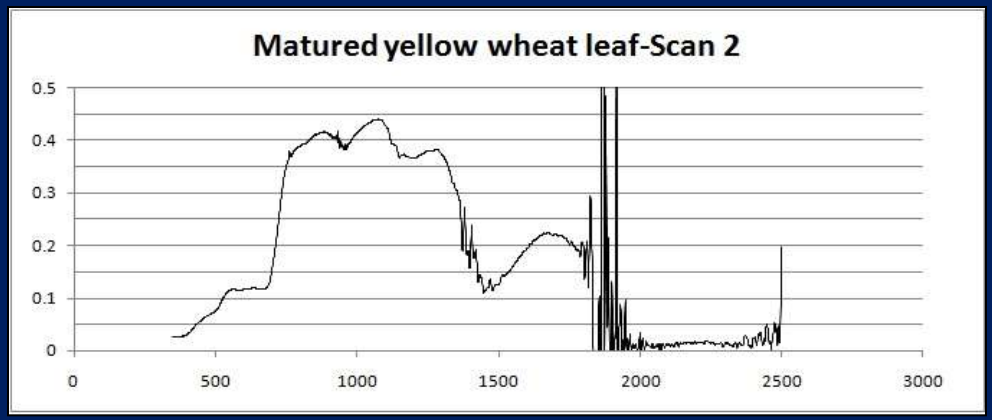




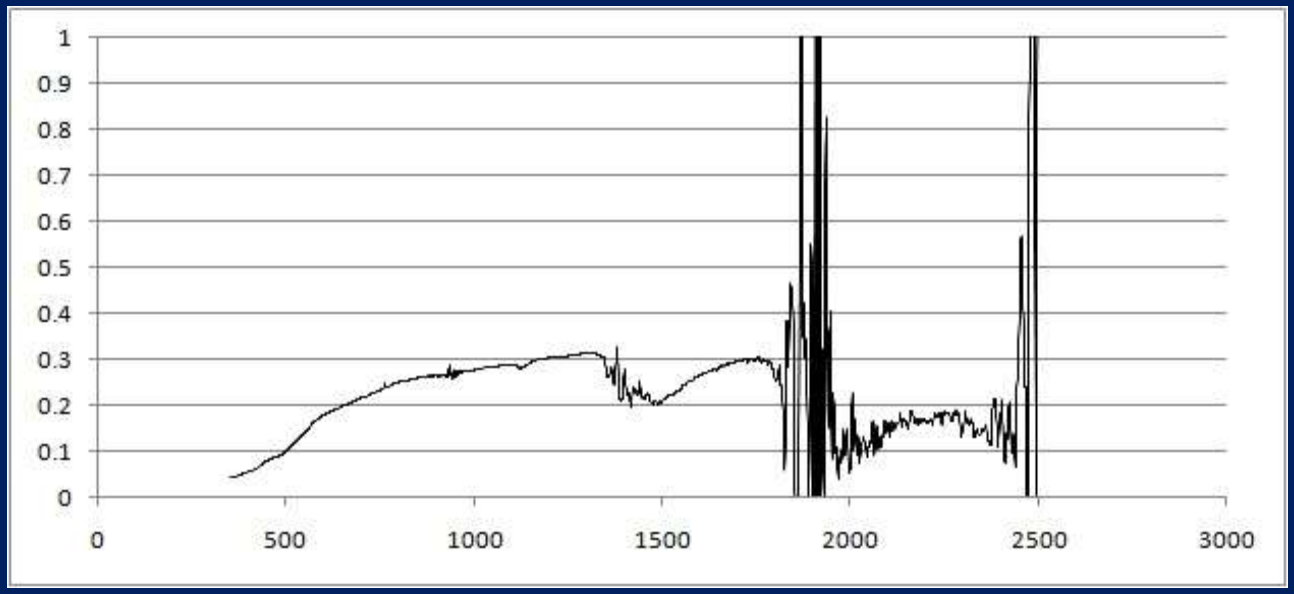
Spectral Signature of Wheat Leaf – SR 3500





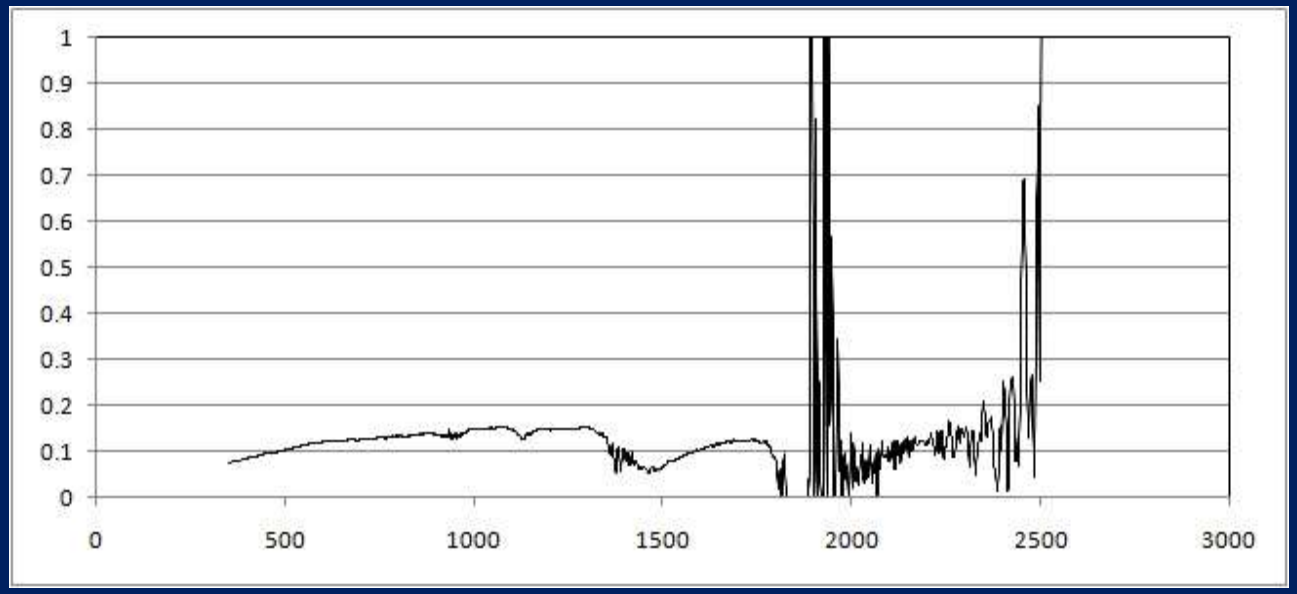


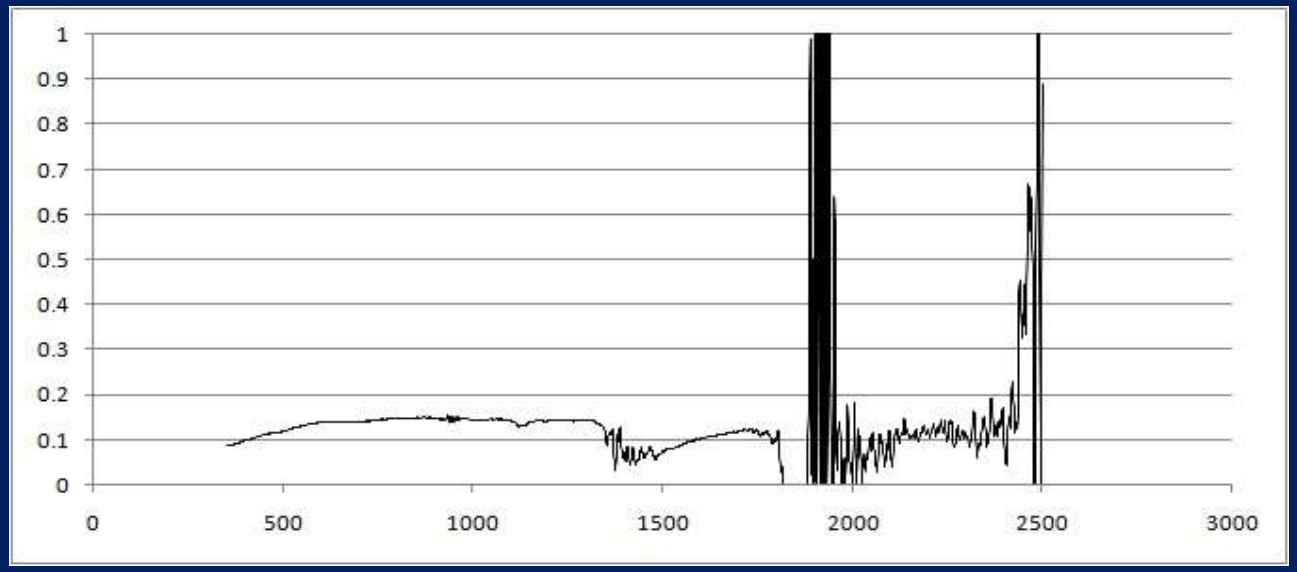
Spectral Signature of dry loose soil– SR 3500



Height of Instrument- 1m
FOV- 44 cm, 25 degree

Spectral Signature of Asphalt Road– SR 3500





Height of Instrument- 1m FOV- 44 cm, 25 degree

HYPEX Database

HYPEX Database

VISUALIZATION

State: UTTARANCHAL | District: ALL | Terrain Type: MOUNTAIN | Terrain Sub Type: NULL

Target: ROCK | Description:

Observation: FIELD | Foreoptics: ALL

SoilTexture: | Soil Condition:

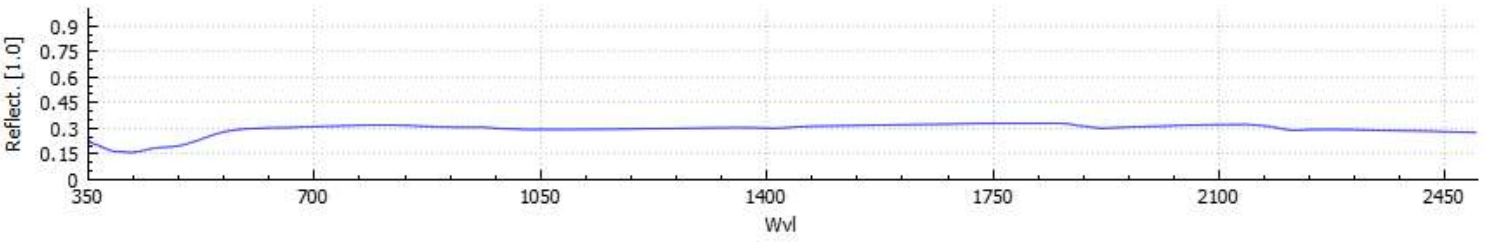
Fetch | Export

POPULATION

Insert Field Data

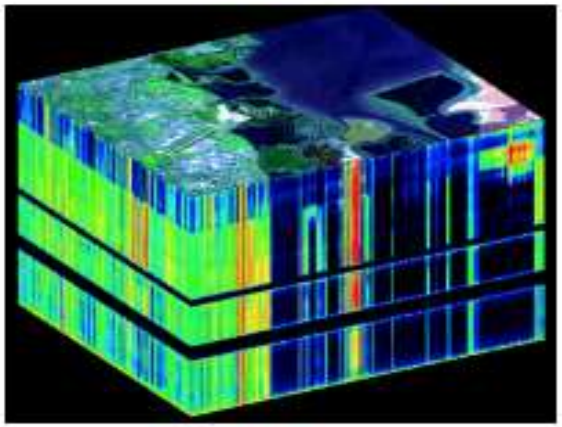
	State	Terrain Type	Target	Time	Date	Latitude	Longitude	Description
1	UTTARANCHAL	MOUNTAIN	ROCK	10:46 AM	11/10/2016	29°39'43.99"N	79°41'55.48"E	QUARTZITE
2	UTTARANCHAL	MOUNTAIN	ROCK	10:47 AM	11/10/2016	29°39'43.96"N	79°41'55.31"E	QUARTZITE
3	UTTARANCHAL	MOUNTAIN	ROCK	10:48 AM	11/10/2016	29°39'43.96"N	79°41'55.33"E	QUARTZITE
4	UTTARANCHAL	MOUNTAIN	ROCK	10:49 AM	11/10/2016	29°39'43.94"N	79°41'55.32"E	QUARTZITE
5	UTTARANCHAL	MOUNTAIN	ROCK	12:08 PM	11/10/2016	29.69281	79.69742	CALCITE
6	UTTARANCHAL	MOUNTAIN	ROCK	12:09 PM	11/10/2016	29.69281	79.69742	CALCITE
7	UTTARANCHAL	MOUNTAIN	ROCK	12:09 PM	11/10/2016	29.69281	79.69742	CALCITE
8	UTTARANCHAL	MOUNTAIN	ROCK	12:11 PM	11/10/2016	29.69277	79.69743	MICACEOUS S...
9	UTTARANCHAL	MOUNTAIN	ROCK	12:11 PM	11/10/2016	29.69277	79.69743	MICACEOUS S...
10	UTTARANCHAL	MOUNTAIN	ROCK	12:11 PM	11/10/2016	29.69277	79.69744	MICACEOUS S...
11	UTTARANCHAL	MOUNTAIN	ROCK	12:45 PM	11/10/2016			PROTOMYLONI...

Site Images



HYPEX

Hyper-Spectral Image Analysis Software



Composite Material Identification

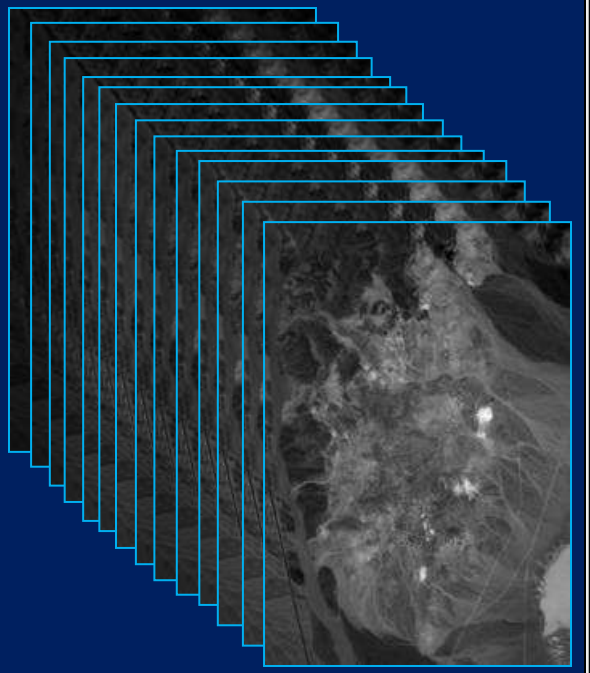
COMI

Soil Texture Analysis

SOTEX

DEFENCE TERRAIN RESEARCH LABORATORY

HYPEX GUI



Load New Image

Image to Display

Show Color Image

Show Gray Image

Image to Display

Red

Band 26 - (wvl. 645.96

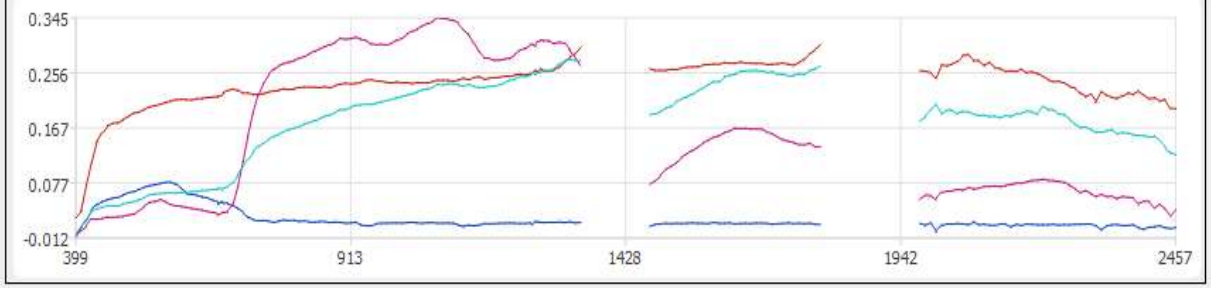
Green

Band 16 - (wvl. 547.2)

Blue

Band 1 - (wvl. 399.37)

Load FCC Image



Conclusions

- **Hyperspectral remote sensing – a great potential which needs to be tapped**
- **Offers fresh avenues of research in the field of military applications**
- **Capacity building required**


THANK YOU