High Resolution Data Sets acquisition through Satellite, Aerial, UAV/UAS and LIDAR and their Applications

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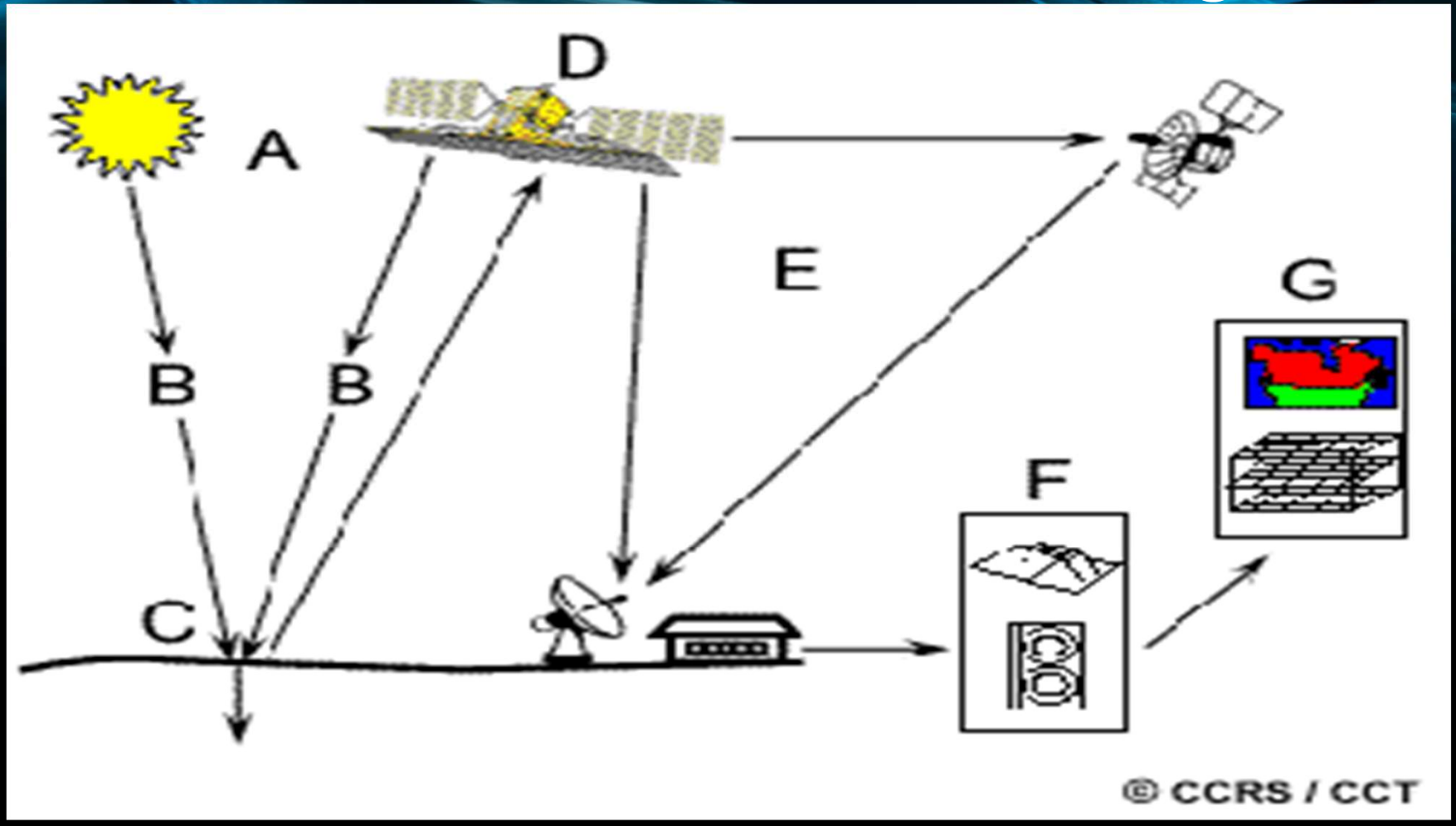
Role of different Geospatial Technologies in high resolution data sets

- Remote Sensing: Acquiring information
- GIS: Managing spatial information (including satellite /aerial (UAV) data integrated with attribute data)
- GNSS/GPS: Location / positional information and navigation
- Photogrammetry: Precise measurement of objects /features from photographs

Elements of Remote Sensing



7 elements of remote sensing process 1.Energy Source (A) 2.Radiation & Atmosphere (B) 3.Interaction with Targets (C) 4.Recording of Energy by Sensor (D) 5.Transmission & Reception (E) 6.Interpretation and Analysis (F) 7.Application (G)

High Resolution Satellite data

- WorldView-4 (0.31m)
- WorldView-3 (0.31m)
- WorldView-2 (0.46m)
- WorldView-1 (0.46m)
- GeoEye-1 (0.46m)
- Pleiades-1A (0.5m)
- Pleiades-1B (0.5m)
- KOMPSAT-3A (0.55m)
- KOMPSAT-3 (0.7m)
- QuickBird (0.65m)
- Gaofen-2 (0.8m)
- TripleSat (0.8m)
- IKONOS (0.82m)
- SkySat-1 (0.8m)
- SkySat-2 (0.8m)
- TerraSAR-X
- SPOT-6 (1.5m)
- SPOT-7 (1.5m)
- Cartosat 2s (.69m PAN), 3A (0.25m PAN, 1m Mx)

High Resolution data sets derived from satellite / Aerial Photographs/ UAVs

- **Land Use / Land cover**
- **DEMs**
- **Ortho Image**
- **Bathymetry**
- **Transport layers (Roads /Rail/ Inland water ways)**
- **3D Fly throughs**
- **Volumetric analytics using near real time**

Remote Sensing Data Policy

National Remote Sensing Centre – is authorized to distribute satellite data
ANTRIX – authority to issue the license

https://nrsc.gov.in/Remote_Sensing_Data_Policy

UAV Remote Sensing

UAV developments world over

Rustom (DRDO) UAV, 90 kg payload, 24 hrs, 720 kg empty wt

USA Predator UAV 14 hrs,

Fixed wing UAVs

Nano drones (UAVs)

Multicopter UAVs

Issues and Challenges: Empty weight, payload, endurance, sensors, DGPS (Real time kinematics), follow me options, flying height, processing s/ws, Rules and regulations (DGCA rules) etc.

What do we get from UAVs

- Very high resolution image/photography
- Frequent repeatitive data
- DSM/DTM/DEMs
- Ortho photo / Ortho image
- Transporting of material for medical emergency / transporting people etc
- Surveillance / security etc.
- Disaster management
- Etc.

Satellite
Aerial
UAS/ UAV
LiDAR
In Situ

Unmanned Aerial Vehicle (UAV) data Acquisition

UAVs are commonly regarded as remotely piloted or autonomous aerial vehicles, Unpiloted Aerial Systems (UAS) or Remotely Piloted Aircraft Systems (RPAS).

Satellite
Aerial
UAS/ UAV
LiDAR
In Situ

Types of UAV Platforms

Multi-rotor - Multi-rotor UAVs are the most widely used platforms. They include tri-copters, quad-copters, hexa-copters and octo-copters with 3, 4, 7 and 8 rotors respectively.

Fixed wing - Fixed wing UAVs encompass small, Medium Altitude Long Endurance (MALE), and High Altitude Long Endurance (HALE). The benefits of fixed-wing over

Hybrid - Hybrid UAVs include Vertical Take-off and Landing (VTOL) fixed wing which are essentially fixed-wing drones with rotors added.

Payloads

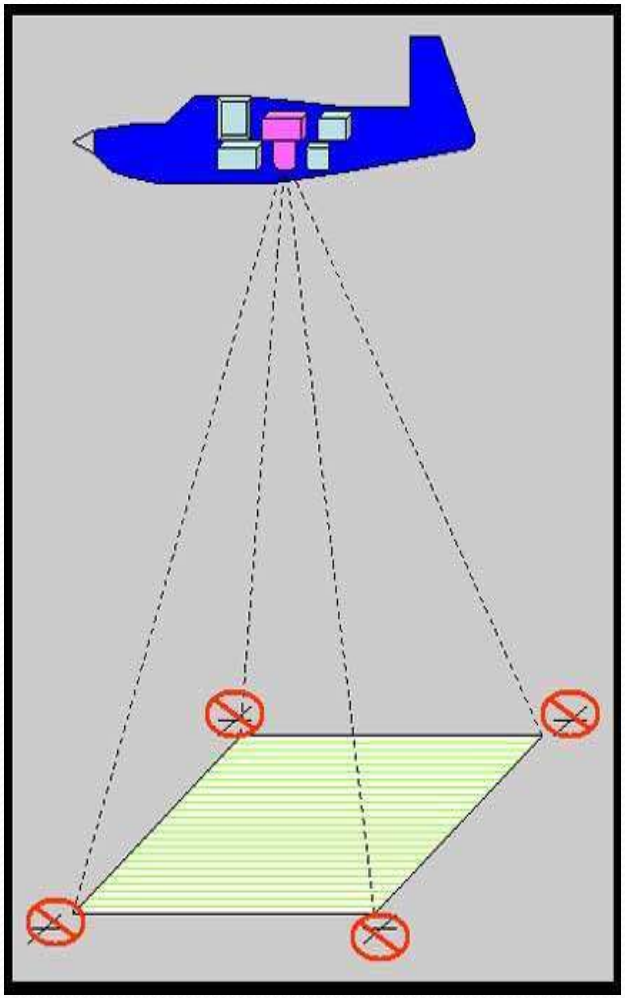
Payload is essentially the carrying capacity of a UAV, usually measured as the weight being carried. UAVs can be used to carry small payloads, perform deliveries and minor services, carry video and static cameras for photography and videography, and perform commercial and military inspections.

Fundamentally pilots must ensure that a UAV can carry the desired payload for the required flight time. As a rule of thumb, the heavier payload a platform carries, the shorter its flight time will be.

UAV payloads can either be sensors such as RGB cameras, Multispectral, Hyperspectral, LiDAR, or other specialized instruments, such as parcels, medical or rescue equipment etc.

Major Steps for UAV Data Acquisition

1. Mission planning
2. Flight planning
3. GCP establishment
4. Data acquisition
5. Quality control



UAV Applications & Limitations

Applications

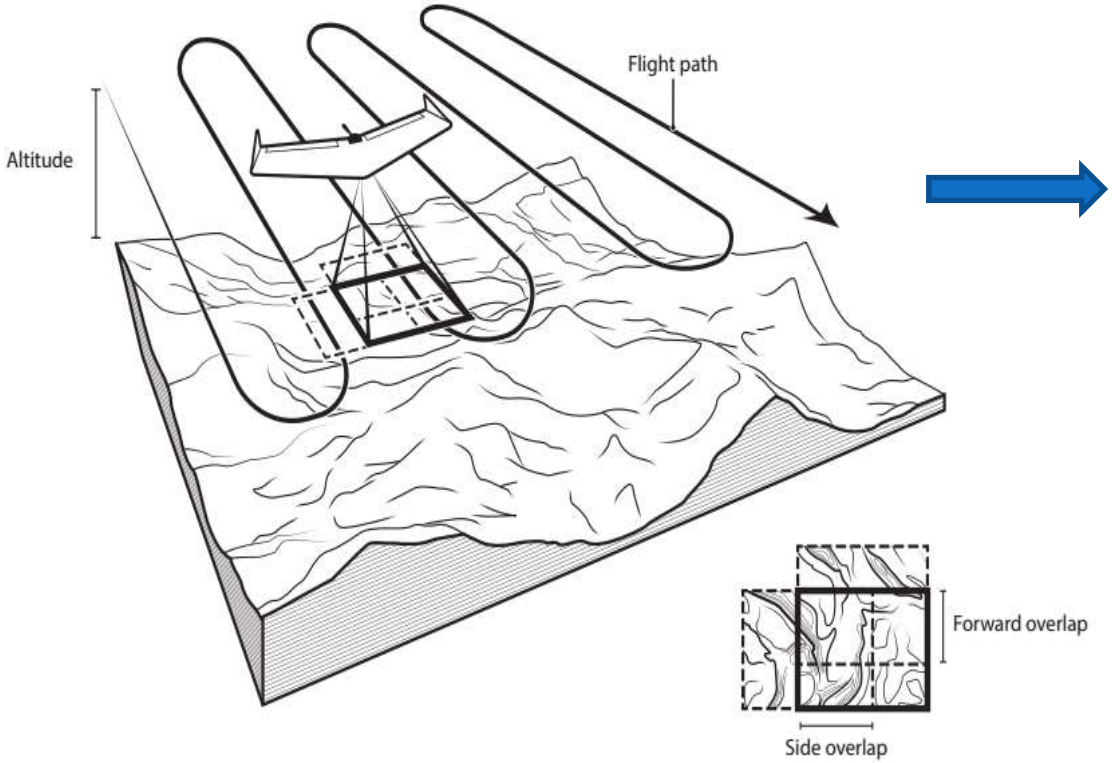
- Quick disaster assessment
- Crop estimation & damage assessment
- City/town planning
- Traffic management
- Aerial movies & videography-Film industry
- Industrial inspection-solar parks, wind parks, power line etc.
- Structural analysis- archaeology & heritage monument inspection
- First responders in accident, fire or crisis

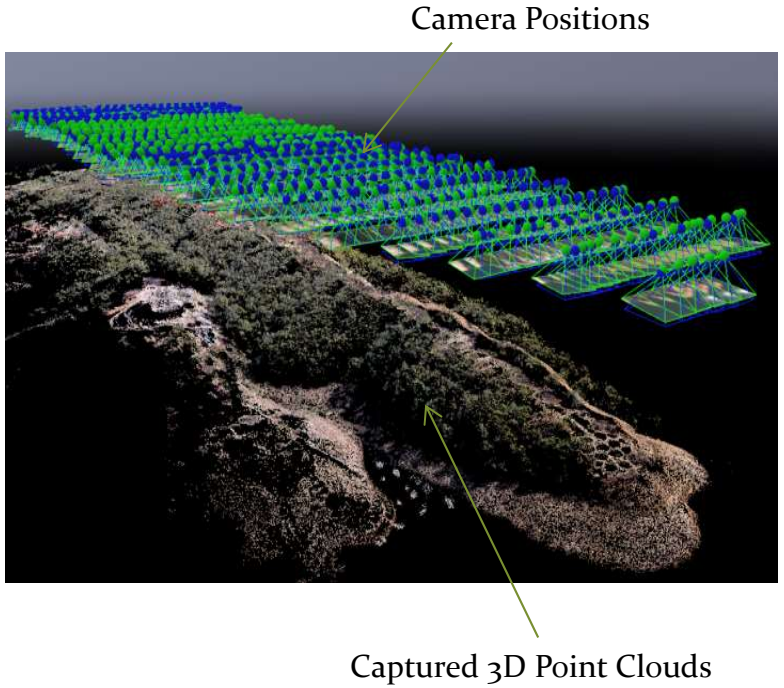
Limitations

- Limited payload capacity
- Limited flight endurance
- Less area coverage
- Relatively costly
- Suitable for small study area
- Can not be operated during rain

UAV Remote Sensing-Overview

Mission Planning





- Define GSD (Spatial Resolution of the image to be captured)

GSD = (pixel size of Camera Sensor x Flight Altitude) / focal length

- Set Image Overlapping for better 3D reconstructions

Forward Overlap = 75 % Overlap | Side Overlap = 60%

UAV Data Processing

Basic UAV Data Processing Flow

Feature Detection
Feature Matching

→

Generation of 3D
Point Clouds

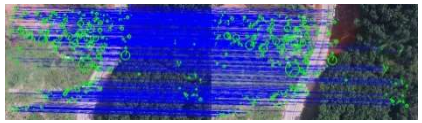
→

3D Surface
Reconstruction
Viz Meshing

→

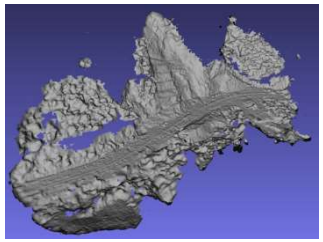
Generation of
3D Surface Models
(DSM/DEM,
Ortho-mosaic, Contours

Feature A Feature B



Feature Matching
(Blue Line : Matching Features from A to B)

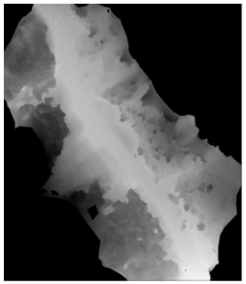
3D Point Clouds



Mesh

Full 3D Textured Model

Orthomosaic



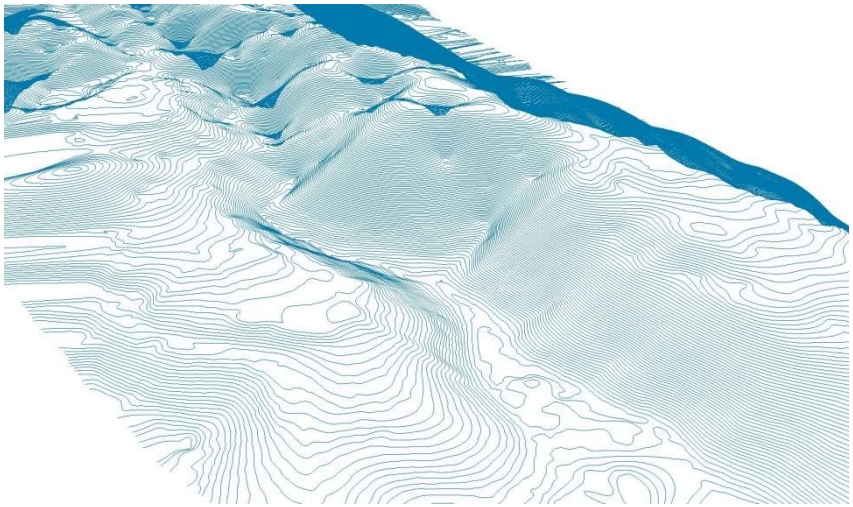
DEM

UAV Data Products

UAV Data Products and some Possible Application

- **Orthomosaic (<5cm spatial resolution)** : High Resolution Planimetric mapping
- **Dense 3D Point Clouds** : Precise Geometric measurement including Volumetric Analysis
- **DSM** : Regional/ Landscape Planning
- **Full 3D Textured Models** : For 3D Visualization / Fly throughs
- **Others** : Sub-meter level Contours etc

Full 3D Textured Model of Nehru Park, Umiam
(made from 580 UAV Images)



Contour map
(0.5 m contour interval)

UAV Open Source Data Process

Open Source Tools and UAV Data Processing

- **OpenCV** : UAV Image Feature Extraction and Matching
- **VLFeat** : Algorithms for Feature Detection/Matching
- **OpenSFM/VisualSFM** : Generation of 3D Point Clouds
- **PMVS/CMPMVS** : Orthophoto Generation
- **MeshLab** : 3D Mesh Editing/Cleaning and reconstruction
- **OpenDroneMap** : For generating 3D Textured Surface Model

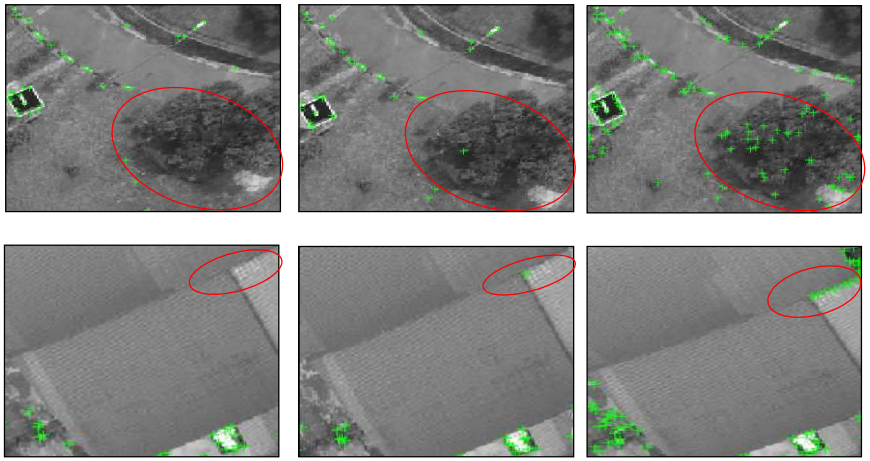


Fig : Analysis of different feature detection algorithms
for 3D scene reconstruction

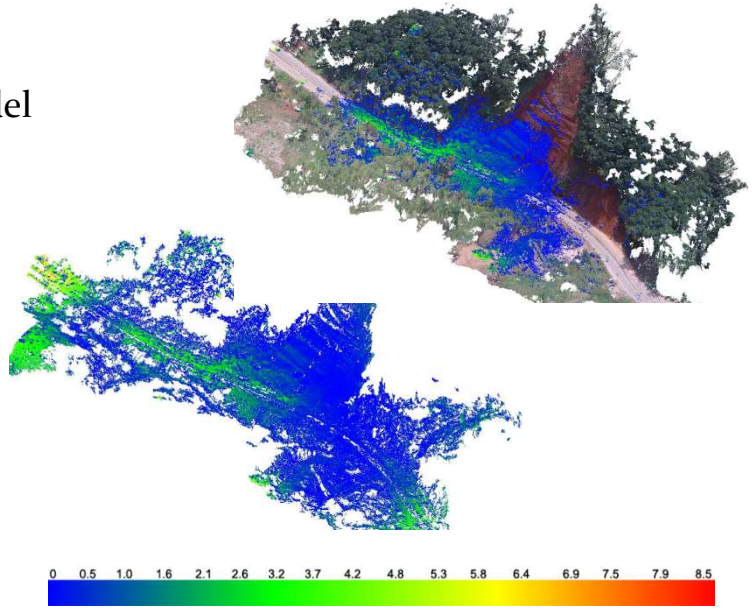


Fig : Accuracy Assessment of 3D Point Clouds
generated from Open Source Tools.
Blue Point Clouds indicates accurate matching
as compared to Pix4D Outputs

UAV Data Processing softwares

Agisoft Professional	Pix4D Mapper Pro	IMAGINE UAV	Open Source Tools
Pros [1]Photogrammetric triangulation [2]Dense point cloud generation. [3]3D model generation and texturing [4]Ability to record thermal imaging. [5]In-built tools to record precise distance, area and volume measurements. **Cons** : [1] No 3D Flythrough [2]Limited Options for Export File Outputs	**Pros**: [1] Capture 3D textured models, digital surface models and NDVI maps to a greater degree of accuracy [2] Fully automatic workflow [3] Ray Cloud Point Cloud Editing [4]3D Flythrough [5] Various File Export Output Formats [6]More User Friendly [7]Good Documentation **Cons:** [1] Large Memory and graphics required for processing [2]Not possible to change the processing parameters in-between processes [2]Costly	**Pros**: [1]The required products of an UAV survey such as point cloud, orthomosaic and digital elevation model are available [2]Less Processing Time [3] No photogrammetric expert knowledge is required to use IMAGINE UAV as the software algorithms (Agisoft PhotoScan) are very robust [4] Customizable using spatial model solution to produce additional customized value-added products **Cons** : [1]Runs on top of ERDAS Imagine [2] Costly	**Pros**: [1] Dense 3D Point Cloud Generation [2] Generation of DSM/DEM [3] Generation of OrthoPhoto [4] Full 3D Textured Models [5] Options to Choose and experiment with different Feature Detection/Matching Algorithms [6] Develop new algorithms and use in the process workflow [7] Free Software! **Cons**: [1] Difficult workflow/High Learning Curve [2] More Processing Time [3] Needs to learn multiple packages and programming/ Configurations required [4] Runs on specific OS

UAV systems at NESAC-UAVs

UAV systems at NESAC- Sensors

12 Mpx optical sensor

4 Band multispectral sensor

Specs:

1. 4 monochromatic bands (Green, Red Red Edge and NIR) 1.2 Mpx each
1. 1 RGB sensor 16 Mpx
2. Total weight about 70-80 gms

UAV Applications with Case Study examples

UAV Activities

Applications till date

River embankment studies, Village modelling, Crop health monitoring (rice, tea etc.), Infrastructure Planning (dam, power house, village etc)

Deliverables

Large scale maps, Real time video

3D surface models/DEM

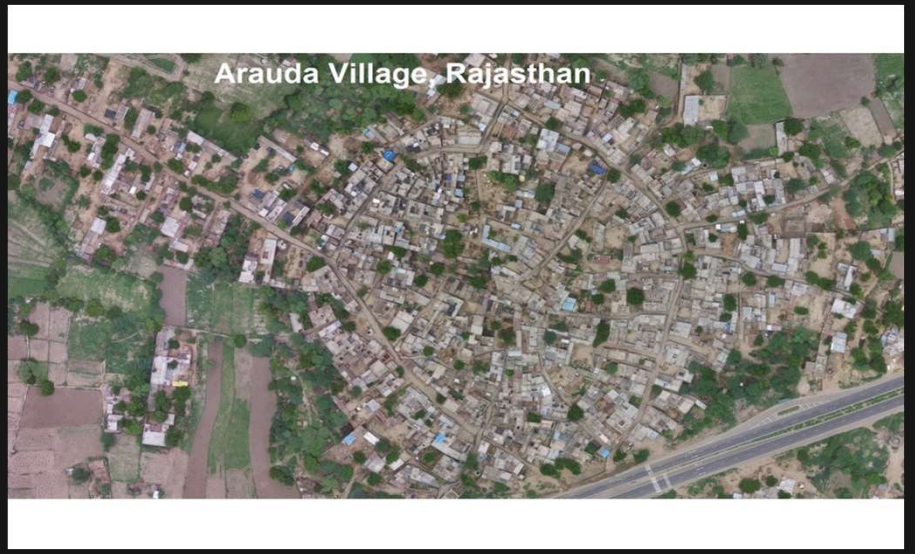
User Request to Fly

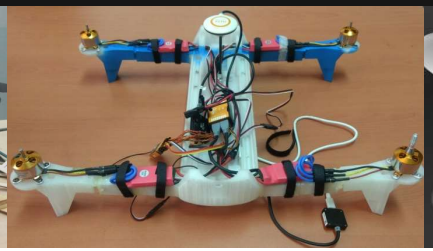
DCs of Meghalaya, Assam Govt., Assam Rifles, NIRD, NEEPCO etc.

Surveys conducted

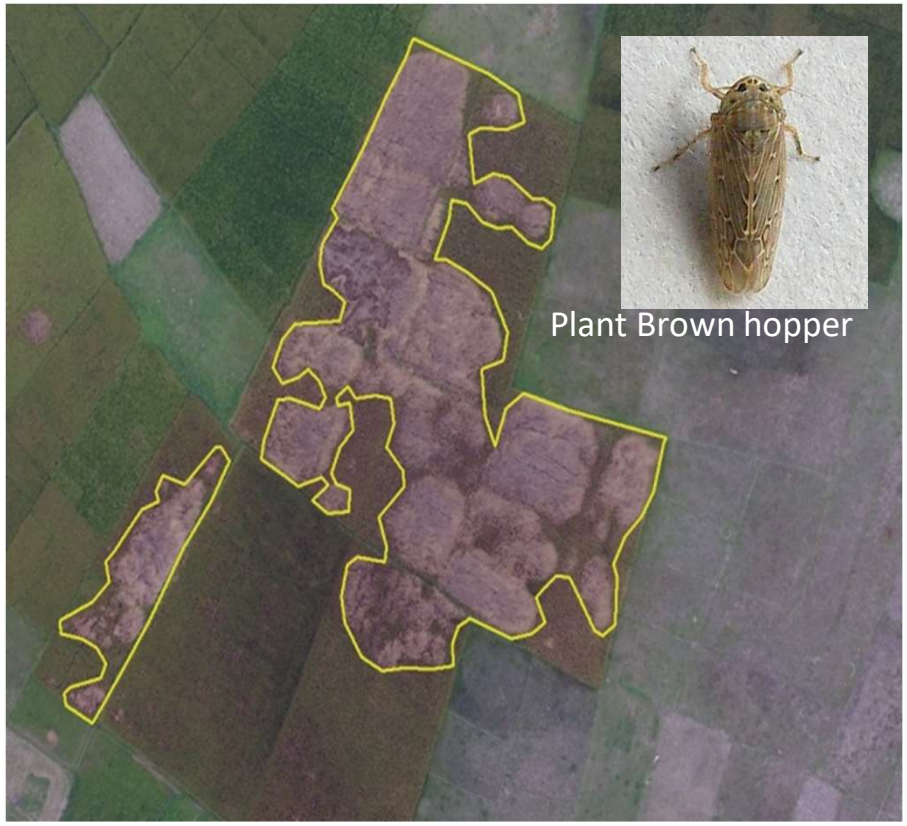
60 + for different users

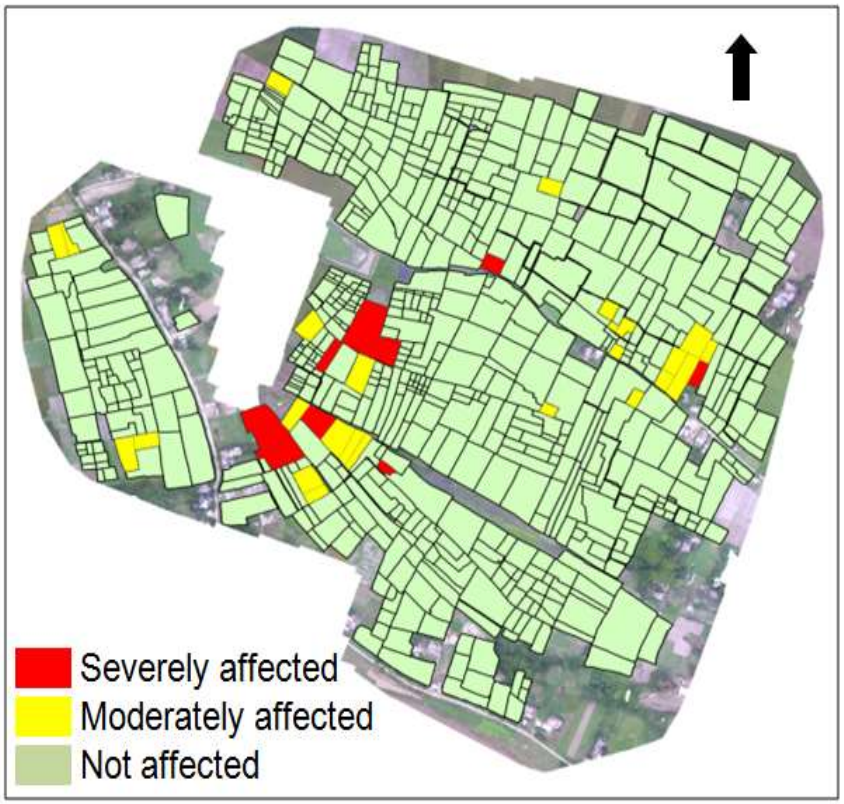
Setting up of UAV facility for all SRSACs of NER-funded by NEC





Case Studies at NESAC: Agriculture-estimation of crop infestation





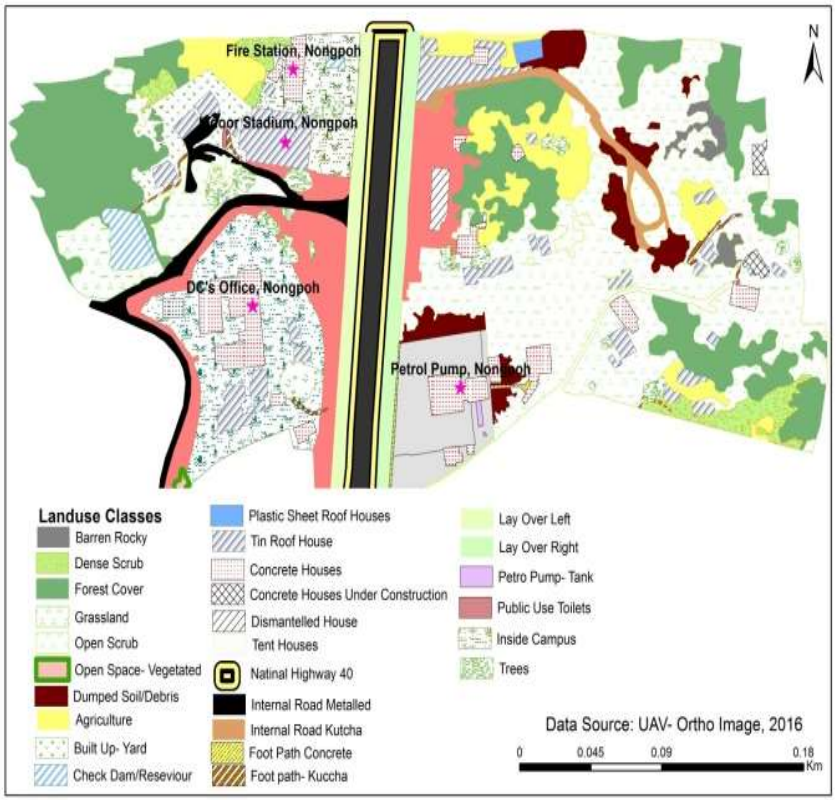
Study Area: Naramari village, Morigaon district, Assam.

Total area covered 55 ha

Severely affected area 1.5 sq. ha (with more than 60% infestation)

Moderately affected area 4 ha (with less than 60% infestation)

Case Studies at NESAC: Large scale land use mapping



Study Area: Nonghpoh town, Ri Bhoi District, Meghalaya.

Total area covered: 84 ha

Existing land use of the town is comprised of 27+ land use class.

Case Studies at NESAC: Mapping of landslide affected area

Study Area: Along NH-40 connecting Guwahati to Shillong city, Meghalaya

Calculated 2D & 3D area: 3471.17 sq m & 4533.96 sq m

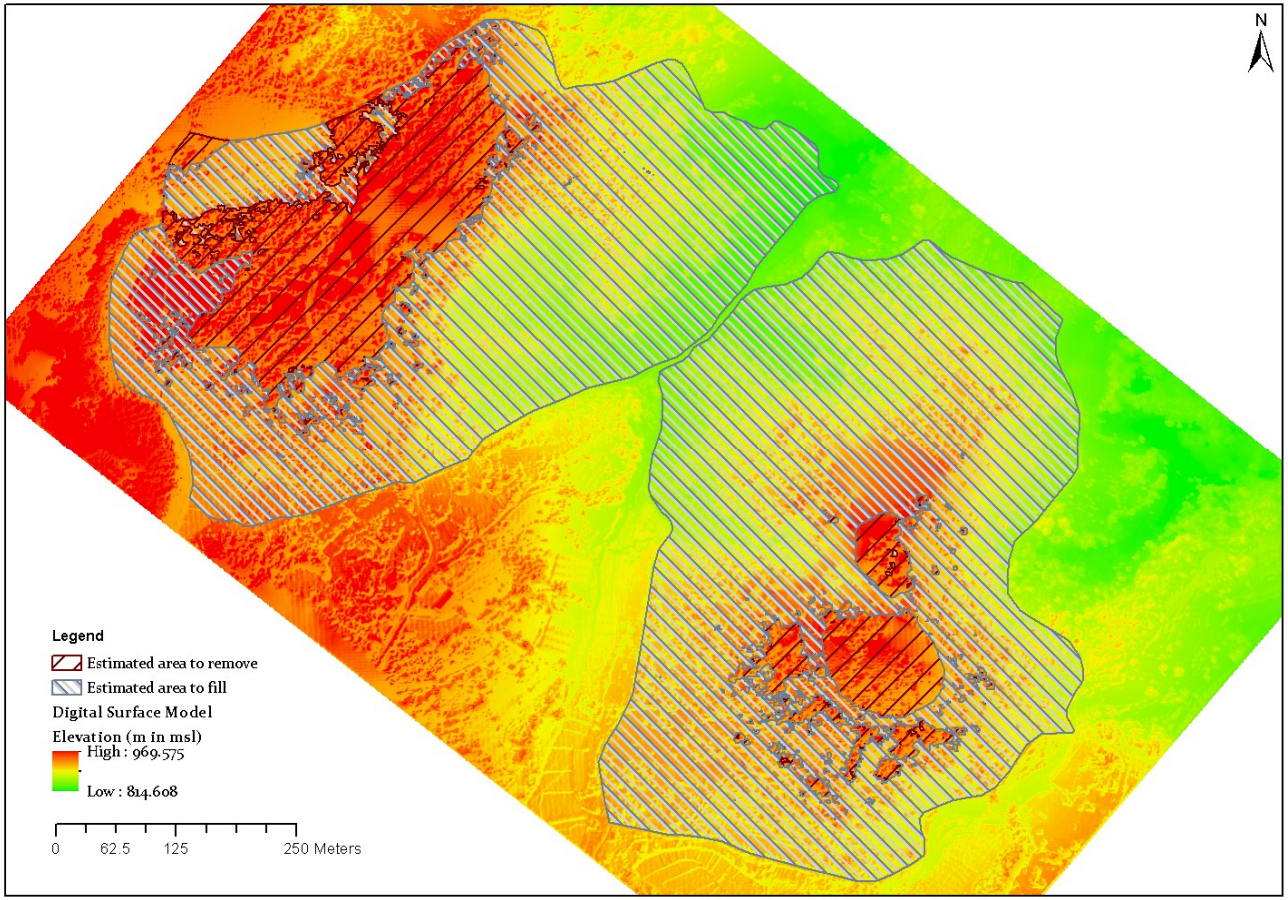
Calculated 3D volume: 7445.26 cubic m

Projected 2D length: 277.99 m

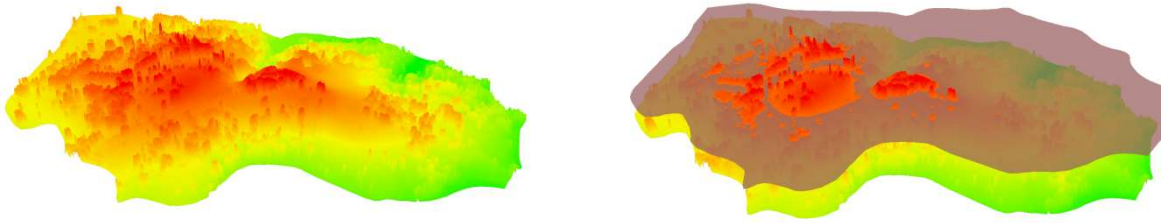
3D length : 303.90 m

Case Studies at NESAC-NEHRU park Umiam

Estimation of Earth Work for Extension of Shillong Airport

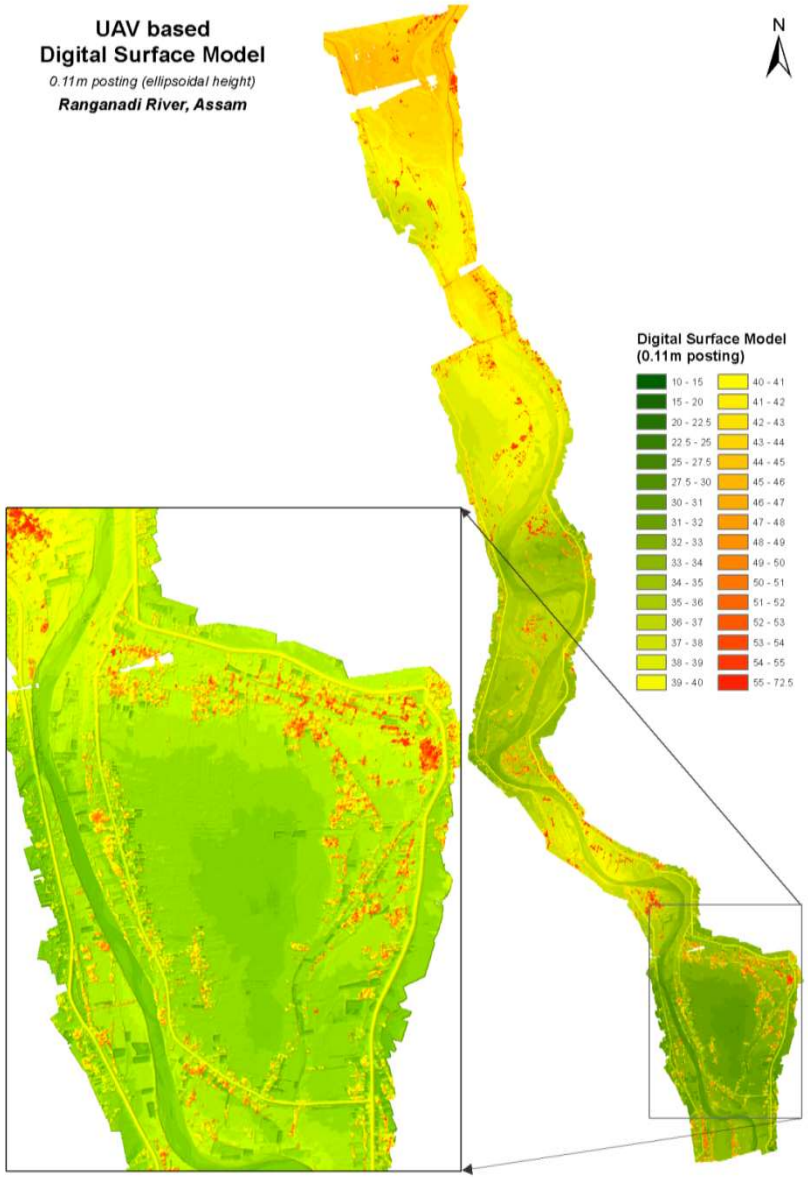


2D map of cut and fill area



3D visualization of DSM and cut & fill area

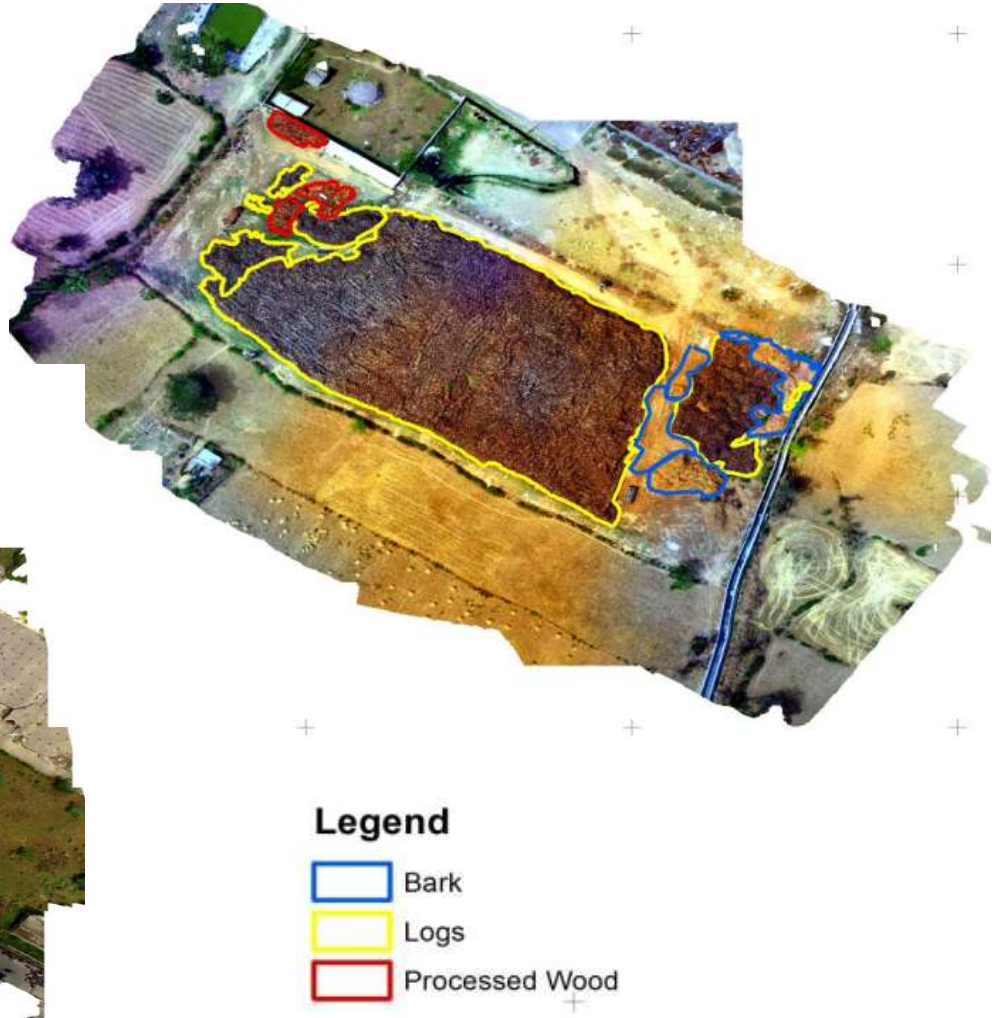
Embankment breach location & monitoring, Assam



3D Views of Embankment

Volume Estimation of Khair Wood in Samba and Kathua districts of Jammu

Jammu police (IG Office) and Jammu & Kashmir State Remote Sensing Application Centre (JKSRSAC)



DGCA regulations for UAVs

Satellite
Aerial
UAS/ UAV
LiDAR
In Situ

DGCA regulations for UAV

Effective: 01st December, 2018

Applicable for All civilian organizations: Central Govt./State Govt./PSUs/Private industries/Academia etc.

Except: Indian Army, Indian Air force, Indian Navy, Police, Central Reserve forces, Security agencies

Classification of UAS

- Classification of UAS as per weight
  - Nano : ≤ 250 gm
  - Micro : > 250 gm and < 2 kg
  - Mini : > 2 kg and < 25 kg
  - Small : > 25 kg and < 150 kg
  - Large : > 150 kg

Application Process:
Online: Digital Sky Platform

Satellite
Aerial
UAS/ UAV
LiDAR
In Situ

General Requirements

Item/ Category	Nano (≤250 gm)	Micro (>250gm≤2kg)	Mini & Above (>2kg≤25kg) (>25kg≤150kg) (>150kg)	Model Aircraft, MTOW < 2kg
Security clearance (organisation)	✗	✓	✓	✗
Unique Identification No. (UIN)	✗	✓	✓	✗
Unmanned Aircraft Operator Permit (UAOP)	✗	✗	✓	✗
Remote pilot approval requirement	✗	✗	✓	✗
Approval Time for UIN/UAOP	✗	02 days	02/07 days	✗

Satellite
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In Situ

Operational Requirements

Item/ Category	Nano (<250 gm)	Micro (>250gm<2kg)	Mini & Above (>2kg<25kg) (>25kg<150kg) (>150kg)	Model Aircraft, MTOW < 2kg
Height Allowed (AGL)	50 ft	200 ft	200 ft (>200 ft restrictive)	200 ft
VLoS and Day Operations	✓	✓	✓	✓
Flight Plan	✗	✗	✓	✗
ADC/ FIC	✗	✗	✓	✗
Local Police	✗	✓	✓	✓
Area of Operation	Uncontrolled airspace and indoor	Uncontrolled airspace	Controlled and uncontrolled airspace	Educational institution premises

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Mandatory Equipment Requirements

Item/ Category	Nano (<250 gm)	Micro (>250gm<2kg)	Mini & Above (>2kg<25kg) (>25kg<150kg) (>150kg)	Model Aircraft, MTOW < 2kg
ID Plate	✗	✓	✓	✓
RF ID/ SIM	✗	✓	✓	✗
GPS	✗	✓	✓	✗
RTH (Return to Home)	✗	✓	✓	✗
Anti Collision Light	✗	✓	✓	✗

Note: For Govt. Security Agencies, no approval required except intimation to Local Police and ATC before operation

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Remote Pilot Training Requirements

1. Remote pilot shall have attained 18 years of age, having passed 10th exam in English, and undergone ground/practical training

2. The ground training shall be obtained at any DGCA approved Flying Training Organization (FTO), and include the following theory subjects:

   a) Basic Radio Telephony (RT) techniques including knowledge of radio frequencies.
   b) Flight Planning and ATC procedures.
   c) Regulations specific to area of operations.
   d) Basic knowledge of principles of flight and aerodynamics for fixed wing, rotary wing, and hybrid aircraft.
   e) Airspace Structure and Airspace Restrictions with knowledge of No Drone Zones
   f) Basic Aviation Meteorology.

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UAS/ UAV
LiDAR
In Situ

Remote Pilot Training Requirements

3. The practical training shall comprise of RPA in flight having live component, and/ or Simulated flight training to demonstrate control of RPA throughout its operating conditions, including safe recovery during emergencies and system malfunction. Minimum syllabus and curriculum for training capsule for Remote Pilot is given at ANNEXURE-IX of CAR.

4. The requirements contained above of this CAR are not applicable for Nano and Micro category RPA pilots intending to operate in uncontrolled airspace. However, the owner and user shall be fully aware of responsibilities for all aspects of flight safety during such operations

Satellite
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UAS/ UAV
LiDAR
In Situ

Legal Obligations

UIN and/or UAOP issued by DGCA shall not:

1. Confer on RPAS operator any right against the owner or resident of any land or building or over which the operations are conducted, or prejudice in any way the rights and remedies which a person may have in respect of any injury to person or damage to property caused directly or indirectly by the RPA.
2. Absolve the operator/remote pilot from compliance with any other regulatory requirement, which may exist under the State or Local law.

Insurance:

All civil RPA operators shall have insurance, with liability that they might incur for any damage to third party resulting from the accident/incident.

Enforcement Action:

1. In case of violation of provisions of this CAR/approved operating conditions the UIN/UAOP issued by DGCA shall be suspended/cancelled.
2. Breach of compliance to any of the requirements and falsification of records/ documents shall attract penal action including imposition of penalties as per applicable IPCs (such as 287, 336, 337,338 or any relevant section of IPC)
3. Necessary actions shall be take as per relevant sections of the Aircraft Act 1934/ the Aircraft Rules 1937 or any statutory provisions.

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UAS/ UAV
LiDAR
In Situ

DGCA Regulations for UAV

No Drone Zone

- Above Obstacle Limitation Surfaces (OLS) of operational aerodrome
- Within permanent/temporary Prohibited, Restricted and Danger Areas including Temporary Reserved Area (TRA) and Temporary Segregated Area (TSA) as notified by AAI
- Within 5 Km (2.7 NM) radius from Aerodrome Reference Point (ARP) of Operational aerodrome
- Within 50 km from international border which includes Line of Control (LoC), Line of Actual Control (LAC) and Actual Ground Position Line (AGPL)
- Beyond 500m (horizontal) into sea from coast line provided the location of ground station is on fixed platform over land

Satellite
Aerial
UAS/ UAV
LiDAR
In Situ

DGCA Regulations for UAV

No Drone Zone

- Within 5 km radius from Vijay Chowk in Delhi
- Within 500 m radius from strategic locations notified by Ministry of Home Affairs and military installations.
- From mobile platforms i.e. moving vehicle, ship or aircraft
- Over eco-sensitive zones around National Parks and Wild life sanctuaries notified by MoEF & CC without prior permission
- Operation of Nano and Micro UAS inside covered premises in No Drone Zone may be carried out subject to permission from local police authorities

DGCA Regulations for UAV

No Drone Zone

- Within a distance of 5 km from perimeter of airports at Mumbai, Delhi, Chennai, Kolkata, Bengaluru and Hyderabad
- Within a distance of 3 km from perimeter of any civil, private or defense airports.
- Within 3km from radius of State Secretariat Complex in State Capitals.

Aerial Data acquisition : Photogrammetric Technology

Understanding High Resolution Data sets

- What is data?
- Why data is required?
- How important is the satellite data?
- All the data acquired from aerial / satellite are same or different?
- What are the Remote Sensing satellites of India?
- What are the RS satellites of other Countries?
- What are the commercially owned satellites?
- What are the highest spatial resolution satellites presently available?
- How the DEM is important for different applications?
- What is the difference between optical RS/thermal RS / MWRS/Lidar RS and their applications?

National Spatial Data Infrastructure

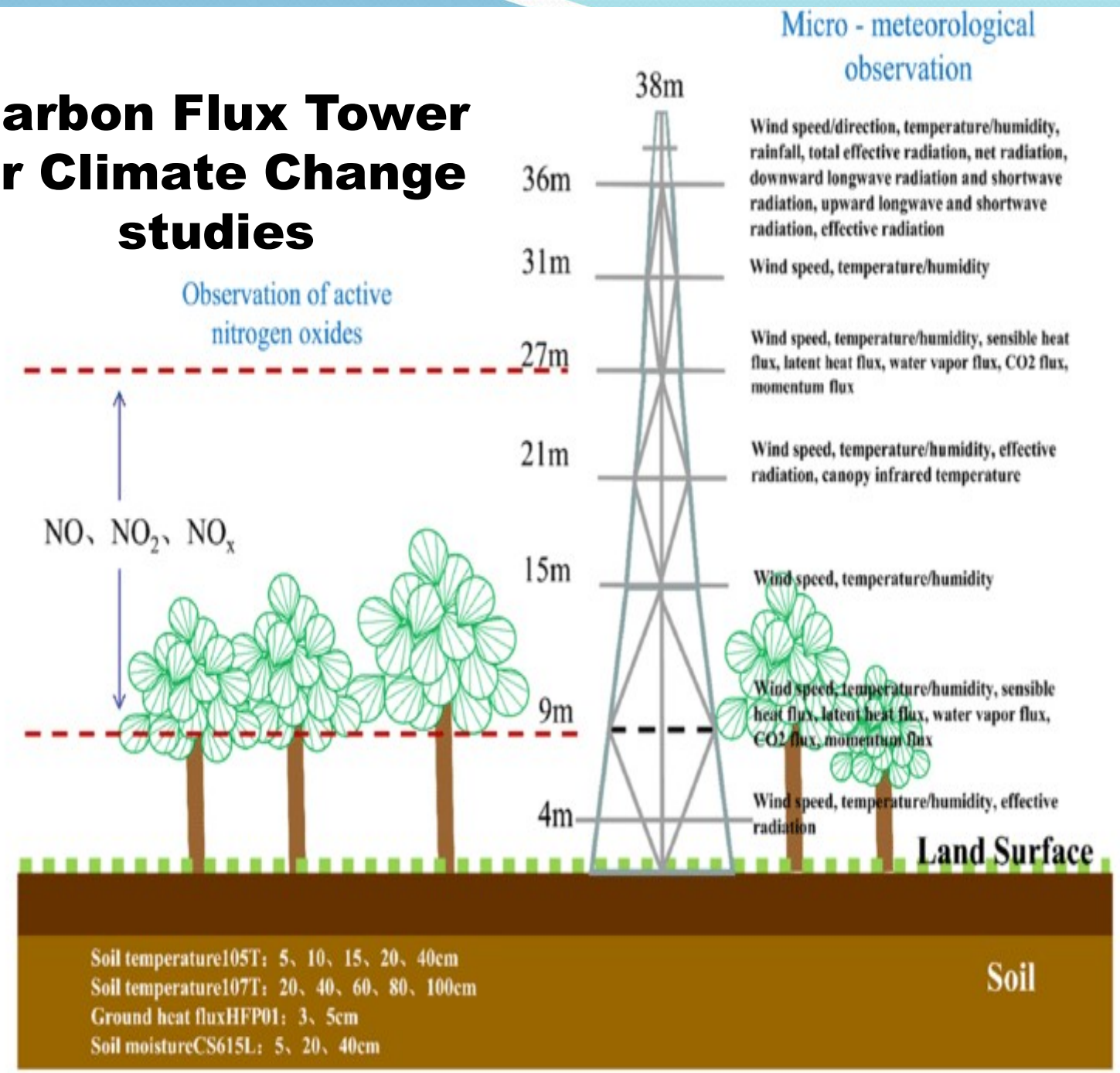
- What are the foundation spatial data?
- What is OGC and it's role in NSDI?
- What are web services?
- List out OGC web services?
- What is cloud computing?
- What are IaaS/PaaS/SaaS/
- Current status of NSDI services outside India?
- Current status of NSDI services in India?
- Hierarchy of SDI services?

In Situ Sensors


camera to see
the road surface
wind speed
wind direction
temperature
and humidity
rainfall
A Roadside
Weather
Station
(some of its features)
Other sensors in the road
measure the temperatures
deeper down, and how
much salt is on the road.


Soil Moisture Sensor
Vernier
www.vernier.com
Patented
R1-03

Carbon Flux Tower for Climate Change studies



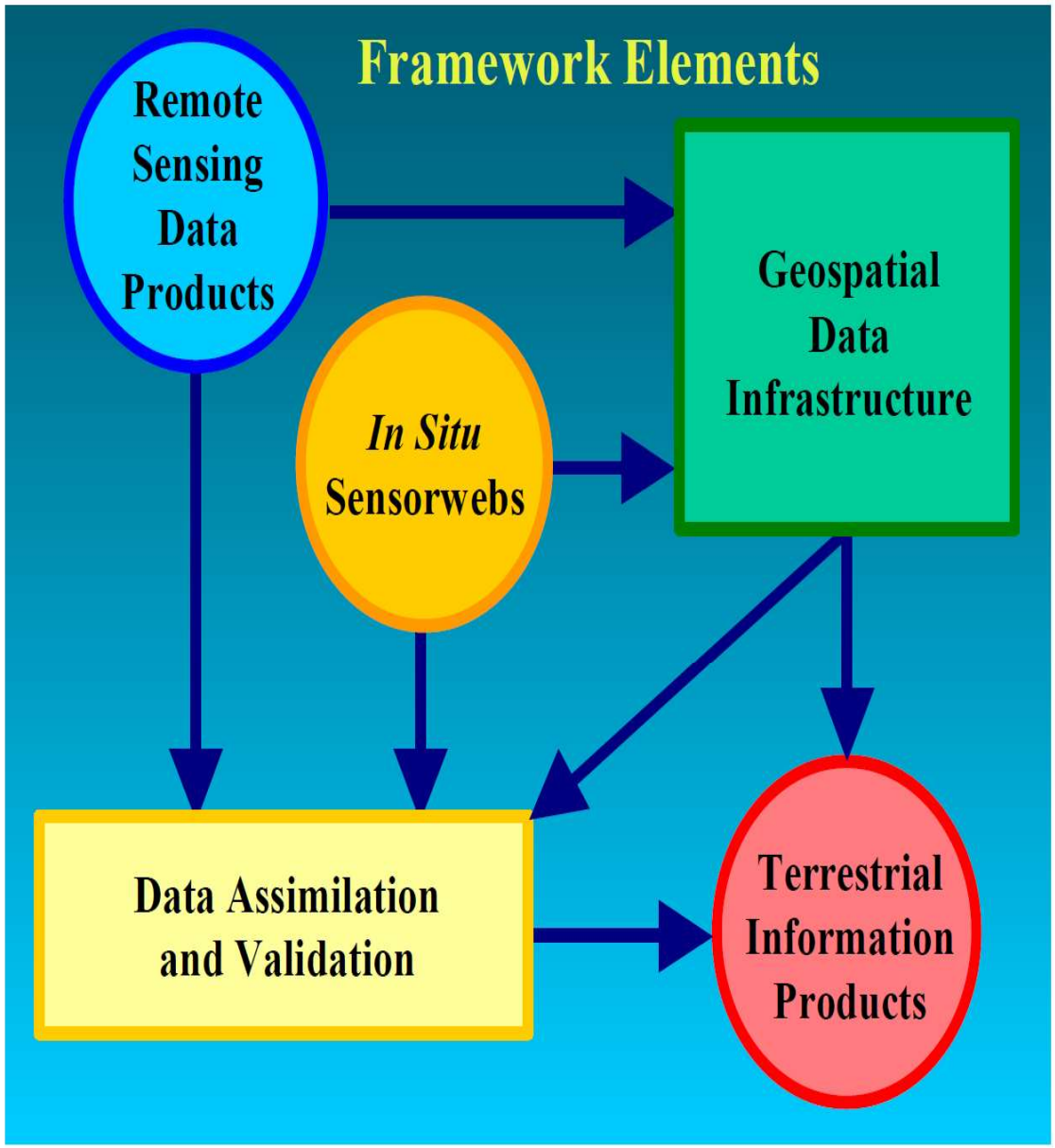


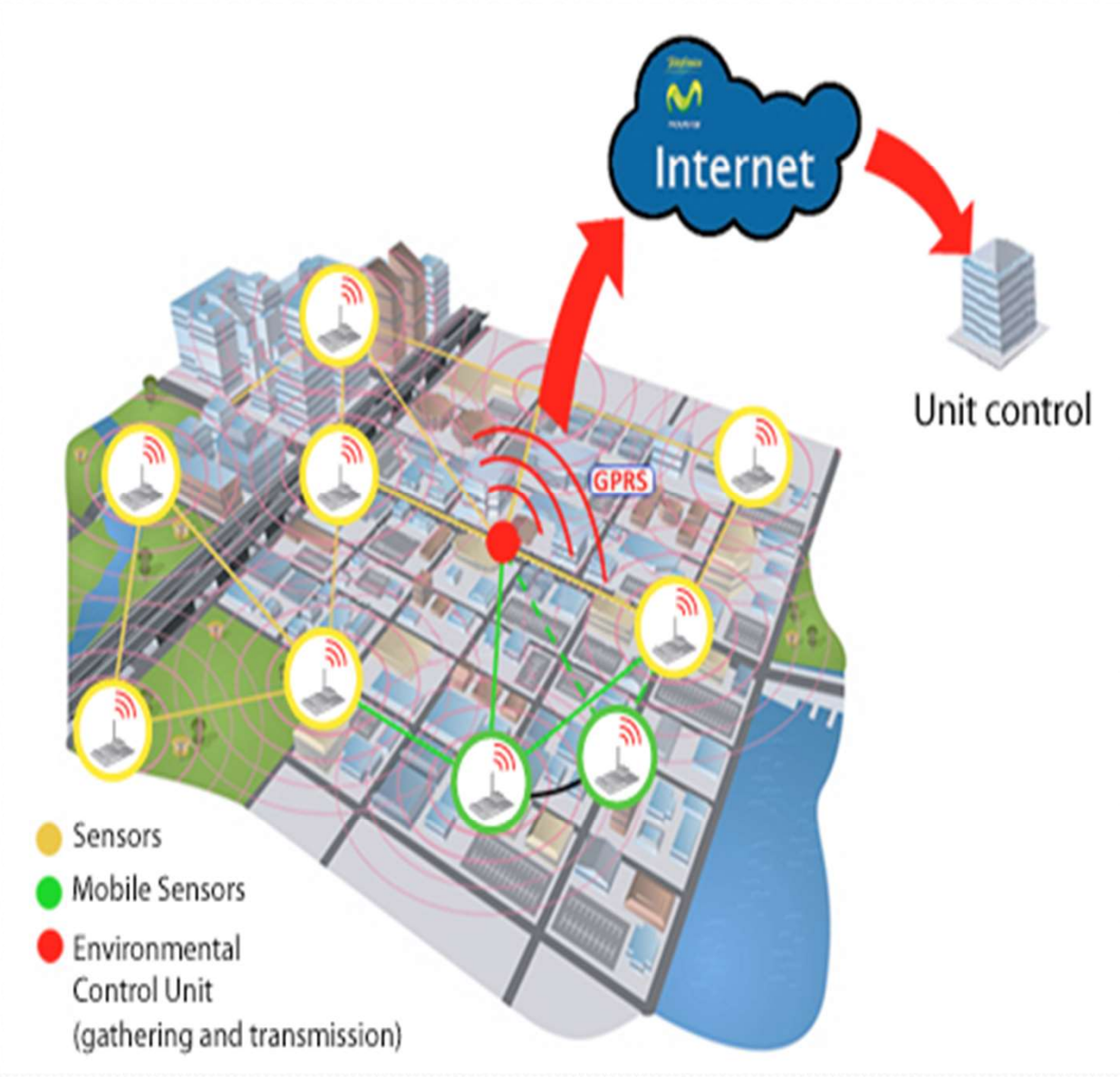
Figure 3. Principal framework elements for *in situ* sensc
measurement assimilation activities.

- **Massive amounts of spatially distributed geo-sensors**
- **Users will interact with models of the sensed phenomena**
- **Users want to predict the future**

Source: http://www.spatial.maine.edu/~max/Bari/a3.pdf, www.esri.com

Sensor Networks

- An association of sensors to monitor an event or conditions.
- Wired
  - Laboratory monitoring
  - Manufacturing monitoring
- Wireless
  - Environmental monitoring
  - Security monitoring
- Hybrid
  - Many types of sensors



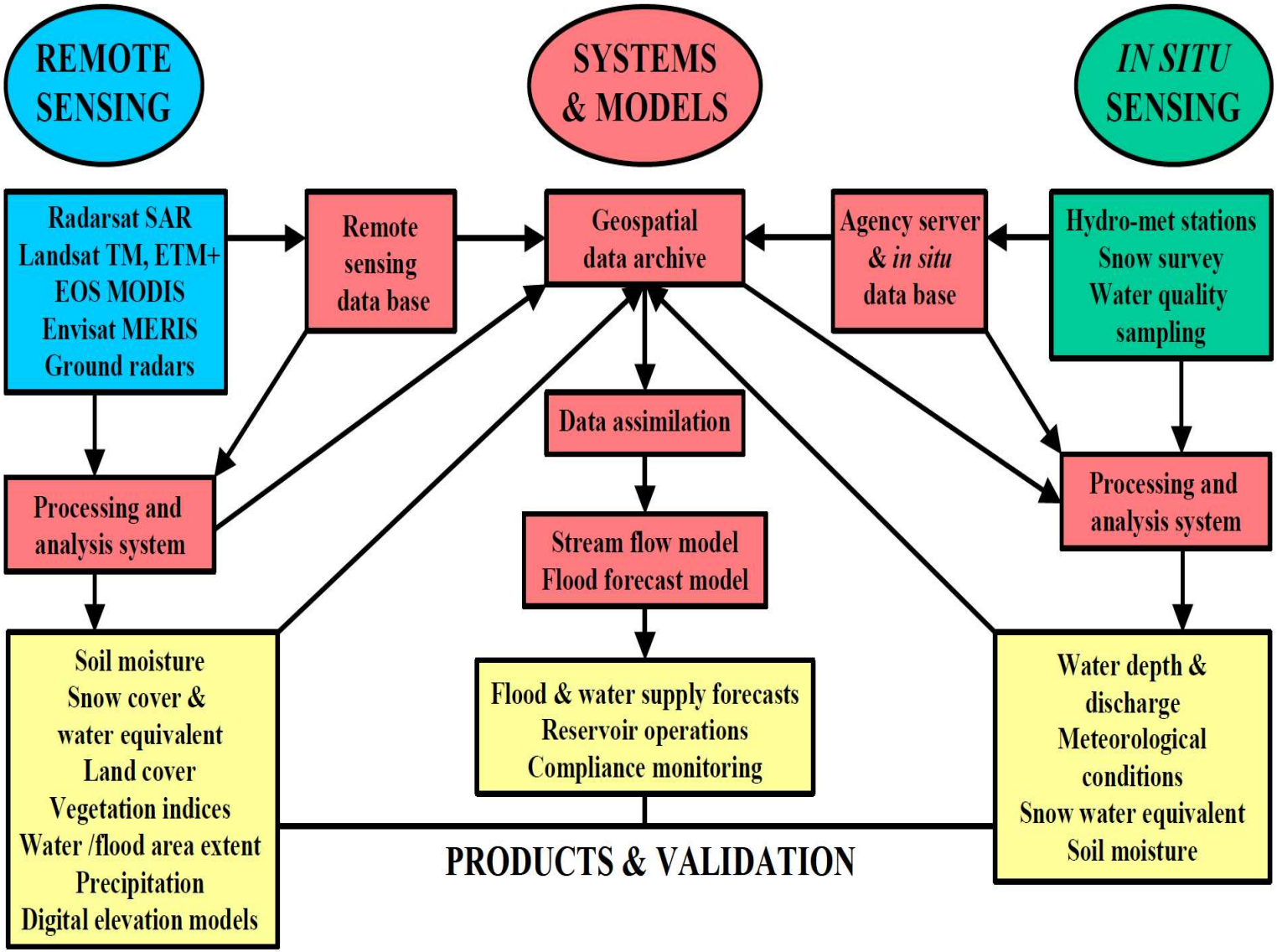


Figure 4. Example of the in situ sensor measurement assimilation framework

INDUSTRIAL IOT WIRELESS TEMPERATURE AND HUMIDITY SENSOR

High Accuracy Readings (±1.7% ±0.3C)

14-bit Resolution

Up to 500,000 Transmissions from 2 AA Batteries

Wireless Mesh Networking using DigiMesh®

Open source, platform independent software gateway via Node-RED NodeJS, Python, LabVIEW, and Visual Studio libraries

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Thank you all
NESAC