GENERIC NANO-SATELLITE FOR MONITORING FLOODS, LANDSLIDES AND FOREST FIRES (CONCEPT PAPER PROPOSAL)

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NIUSAT STUDENT NANOSATELLITE IS UNIQUE?

ALL SUB-SYSTEMS ARE HAVING REDUNDANCY
Why NIUSAT is a Generic Satellite . . .

- NIUSAT is configured as bus module and payload module
- The bus module can support any payload with size <300x300x150mm and power requirement of about 10 to 15 watts
- Flexible attitude control accuracy from 0.5 deg to <10 arc sec
- Fully redundant for all the bus systems (Power, TTC, AOCS & RF systems)
- Functionally co-located systems (Solar panel, Battery, & Power Electronics in single panel)
- Provision for PPT/any other thrusters for orbit maintenance and deorbiting
- Use of Cube sat standard modules for all subsystems
- Fully accessible to any of the subsystems for any problems
PROPOSED CONCEPT

- Realization of suitable nano sensors for monitoring of the disasters like Floods
  - Landslides
  - Forest fire (SWIR)

Constellation (SAR Camera Resolution:<20m)

- Selection of suitable spectral bands and spatial resolution
- Generic Nano satellite configuration
- Nano satellite constellation for global coverage
- Summary of Constellation options
- Possible collaborations
## Proposed Spectral Bands and Possible Applications

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectral Definition</th>
<th>Possible Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Blue</td>
<td>420-510 nm</td>
<td>Provides the best data for mapping depth-detail of water-covered areas. It is also used for soil-vegetation discrimination and forest mapping.</td>
</tr>
<tr>
<td>Visual Green</td>
<td>490-590 nm</td>
<td>The blue-green region of the spectrum corresponds to the chlorophyll absorption of healthy vegetation and is useful for mapping detail such as depth or sediment in water bodies.</td>
</tr>
<tr>
<td>Visual Red</td>
<td>580-670 nm</td>
<td>Chlorophyll absorbs these wavelengths in healthy vegetation. Hence, this band is useful for distinguishing plant species.</td>
</tr>
<tr>
<td>SWIR</td>
<td>1550-1700 nm</td>
<td>Forest fire detection. This region is also sensitive to plant water content, which is a useful measure in studies of vegetation health. This band is also used for distinguishing clouds, snow, and ice.</td>
</tr>
</tbody>
</table>
# Proposed RGB Camera

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground sample distance (GSD) (m)</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Coverage area (Km)</td>
<td>61.4 x 61.4</td>
</tr>
<tr>
<td>3</td>
<td>Spectral band (µm)</td>
<td>B (0.42—0.51), G (0.49-0.59) &amp; R (0.58-0.67)</td>
</tr>
<tr>
<td>4</td>
<td>Saturation Radiance (mW/cm²-sr-µm)</td>
<td>B: 53; G: 53; R: 47</td>
</tr>
<tr>
<td>5</td>
<td>Integration time (µs)</td>
<td>130</td>
</tr>
<tr>
<td>6</td>
<td>Quantization (bits)</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>SNR at saturation</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>8</td>
<td>Operating freq (MHz)</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>Altitude</td>
<td>600</td>
</tr>
<tr>
<td>10</td>
<td>Pixel size (µm)</td>
<td>5.5</td>
</tr>
<tr>
<td>11</td>
<td>Frame (pixels)</td>
<td>2048 x 2048</td>
</tr>
<tr>
<td>12</td>
<td>Effective focal length (mm)</td>
<td>110</td>
</tr>
<tr>
<td>13</td>
<td>F/#</td>
<td>4</td>
</tr>
<tr>
<td>14</td>
<td>Field of view (°)</td>
<td>8.4</td>
</tr>
</tbody>
</table>
# PROPOSED SWIR CAMERA

<table>
<thead>
<tr>
<th>Sr No</th>
<th>PARAMETER</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground sample distance (GSD) (m)</td>
<td>120</td>
</tr>
<tr>
<td>2</td>
<td>Coverage area (Km)</td>
<td>76.8 x 61.4</td>
</tr>
<tr>
<td>3</td>
<td>Spectral band (µm)</td>
<td>1.55-1.7</td>
</tr>
<tr>
<td>4</td>
<td>Saturation Radiance (mW/cm²-sr-µm)</td>
<td>7.5</td>
</tr>
<tr>
<td>5</td>
<td>Integration time (µs)</td>
<td>140</td>
</tr>
<tr>
<td>6</td>
<td>Quantization (bits)</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>SNR at saturation</td>
<td>&gt; 150</td>
</tr>
<tr>
<td>8</td>
<td>Altitude</td>
<td>600</td>
</tr>
<tr>
<td>9</td>
<td>Pixel size (µm)</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>Frame (pixels)</td>
<td>640x512</td>
</tr>
<tr>
<td>11</td>
<td>Effective focal length (mm)</td>
<td>125</td>
</tr>
<tr>
<td>12</td>
<td>F/#</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>Field of view (°)</td>
<td>9.4</td>
</tr>
</tbody>
</table>
BASIC BLOCK DIAGRAM OF NIUSAT CAMERA
FEATURES OF NIUSAT NANO SATELLITE

**Structure/Thermal/Mechanism**
- Overall size: 274 x 274 x 195mm³
- Mass: < 15 kg
- Structure mass: 3.8 kg
- Solar Panel Deployment Mechanism
- Antenna Deployment Mechanism
- Passive and Active Thermal Control System

**Communication System**
- HKTM data transmitter in UHF (420-450 MHz) band
- Tele-Command receiver in VHF (144-148 MHz) band
- Payload data transmission in S-band (2240MHz)
- Monopole Antenna for UHF/VHF for data transmission & reception
- High gain patch antenna for S-band transmitter

**Payload**
- WIDEFIELD SENSOR (4 band)
- Resolution: 35m at 600km altitude
- Swath: 140 km
- Quantisation: 12 bit
- Input Data Rate: 28 Mbps
- Data Compression: JPEG 2000
- Output Data Rate: 1 Mbps

**Mission**
- Polar Sun Synchronous Orbit
- Orbit altitude: 560 – 880 km
- Orbital inclination: 97° - 99°
- Orbital Period: 96-100 min
- Repeatability/Visit: Every day
- Visibility: 4 orbits per day
- 3 axis attitude Stabilized configuration
  - Sun sensors, Magnetometers and MEMS Gyroscopes
  - Magnetic Torquer and 4 Nos of Micro Reaction Wheel
  - Control Algorithm residing in OBC
  - STAR SENSOR and PPT provision kept for fine pointing and orbit correction

**Power**
- Total Power Generation: ~40 W
- Battery Capacity (2 nos.): 5Ah
- Multi Junction Solar Cells based Solar Array
- Stowed during launch and deployed in Orbit
- MPPT based Battery Charge Regulator

**On Board Computer**
- High performance dual core 32 bit E200 Power Architecture
- 2 MB Code flash memory with ECC
- 32 GB storage flash for payload data storage
- Supports I²C, CAN and UART ports
- Supports software tunes and WDT

**Ground Station**
- UHF Downlink and VHF Uplink antennae
- 3 meter reflector S-band antenna for payload data reception
- Mission Control Centre
- Payload Data Processing Centre
- Auto tracking Using TLE/ OD Data
FUNCTIONAL BLOCK DIAGRAM OF NIUSAT
STRUCTURAL LAYOUT OF NIUSAT WITH MULTISPECTRAL CAMERA
STRUCTURAL LAYOUT OF NIUSAT
NIUSAT WITH MULTISPECTRAL CAMERA MOUNTED ON TOP DECK
S-BAND, UHF/VHF ANTENNA AT NIU
Sensors and Constellation options

Proposed sensor options for the constellation

- 2 medium resolution (30m, 4 bands) optical imaging satellite
- 1 high resolution (5m) optical imaging satellite
- 1 SAR (10-20m resolution) imaging satellite

Constellation options

- 4 satellites in a single plane (24 passes per day)
PROPOSED NANO SATELLITE CONSTELLATIONS

Ground Trace of One Satellite (24 hrs)

No. of contacts with ground station in one day: 6 passes
Duration of Access time with ground station: 60mins

International workshop on SSTDM, IISc Bangaluru, India

22-04-2014
Ground Trace of 4 Satellites in Single Plane (24 hrs)

No. of contacts with ground station in one day: 24 passes (4 No. of satellite x 6 pass)

Duration of Access of 1 satellite with ground station: 60 mins

Total Access time of 4 satellites with ground station: 240 mins
Ground Trace of 5 Satellites in Single Plane (24 hrs)

No. of contacts with ground station in one day: 30 passes ($5 \times 6$ passes)

Duration of Access of 1 satellite with ground station: 60mins

Total Access time of 5 satellites with ground station: 300mins (4.5hrs)
Ground Trace of 10 Satellites in Single Plane (24 hrs)

No. of contacts with ground station in one day: 60 passes (10 No. of satellite x 6 pass)
Duration of Access of 1 satellite with ground station: 60 mins
Total Access time of 10 satellites with ground station: 593.8 mins (9.8 hrs)
Ground Trace of 6 Satellites in Two Planes (24 hrs)

No. of contacts with ground station in one day: 36 passes (18AM & 18PM)

Duration of Access of 1 satellite with ground station: 60.12mins

Total Access time of 6 satellites with ground station: 360.72mins (6.012hrs)
Ground Trace of 8 Satellites in Two Planes (24 hrs)

No. of contacts with ground station in one day: 48 passes (24AM & 24PM)

Duration of Access of 1 satellite with ground station: 60.12mins

Total Access time of 8 satellites with ground station: 480.96mins (8.01hrs)
Summary of Constellation options

Proposed sensor options for the constellation

- 2 medium resolution (30m, 4 bands) optical imaging satellite
- 1 high resolution (5m) optical imaging satellite
- 1 SAR (10-20m resolution) imaging satellite

Constellation options

- 4 satellites in a single plane (24 passes per day)
- 5 satellites in a single plane (30 passes per day)
- 10 satellites in a single plane (60 passes per day)
- 6 satellites in a two planes (36 passes per day)
- 8 satellites in a two planes (48 passes per day)
PRESENT STATUS OF NIUSAT........

ALL SUB-SYSTEMS ARE IN BOARD-LEVEL TESTING...

PAYLOAD IS IN PDR LEVEL
Possible Collaborations……..

Joint development of

- High resolution optical payload
- High resolution SAR payload
- High resolution hyper spectral payload

- Specification and configuration can be worked out based on the DMC requirements
- Generic NIUSAT Bus can be offered for any payload upto 5Kg mass and 10W average power
Thank you