Singapore Country Report

by
KWOH, Leong Keong
Director, Centre for Remote Imaging Sensing and Processing
Email: lkkwoh@nus.edu.sg

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History and Outline

• Weather Satellite Reception Facilities in Meteorological Service Singapore (MSS)
• Centre for Remote Imaging, Sensing and Processing (CRISP) remote sensing satellite ground station established in 1995
• Centre for Research in Satellite Technology (CREST) established in 2001 (responsible for XSAT satellite)
• Singapore Technologies SatSys (joint venture of ST, NTU and DSO) in May 2011
• Universities programmes – NTU and NUS
• Economic Development Board establish Office for Space Technology and Industry (OSTIn) in August 2012
• Future – TeLEOS-1, CSAT, KR-1...
CRI SP Ground Station
Centre for Remote Imaging, Sensing and Processing (CRISP) - started in late 1992, as a research centre in the National University of Singapore

CRISP Ground Station currently operates 3 X-band tracking antennas, a 4th antenna has just been installed in December 2013.
Satellite Data CRISP currently receives

1. TERRA MODIS (USA, March 2001)
2. IKONOS (USA, August 2001) – 0.82 m resolution
3. AQUA MODIS (USA, July 2002)
4. SPOT 5 (October 2002) – 2.5 m resolution
5. GeoEye-1 (June 2009) – 0.41m resolution
6. Worldview I & II (Nov 09) – 0.47m resolution
7. XSAT – May 2011
9. CBERS-03 – 2014 (collaboration with Chinese CRESDA and Brazil INPE, receiving data for ASEAN countries)
Environmental Monitoring
Land / Forest Fire monitoring
Daily Fire Monitoring in CRISP using high resolution satellite imagery

- Background: During the 1997/98 El-Nino event, Singapore, like many other countries in the region, experienced severe haze.
- The National Environment Agency (NEA) decided to adopt measures in advance of another occurrence of serious haze.
- CRISP demonstrated the possibility of obtaining clear, unambiguous views of fire using high resolution satellite imagery.
- SPOT 4 added subsequently in 2000. Easier to detect fires due to the shortwave infrared (SWIR) band.
- XSAT join forest monitoring project after launch in 2011
- Recently in 20 June 2013, forest fires in Riau brought haze to Singapore and Malaysia, raising the air pollution index to record high of more than 400 (hazardous level)
XSAT Image of Indonesia Fire (Riau Province) on 19 June 2013
WorldView 2 Image, 23 June 2013
Humanitarian Assistance Support
Indonesia and Singapore Humanitarian Assistance Forces working together at Meulaboh (Sumatra Tsunami 2004)
Singapore Plane and Relief Forces in Tacloban City, November 2013
• Data also shared with agencies of affected countries

• Other disasters supported:
  – Earthquakes
  – Volcanoes Eruptions
  – Floodings
  – Etc
Research Groups

• Very High Resolution (1-2m data)
  • DEM generation, mapping, feature extraction
• Hyperspectral (tens to hundreds of Spectral Channels)
  • Toxic red tides monitoring, ocean pollution, coastal erosions studies
  • Water qualities, atmospheric aerosols and land vegetation
• Multiple Beam, Multiple Polarization SAR
  • Natural hazards monitoring, ocean pollution and land cover studies
• Regional Land Cover and Climate Change
Research
Using radar to better predict earthquakes

NTU and NUS centres studying data to unearth clues on future quakes

BY AMRESH GUNASINGHAM

LARGE earthquakes occur when faults deep beneath the ground rupture. This, in turn, can cause the earth’s surface to move several metres. To geologists, measuring this movement can provide important clues in pinpointing when and how the next severe quake will strike.

Though still not an exact science, such research has been boosted significantly since the 1980s, with the invention of high-precision instruments such as Global Positioning System (GPS) stations and satellites.

The advantage of using individual GPS stations is that they provide precise measurements of any movement of the ground within a given area, said geologist Kerry Sieh, who heads the Earth Observatory of Singapore (EOS) at the Nanyang Technological University.

The disadvantage, though, is that they cannot give the same information over a wider area, and they are also costly to maintain.

Now, researchers at the Centre for Remote Imaging, Sensing and Processing (Crisp) at the National University of Singapore (NUS) believe access to another type of satellite technology, which uses radio waves, could plug this gap.

Interferometric Synthetic Aperture Radar (InSAR) images, in a nutshell, involve Crisp buying data from the Japanese satellite Alos Palsar, which it then uses to produce interferometric maps of equatorial regions.

These maps show the displacement that occurs during an earthquake with an accuracy of within a centimetre for areas that are as large as a few hundred square kilometres, or roughly the size of Singapore.

Radar works by transmitting a radio wave signal, and measures the energy and wavelength that bounce back, said Crisp director Kwoh Leong Keong.

He added that Singapore was only the second country in Asia, after Japan, to gain access to the technology.

InSAR images have been used in the West to track quake activity since the early 1980s, but the launch of the Japanese satellite five years ago provides radar signals with a “longer wavelength”.

Crisp research scientist Emmanuel Christophe explained that this was a boon for tropical terrains, where radar images had previously been hampered by the presence of thick vegetation or a high concentration of water vapour in the air.

“The challenges of measuring a few centimetres of displacement from a satellite flying at 7 km per second and 700 km above the ground are particularly difficult, while the equatorial region, with its typical dense vegetation and mountainous terrain, makes the task even harder,”

The technology has already been put to the test: Dr Christophe has mapped ground shifts along the disaster zone from the Jan 12 Haiti quake that struck about 25km from the capital Port-au-Prince.

Initial findings suggest that the length of the rupture was shorter than originally estimated, implying that other parts of the fault remain under strain and could jolt a quake in future.

Such information, if verified, is important for policymakers tasked with reconstruction efforts in the city, as an equally strong quake could occur in future when the section of the fault nearer the city ruptures, said Professor Sieh.

He leads a team of researchers gathering data from a network of GPS stations stretching around quake-prone Sumatra to determine the level of seismic activity going on there.

Using both technologies together makes for a “powerful combination”, Prof Sieh said. EOS is collaborating with Crisp on the study.
**Greenish Water with Chlorophyll**

**Brownish Turbid River Water**

**Bluish Swimming Pool Water**

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**Reflectance vs. Wavelength (nm)**

- **Swimming Pool**
- **S. Ulu Pandan**
- **Kent Ridge Pk Pnd**

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**Kayak Experiment (w CENSAM)**

**Field Measurement**
### Comparison of NTU from SPOT and PUB in-situ data

<table>
<thead>
<tr>
<th>Reservoir Name</th>
<th>Turbidity (NTU)</th>
<th>Colour (Hazen)</th>
<th>NTU from Satellite Imagery</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACRITCHIE RESERVOIR - RMCD1</td>
<td>5.3</td>
<td>35</td>
<td>9.8</td>
</tr>
<tr>
<td>LOWER SELETAR RESERVOIR - RLSC1</td>
<td>13.5</td>
<td>55</td>
<td>18.0</td>
</tr>
<tr>
<td>BEDOK RESERVOIR - RBEC1</td>
<td>2.3</td>
<td>10</td>
<td>0.4</td>
</tr>
<tr>
<td>JURONG LAKE - RJLD1</td>
<td>13.9</td>
<td>50</td>
<td>7.1</td>
</tr>
<tr>
<td>Kranji - RKRA1</td>
<td>22</td>
<td>100</td>
<td>17.6</td>
</tr>
<tr>
<td>LOWER PEIRCE RESERVOIR - RLPD1</td>
<td>5.3</td>
<td>25</td>
<td>9.8</td>
</tr>
<tr>
<td>PANDAN RESERVOIR - RPAF1</td>
<td>6.6</td>
<td>35</td>
<td>0.4</td>
</tr>
<tr>
<td>POYAN RESERVOIR - RPOB1</td>
<td>2.1</td>
<td>15</td>
<td>6.3</td>
</tr>
<tr>
<td>MURAI RESERVOIR - RMUD1</td>
<td>3.5</td>
<td>10</td>
<td>6.3</td>
</tr>
<tr>
<td>Tengeh - RTEB2</td>
<td>5.9</td>
<td>25</td>
<td>4.3</td>
</tr>
<tr>
<td>SARIMBUN RESERVOIR - RSAD1</td>
<td>2.9</td>
<td>30</td>
<td>18.0</td>
</tr>
<tr>
<td>UPPER PEIRCE RESERVOIR - RUPE1</td>
<td>3.9</td>
<td>20</td>
<td>9.4</td>
</tr>
</tbody>
</table>
Land Cover Change and Deforestation
2000 Regional LC map for Southeast Asia in 500m resolution
2010 Regional LC map for Southeast Asia in 250m resolution
Results I – deforestation rates by forest type

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>2000</th>
<th>2010</th>
<th>Change 2000-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 ha</td>
<td>%</td>
<td>1000 ha</td>
</tr>
<tr>
<td>Mangrove</td>
<td>2706</td>
<td>1.2</td>
<td>2367</td>
</tr>
<tr>
<td>Peat swamp forest</td>
<td>13970</td>
<td>6.4</td>
<td>11214</td>
</tr>
<tr>
<td>Lowland evergreen f.</td>
<td>70889</td>
<td>32.2</td>
<td>63020</td>
</tr>
<tr>
<td>Lower montane forest</td>
<td>18397</td>
<td>8.4</td>
<td>18019</td>
</tr>
<tr>
<td>Upper montane forest</td>
<td>6574</td>
<td>3.0</td>
<td>6814</td>
</tr>
<tr>
<td>Total forest area</td>
<td>112536</td>
<td>51.2</td>
<td>101434</td>
</tr>
</tbody>
</table>

Note:
- the clearly highest deforestation rate in peat swamp forests.
- the reported estimates for overall deforestation rates for the 1990’s reached up to 1.7%/a (but 0.8%/a before 1997).
CREST and XSAT
CREST and XSAT

• The Centre for Research in Satellite Technologies was established in Nanyang Technology University, in collaboration with DSO National Laboratories in 2001

• The first deliverable is XSAT satellite, developed with partners such as CRISP, and overseas collaborators (SaTReCi, ISRO, DLR, DTU etc.)

• The X-SAT experimental satellite:
  – 10 m resolution
  – 3 bands (red, green, NIR)
  – Swath 50km
  – Downlink 50 mbps

• Launched April 2011
• Mission Control System (MCS) developed in-house by CREST/NTU
• Image Receiving and Processing System (IRPS) developed in-house by CRISP/NUS
Geometrically Rectified XSAT Image of Singapore
ST SatSys
Follow-on to XSAT …

Singapore Technologies (ST) Electronics set up a new joint venture company (with DSO and NTU) called ST Electronics (SatSys) Pte Ltd in May 2011

• To design, develop & produce advance satellites
• To exploit & commercialise indigenous satellite engineering capabilities

First satellite to be built by this venture is TeLEOS-1
TeLEOS-1

- Launch Date: 2nd Half 2015
- Designed Life: 5 years
- Orbit: Near Equatorial Orbit (10° to 15° Inclination)
- Orbital height: 550km
- Mass: About 400kg

Imaging & Collection Specifications
- Mean Revisit Time: 12 to 16 hours
- Resolution: 1m nominal at nadir
- Swath width: 12km
- Dynamic Range: 10bits per pixel
- Slew Rate: 2.5 deg/sec

Image Reception and Processing System (Ground Station)
- In-house development of CRISP
TeLEOS-1 NEqO Coverage
OSTIn

Office for Space Technology and Industry
Office for Space Technology and Industry

The Office for Space Technology and Industry (OSTIn) was established by the Singapore government in August 2012 with the mandate to serve as the designated office to develop Singapore’s space industry.

OSTIn was established with the following mandate:

• Plan and execute economic strategies to grow Singapore’s space industry in a sustainable manner.
• Forge collaborations within Singapore, as well as between Singapore and the international community on space initiatives.
• Champion the growth of Singapore’s pool of human capital for the space industry.
Universities
Programmes

Nanyang Technology University
National University of Singapore
**NUS and NTU Satellite with OSTIn Funding**

In January 2013, OSTIn provided partial funding to NTU School of EEE, Satellite Research Centre (SaRC) and NUS School of ECE to build a microsatellite each for launch with TeLEOS-1 in 2015.

NTU satellite is called CSAT-1

NUS satellite is called KR-1 (Kent Ridge 1)

(name subject to change)
NTU CSAT-1
*(Tropical Environmental Monitoring Microsatellite)*

Weight: 100~120 kg

Payload:

i. GPS Occultation (main)

ii. Other experimental missions:
   e.g. Altitude determination with GPS

Planned launched in 2015 with TeLEOS-1
**NUS Kent Ridge-1 (KR-1)**  
*(Earth Observation Microsatellite)*

Collaboration with Berlin Space Technologies  
Weight: ~50 kg

**Payload**
- (Main) super-spectral camera  
  - ~30 bands from Blue to NIR  
  - resolution: ~50m  
  - swath width: ~50 km

- (Sec) Video camera  
  - resolution: ~15m  
  - swath: 10km

Planned launch in 2015 with TeLEOS-1
2015 Launch(?)
TeLEOS-1 (400 kg)
CSAT-1 (100 kg)
KR-1 (50 kg)
+ a few CubeSats of NTU and NUS
Thank You