Disaster monitoring utilizing EO satellite system and DMS-Net

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General Manager
Satellite Business Division
PASCO CORPORATION
Agenda

1. Overview of PASCO
2. Concept of Disaster Monitoring
3. Action for “The Great East Japan Earthquake and Tsunami”
4. Introduction of DMS-Net
Overview of PASCO

- Establishment: 1953
- Head Office: Tokyo, Japan
- Main Services: Aerial survey, Mapping, GIS development, Civil Engineering and Satellite Operation
- Number of Employees: 2,413
- Global Network: USA, Finland, Belgium, Brazil, Indonesia, Thailand, Philippines, China, Vietnam (JICA project office)

- Satellite Business
  - EO satellite Grand Stations in Okinawa and Hokkaido
  - TerraSAR-X operation: since 2007
  - ALOS data archives operation: since April 2011 as a contractor with JAXA.
  - Pleiades operation: since 2012
  - ASNARO operation (planning)
Concept for the Disaster Monitoring

- Observing wide area information and 3D data creation
- Speedy day/night observation and data creation
- Narrow area with higher accuracy
- Quick analysis of acquired data from various sensors, its visualization and supply
- Data relay and immediate processing in the areas of disaster

Satellite data reception and processing
Expansion of the Satellite Ground Station Network

Constructing the integrated social system and aiming to provide information within 3 hours

Global Disaster Management
## PASCO’s Products of Satellites

Distributionship for the various commercial satellites.....14 satellites series

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Satellite</th>
<th>Appearance</th>
<th>Launch</th>
<th>Operated by</th>
<th>Resolution</th>
<th>Swath</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Optical Sensor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IKONOS</td>
<td></td>
<td>Sep. 1999</td>
<td>Geoeye (USA)</td>
<td>Pan(0.82m)</td>
<td>11.3km</td>
</tr>
<tr>
<td></td>
<td>GeoEye-1</td>
<td></td>
<td>Sep. 2008</td>
<td>Geoeye (USA)</td>
<td>Pan(0.41m)</td>
<td>15.2km</td>
</tr>
<tr>
<td></td>
<td>WorldView-2</td>
<td></td>
<td>Oct. 2009</td>
<td>Digital Globe (USA)</td>
<td>Pan(0.46m)</td>
<td>16.4km</td>
</tr>
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<td></td>
<td>QuickBird</td>
<td></td>
<td>Oct. 2001</td>
<td>Digital Globe (USA)</td>
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<tr>
<td></td>
<td>SPOT-5</td>
<td></td>
<td>May 2002</td>
<td>SPOT Image (USA)</td>
<td>Pan(5.0m)</td>
<td>60km</td>
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<tr>
<td></td>
<td>RapidEye</td>
<td></td>
<td>Aug 2008</td>
<td>RapidEye (Germany)</td>
<td>Multi(6.5m)</td>
<td>77km</td>
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<tr>
<td></td>
<td>EROS-A</td>
<td></td>
<td>Dec 2000</td>
<td>Imagesat (Israel)</td>
<td>Pan(1.9m)</td>
<td>14km</td>
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<tr>
<td></td>
<td>EROS-B</td>
<td></td>
<td>Apr. 2006</td>
<td>Imagesat (Israel)</td>
<td>Pan(0.7m)</td>
<td>7km</td>
</tr>
<tr>
<td></td>
<td>Cartosat-1</td>
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<td>May 2005</td>
<td>ISRO (India)</td>
<td>Pan(2.5m)</td>
<td>27.5km</td>
</tr>
<tr>
<td></td>
<td>Cartosat-2</td>
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<td>9.6km</td>
</tr>
<tr>
<td></td>
<td>Optical / SAR</td>
<td>ALOS</td>
<td>Jan. 2006</td>
<td>JAXA (Japan)</td>
<td>SAR(10m)</td>
<td>SAR 40-70km Optic 35-70km</td>
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<tr>
<td></td>
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<td></td>
<td>Pan(2.5m)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Multi(10m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAR</td>
<td>TerraSAR-X</td>
<td>Jun. 2007</td>
<td>DLR/Infoterra</td>
<td>1m(highest)</td>
<td>10～100km</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Range direction)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TanDEM-X</td>
<td>Jun. 2010</td>
<td>DLR/Infoterra</td>
<td>1m(highest)</td>
<td></td>
</tr>
</tbody>
</table>

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# PASCO’s Products of Satellites

Satellites in red were utilized for the Great East Japan Earthquake

<table>
<thead>
<tr>
<th>Sensor Type</th>
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<td>Pan(0.61m) Multi(2.44m)</td>
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<tr>
<td></td>
<td>SPOT-5</td>
<td></td>
<td>May 2002</td>
<td>SPOT Image</td>
<td>Pan(5.0m) Multi(10m) SWIR(20m)</td>
<td>60km</td>
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</tbody>
</table>
PASCO’s Action for

The Great East Japan Earthquake and Tsunami in 2011
Overview of actions after the Earthquake

Essential to make an action plan for acquisition, processing, analysis and providing In the same day of the great earthquake
- Consistent monitoring over affected area and inundation area by TerraSAR-X
- Aerial photogrammetry and high resolution panoramic photo by air
- Detail road damaged assessment by Mobile Mapping System Vehicle.

Space
Consistent monitoring over inundation areas by tsunami by means of Synthetic Aperture Radar satellite (TerraSAR-X)
Map of estimated flood areas
Map of damage status by tsunami
High Resolution Panoramic Aerial Photography
Assessment map of damage in detail

Air
Photogrammetry from airplane over affected areas

Ground
Mobile Mapping System utilized in affected areas.
First Actions within 72 hours for human life
## First Actions within 72 hours

<table>
<thead>
<tr>
<th>Disaster</th>
<th>24 hours</th>
<th>48 hours</th>
<th>72 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:46JST Mar. 11</td>
<td>Mar. 12 (Sat)</td>
<td>Mar. 13 (Sun) First Observation</td>
<td>Mar. 14 (Mon) Second Observation</td>
</tr>
</tbody>
</table>

### Geospatial Information

- Satellite images
- Aerial photos
- Census Map
- Vector Map
- DEM etc.

### Pre-Disaster Image

- Oct. 21, 2010

### Est. Flood Areas (Coastline of SENDAI)

- Est. flood area 18:00 -

<table>
<thead>
<tr>
<th>Location</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sendai City</td>
<td>154.0 km²</td>
</tr>
<tr>
<td>Sendai City (Wabash Park)</td>
<td>13.0 km²</td>
</tr>
<tr>
<td>Sendai City (Wabash Park)</td>
<td>0.8 km²</td>
</tr>
<tr>
<td>Total</td>
<td>157.8 km²</td>
</tr>
</tbody>
</table>

### Est. Seismic Intensity

- 6:00 Observation
- 12:00 Start of data provision

### Change Detection

### Acquisition by EROS-B

- Fukushima Nuclear power plant
- Areas less than 10m elevation above sea level
- 20km radius from Fukushima Nuclear Power Plant

### Detection of Floating Objects

- (Hokkaido – Chiba)

### Flood Areas

- 15.1 km² 48.4 km²
- 15.2 km² 100.7 km²
- 6.0 km² 58.1 km²
- 17.7 km² 101.9 km²
- 68.6 km² 369.8 km²

### Notes

- 12:00 Start of data provision
- 6:00 Observation
- 15:30 Start Observation plan and order
- 20:00 Preparation for analysis and pre-Disaster images
- PASCO carried out automatic change detection between pre- and post-disaster by using TerraSAR-X images.
- This allowed us to quickly estimate the inundation areas around SENDAI in the same day of data acquisition.

First image for estimated inundation area

Pre-disaster data

Mar. 11 14:46
Earthquake

Sendai-city

Observed on Oct. 21, 2010

Post-disaster data

Mar. 13 6:00
Data
Acquired

Sendai-city

Observed on Mar. 13, 2011 (JST)

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Inundation map was made in 6 hours after data acquisition.

Dark red areas indicate inundation areas.
Affected area, Detection of floating objects and etc.

- Est. affected area by tsunami
  Northern part of Fukushima
  Around nuclear power plant
  Using TerraSAR-X

- Detection of floating objects
  Iwate-Sanriku
  Pacific Ocean
  Using TerraSAR-X

- Optical Images (EROS-B)
  Fukushima nuclear power plants
Rapid mapping within 1 week for mitigation
Map of Flooded Areas for 500km

- Satellite images for interpretation of flood areas (March 12-18)

WorldView-1,2 (Hitachi Solutions)
- 61 scenes 19,764km²
  - Obs. Date: Mar 12, 13 and 14
  - Area: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, Chiba

ALOS [PRISM/AVNIR-2](JAXA)
- 44 scenes 215,600km²
  - Obs. Date: Mar 12, 13 and 14
  - Area: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, Chiba

SPOT-5 (Spot Image)
- 9 scenes 32,400km²
  - Obs. Date: Mar 12, 18
  - Area: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, Chiba

RapidEye (Panaxx)
- 40 scenes 237,160km²
  - Obs. Date: Mar 12, 13, 14, 15, 16
  - Area: Aomori, Iwate, Miyagi, Fukushima, Ibaraki

TerraSAR-X (PASCO)
- 40 scenes 60,000km²
  - Obs. Date: Mar 13, 14, 15, 16
  - Area: Hokkaido, Aomori, Iwate, Miyagi, Fukushima, Ibaraki, Chiba, Tokyo, Kanagawa, Niigata, Nagano, Gunma, Yamanashi

A total of 194 scenes
(about 560,000 Km²)

Total of 50 technical experts were involved in this project.

< Interpretation Criteria >
1. Flood water is visible.
2. Boundary of farm lands disappears.
3. Properties like houses are broken.
4. Color changes due to debris deposits are visible.
(This procedure was developed to ensure accuracy and consistency of interpretation)

Identification of flood areas
GIS data
Creating Maps
Calculation of flood area

<Created products of est. flood map>
1. Overview Map
2. Detailed Map
3. Size of flooded areas by municipality
4. GIS polygon data (SHP, KML)
Continuous Monitoring within 1 month for recovering properties
Inundation Monitoring Using TerraSAR-X

Daily report update of inundated areas for Automatic change detection
Provided to MLIT, Cabinet Office and Local government
Ten times Observation using TerraSAR-X between March 13 and April 4

Water-pumping effort
Satellite Stereo-Mapping by WorldView

Near the Fukushima first Nuclear Power Plant, Photogrametry or field survey is never permit. Applied to satellite stereo-mapping by WorldView.
High resolution Panoramic Oblique photos by helicopter are useful for damage estimation of houses and buildings and properties.
Road damaged assessment by MMS

Detail road information were collected and analyzed while driving vehicle with mobile mapping system.
Quick delivery by any means...

-Maps were provided to the ministries and local governments by hand-carry in a short time.
-Maps were published on PASCO’s web site as free access.

Published on major News Papers
Asahi, Yomiuri, Mainichi...

Ashahi Press on Mar. 29.
Result

- **Multi-source data were required.**
  Data from Satellites, airplanes, helicopters and vehicles need to be utilized to monitor the wide areas in detail.

- **Multi-temporal data were also necessary.**

- **Urgent processing of data**
  Automatic change detection method was effective.
  Aerial photo, Field survey and visual check ensure the accuracy.

- **Quick delivery**
  By any means; website, FTP and hand carry.
  Within a few hours, or within a day.
DMS-Net

Disaster Management Satellite Network
Using Satellite System for the ASEAN region
Background

• Japan proposed and launched efforts to establish a "Disaster Management Network for ASEAN Region" at the 14th ASEAN-Japan Summit in November 2011.
• METI (Ministry of Economy, Trade and Industry of Japan) has been developing a high performance small satellite to be launched in December 2012 as well as an Integrated Mobile Ground Station.
• JAXA will also launch ALOS-2 in 2013.
• METI takes initiative to establish the Disaster Management Network by means of satellite system.
Natural Disasters in the ASEAN Region


<table>
<thead>
<tr>
<th>Disaster</th>
<th>No. of disasters (/year)</th>
<th>Death toll</th>
<th>Deaths (/year)</th>
<th>Relative Vulnerability (death/yr/million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td>10.05</td>
<td>17,800</td>
<td>445.0</td>
<td>0.75</td>
</tr>
<tr>
<td>Storm</td>
<td>9.65</td>
<td>184,063</td>
<td>4,501.6</td>
<td>7.76</td>
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<tr>
<td>Earthquake</td>
<td>2.58</td>
<td>105,735</td>
<td>2,543.4</td>
<td>4.46</td>
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<tr>
<td>Epidemic</td>
<td>2.28</td>
<td>7,294</td>
<td>182.4</td>
<td>0.31</td>
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<tr>
<td>Landslide</td>
<td>2.05</td>
<td>5,058</td>
<td>126.5</td>
<td>0.21</td>
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<tr>
<td>Volcano</td>
<td>1.33</td>
<td>1,380</td>
<td>34.5</td>
<td>0.06</td>
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<tr>
<td>Drought</td>
<td>0.98</td>
<td>1,337</td>
<td>33.4</td>
<td>0.06</td>
</tr>
<tr>
<td>Forest-Fire</td>
<td>0.45</td>
<td>310</td>
<td>7.8</td>
<td>0.01</td>
</tr>
<tr>
<td>Tsunami</td>
<td>0.15</td>
<td>92,021</td>
<td>2,300.5</td>
<td>3.88</td>
</tr>
</tbody>
</table>

Annual Economic Loss ($ million)

- Flood: 312.1
- Storm: 339.4
- Tsunami: 214.2
- Earthquake: 243.9
- Volcano: 32.1
- Drought: 45.8
- Forest-Fire: 511.9

Total: 1703.8

Data for other disasters not comprehensive.
Each country can select their resources to share with this network and has many ways to join this network.

Country A <Starter (Cloud)>
- Data use only through cloud networking

Country B <Standard A>
- Mobile Ground Station

Country C <Standard B>
- Satellite
- Ground Station
- Data Center

Country D <Upgrade A>
- Ground Station
- Mobile Ground Station
- Data Center

Country E <Upgrade B>
- Satellites
- Ground Stations
- Mobile Ground Station
- Data Center

Central Control Center (JAPAN) is capable of selecting the first visible satellite and the best ground station to downlink.
Architecture of DMS-Net

- Possible types of system composition at the country level.

<table>
<thead>
<tr>
<th>Plan</th>
<th>Starter</th>
<th>Standard A</th>
<th>Standard B</th>
<th>Upgrade A</th>
<th>Upgrade B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Cloud</td>
<td></td>
<td>New ground station and new satellite</td>
<td>Upgrading existent ground station for Japanese satellite</td>
<td>Upgrading existing ground stations for new own satellites</td>
</tr>
<tr>
<td>Japanese Satellites</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Own Satellite (NEW)</td>
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<td>Ground Station (Existing)</td>
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<td>Ground Station (NEW)</td>
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<tr>
<td>Mobile Ground Station (NEW)</td>
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<td>Data Center</td>
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<tr>
<td>Cloud</td>
<td></td>
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</table>
# Japanese Capability for DMS-Net (Satellite)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Outlook</td>
<td>Launch 2012</td>
<td>Launch 2015</td>
<td>Launch 2013</td>
</tr>
<tr>
<td></td>
<td>Sensor Optical</td>
<td>Sensor X-band Radar</td>
<td>Sensor L-band Radar</td>
</tr>
<tr>
<td></td>
<td>GSD (Pan) 0.5m</td>
<td>Polarization HH or VV</td>
<td>Polarization HH or HV or VV or</td>
</tr>
<tr>
<td></td>
<td>GSD (Multi) 2.0m</td>
<td></td>
<td>VH</td>
</tr>
<tr>
<td></td>
<td>Swath 10km</td>
<td>Spotlight (GSD / Swath)</td>
<td>Spotlight (GSD / Swath)</td>
</tr>
<tr>
<td></td>
<td>Life 5years</td>
<td>1m<em>1m / 10km</em>10km</td>
<td>1m<em>3m / 25km</em>25km</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Orbit Sun-synchronous</td>
<td>Stripmap (GSD / Swath)</td>
<td>Stripmap (GSD / Swath)</td>
</tr>
<tr>
<td></td>
<td>Weight 500kg</td>
<td>2m*2m / 12km</td>
<td>3m<em>10m / 50km</em>70km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ScanSAR (GSD / Swath)</td>
<td>ScanSAR (GSD / Swath)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16m*16m / 50km</td>
<td>100m / 350km*490km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous obs. 1,300km</td>
<td>Continuous obs. 22,000km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Life 5years</td>
<td>Life 5years - 7years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orbit Sun-synchronous</td>
<td>Orbit Sun-synchronous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weight 550kg</td>
<td>Weight 550kg</td>
</tr>
</tbody>
</table>
Japanese Capability for DMS-Net (Multi-Satellite)

2012 ASNARO (Optical)
2013 ALOS-2 (Radar)
2015 ASNARO-2 (Radar)

Wide Coverage Multi-Observations
Access Corridors in one day
Japanese Capability for DMS-Net (Ground Station Network)

PASCO's Ground Stations network

Integrated Mobile Ground Station

- TT&C and data reception
- Control and Monitoring of spacecraft
- Orbit Determination
- Acquisition Planning
- Image Processing & Data Fusion

TT&C: Telemetry, Tracking & Command
Data and Applications

Landslides caused by torrential rain over wide areas of the Kyusyu Region, 2012

Pre-disaster
ALOS Pansharpen image (Res. 2.5m)

Post-disaster
Monitoring of the flood caused by Typhoon 12 in Japan, 2011

Area: Kihou-Town, Mie Prefecture

The estimated flooded areas were extracted using SAR (TerraSAR-X), acquired on September 4th [left image: low backscattering areas appeared in red color; right image: extracted areas from SAR data were overlaid on Optical imagery (ALOS)].
Data and Applications

Flood monitoring of Chao Phraya River in Thailand, 2011.

- 10th, Feb 2011, 11:00 [UTC]
- 10th, Oct 2011, 23:00 [UTC]
- 16th, Oct 2011, 23:00 [UTC]
- 12th, Nov 2011, 23:00 [UTC]

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Automatic extraction of flooded areas was carried out with a series of images acquired by Radar satellite. Inundation areas are shown as dark areas in SAR images. Estimated flooded area was about 9000km² from August to October. Those are indicated in green, yellow and light blue as of August 8, September 10 and October 24 respectively.
Monitoring of volcanic eruption in Indonesia, 2010

- On October 26, 2010, Mt. Merapi in Central Java erupted and caused massive pyroclastic flows down to the heavily populated areas.
- Radar Sensor was effective under heavy ashes covering over the areas.
Data and Applications

Monitoring of ground surface movement over Valley fault in Philippines, 2008-2010

Using technique of DInSAR by X-band SAR images

Steep phase

Uplift in the east side of Valley fault

Uplift in the west side of Valley fault

Subsidence in the west side of Valley fault
## Contribution for DMS-Net

### Japanese Contribution

- Overall coordination for DMS-Net
- Development of partnership among ASEAN member states
- Promotion of satellite data utilization
- Development and operation of satellites and ground stations
- Capacity building
- Creation of Central Control Center
- Cost-Benefit Analysis
- Financial option
- Drafting of Request For Information
Summary

- **Multi-source data** were required.
  Data from Satellites, airplanes, helicopters and vehicles need to be utilized to monitor the wide areas in detail.

- **Multi-temporal data** were also necessary.

- **Urgent processing** of data
  Automatic change detection method was effective.
  Aerial photo, field survey and visual check ensure the accuracy.

- **Quick delivery**
  By any means; website, FTP and hand carry.
  Within a few hours, or within a day.
Thank you for your attention
This website aims at the dissemination and collection of information regarding the Satellite Network for the ASEAN Region, which is proposed by Japanese government. We are now discussing with ASEAN member states and expect your participation through this website.

http://www.aseandmsat.net