



## CL-09-03B: Forest Carbon Tracking

### Summary and Status

May 2010

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with contributions from other co-leads and partners



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## Overview

- Task Organisation and Objectives
- National Demonstrators and Verification Sites
- EO Data Acquisitions
- Product Development - First Results
- FCT Events and Future
- Summary



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## Task Organisation 1: Co-leads

- Japan (JAXA)
- Australia (Department of Climate Change & CSIRO)
- Canada (CFS-CSA)
- Norway (NSC)
- FAO
- CEOS (ESA)



Sub-task Number: CL-09-03b  
Overarching GEO Task: Global Carbon  
Observation and Analysis System

[www.geo-fct.org](http://www.geo-fct.org)

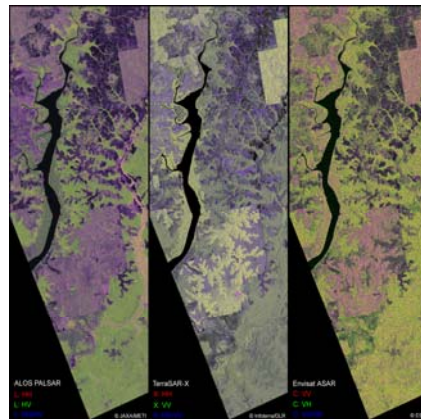


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## Task Organisation 2: Participants

- The Netherlands (WU)
- USA
  - USGS
  - USDA
  - Woods Hole Research Center
- Various CEOS Agencies
- Brazil (INPE)
- Japan (Restec & NIES)
- Australia (Geoscience Australia; CRC Spatial Information)
- Norway (UMB & KSAT)
- Thailand (GISTDA)
- GOFC-GOLD
- Google
- EC/JRC



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## GEO FCT Task Goal

Demonstrate to climate negotiators that coordinated satellite Earth observations, field measurements and reporting can provide the basis for reliable information services of suitable consistency, accuracy and continuity, to support Forest Carbon Tracking, leading to eventual establishment of a global **network of national forest carbon monitoring, reporting and verification systems.**



## GEO FCT OBJECTIVES

- Consolidation of observational requirements and associated products, ultimately leading to unencumbered delivery of annual, mid-resolution global forest-change monitoring information, augmented by frequent near-real time observations in special areas
- Demonstrate initial monitoring capability via establishment of regional demonstration/reference test-sites, using similar input satellite data and agreed methodologies, to demonstrate forest-change monitoring capability, in support of climate policy needs
- Coordination of protocols for consistent field measurement and validation
- Coordination of data analysis tools and standards methodologies
- Coordination of the production of reference documents and datasets
- Improvement of access to observations, datasets, tools and expertise and associated capacity building activities.





## GEO FCT task deliverables

1. **Establish guidelines** for annual, mid-resolution global forest-change monitoring program
- **Optical and SAR data acquisition strategy agreed** and established via CEOS agencies
- Identifying future missions under development vital in **securing data continuity**
- Satellite data processing, accuracy assessment and correction **methods widely agreed and documented**
- Consistent **field measurement guidelines and protocols implemented** across National Demonstrators
- **National Demonstrators and Verification Sites established** in consultation with national governments, NGO's and expert teams
- **Forest reference datasets and change products agreed and routinely produced** by national/regional activities
- Provision of **in-country access** to observations, datasets, tools and expertise and associated capacity building activities.



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## CEOS Communiqué - Highlights

**CEOS will coordinate with the other GEO Co-leads in order to establish and deliver 5 key joint outcomes of the GEO task on Forest Carbon Tracking:**

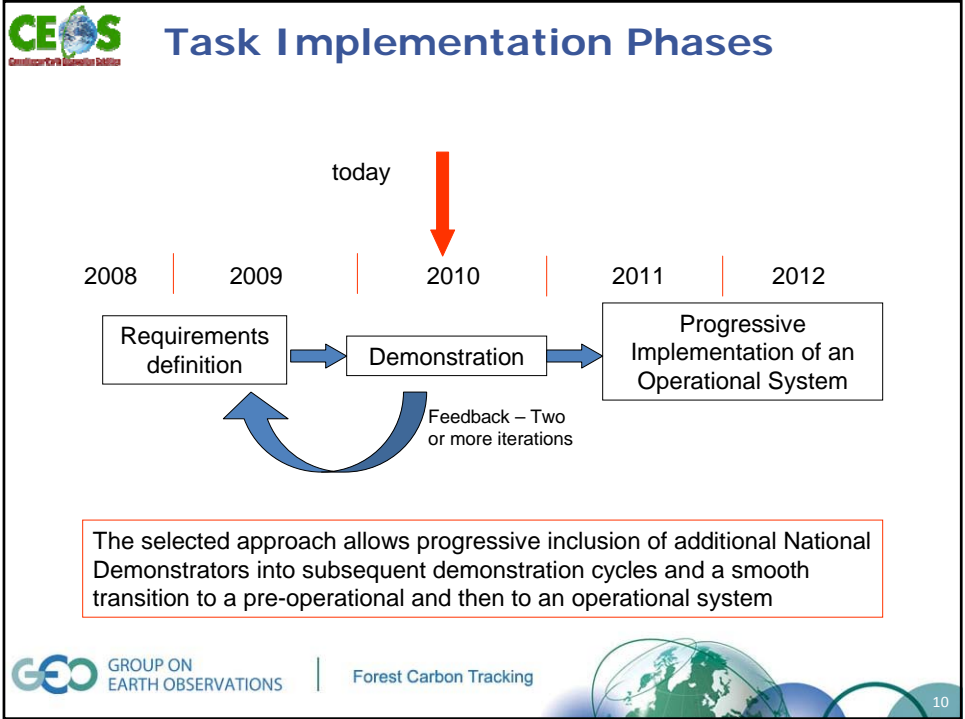
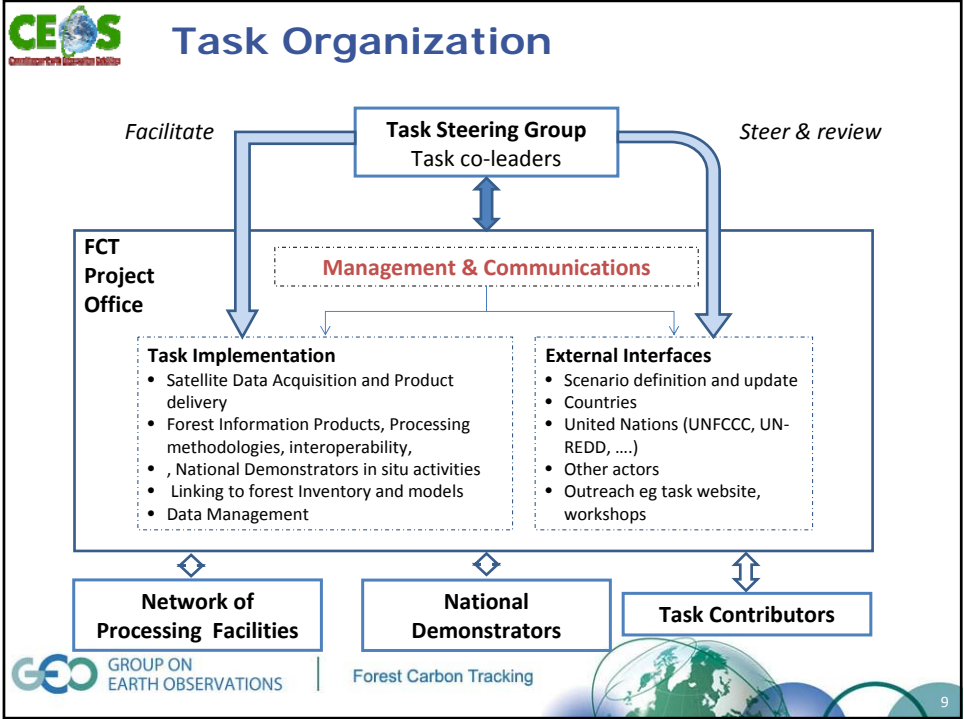
1. Agreement among willing CEOS Member agencies to ensure availability of current and future data supply on a basis adequate for the implementation and operation of continuous services;
2. Documented procedures to secure interoperability of optical and SAR sensors based on case study results;
3. Documented procedures on linking wall-to-wall, time series satellite data coverage to (1) ecosystem models and (2) traditional forest inventories, to consistently estimate carbon stocks at project and national scales;
4. Validation procedures for satellite applications in forest monitoring;
5. Visualisations of progress and demonstration results for GEO-VI and COP-15, making clear the capacity of these initiatives to support policy objectives.



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## Task Definition Documents

### System Definition Documents

FCT Concept and Implementation Strategy

FCT Summary description

FCT Data Management & Access Guidelines for National Demonstrators

FCT Guidance on National Demonstrator activities, benefits and responsibilities

### Design Documents

FCT Products Requirements

FCT Satellite Interoperability and processing methods

FCT Processing Hubs Network for the Demonstration phase – Terms of Reference

FCT Guidelines for in-situ data and observations at Verification sites

FCT Ground Measurements, Inventory and Model Calibration/Validation



## GEO FCT Data Portal: [www.geo-fct.org](http://www.geo-fct.org)

**Visualisations >**  
**Data Acquisitions**

**GEO FCT: ND coverage**

- FCT
- National Demons
- Future ND
- Forest Products
- Satellite Coverage
- ASAR
- 2009 (83)
- LANDSAT
- 1999 (0807)
- PALBAR
- 2009 (0054)
- RADARSAT
- 2009 (092)

Opacity percent: 100

Coordinates: 18 971, -58 895

Supported by Google

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## National Demonstrators and Verification Sites



## National Demonstrators

- Initially 7 National Demonstrators selected
- Acquisition time windows: June - September 2009 and January - March 2010





## ND - Selection Criteria

- they represent countries with a stated intent to develop national forest carbon monitoring systems; participation of mandated government agency **is essential**;
- they represent **large areas in all continents with tropical forests** to demonstrate repetitive, wall-to-wall, accurate wide-area forest mapping capabilities;
- where relevant, **donor** countries/organisations have been clearly identified for long-term involvement, should support be required;
- they include recognized scientific study validation sites with **appropriate in-situ observations**;
- Country's participation at **UN-REDD**;
- Country's application for **World Bank FCPF (R-PIN)**.



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## Verification Sites

### Purpose:

- Link to the national demonstrators
- 3-7 validation sites per ND
- Testing of various validation procedures
- On-going monitoring activities
- Gathering of in-situ data
  - Ground truth: species, age, DBH, tree height, ...
  - VHR data: aerial photographs, laser, satellite, ...

### Description:

- Land cover and LC dynamics, area peculiarities, research and monitoring topic
- Cooperation: Partners (local, national, international)
- Visualisation: Shapefile (Arcview, KML)



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## Verification Sites (1/2)

ND	VS	Name	lat	long	Priority
Brazil	BRA-1	INPE_IFT	S3.74	W48.34	2
	BRA-2	INPE_Tapajos	S3.20	W55.50	1
	BRA-3	INPE_Marcelandia	S11.30	W54.75	2
	BRA-4	INPE_Braganca	S0.85	W46.65	2
	BRA-5	WHRC_Xingu-1	S11.91	W52.58	2
	BRA-6	WHRC_Xingu-2	S13.06	W52.38	1
Guyana	GUY-1	WUR_FRASAR-1	N5.00	W59.00	2
	GUY-2	WUR_FRASAR-2	N3.00	W59.00	1
Mexico	MEX-1	Chiapas-1	N17.00	W93.55	1
	MEX-2	Chiapas-2	N16.33	W90.65	2
	MEX-3	Campeche	N18.52	W92.25	2
	MEX-4	Oaxaca	N17.58	W96.46	2
	MEX-5	Hidalgo	N20.62	W98.62	1
	MEX-6	Nuevo León	N25.43	W98.52	2
	MEX-7	Michoacán	N19.57	W101.18	2

Verification sites: circular with 20 km radius



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## Verification Sites (2/2)

ND	VS	Name	lat	long	Priority
Cameroon	CAM-1	ESA-1	N4.03	E10.23	2
	CAM-2	ESA-2	N3.22	E13.68	1
	CAM-3	ESA-3	N3.87	E14.78	1
	CAM-4	ESA-4	N5.00	E13.51	2
Tanzania	TNZ-1	FAO_FRA-1	S4.00	E32.00	2
	TNZ-2	FAO_FRA-2	S10.00	E36.00	2
	TNZ-3	FAO_FRA-3	S10.00	E38.00	1
	TNZ-4	Nilo Forest Reserve	S4.92	E38.66	1
Borneo	BOR-1	WUR_E-Kalim/Sbh	N4.33	E117.01	2
	BOR-2	WUR_SW-Kalimantan	S1.82	E111.61	1
	BOR-3	WUR_SE-Kalimantan	S2.24	E114.41	1
	BOR-4	WUR_C-Kalim/Sarawak	N2.55	E115.08	2
Tasmania	AU-1	Mathinna	S41.37	E147.76	1
	AU-2	Takone	S41.19	E145.60	2
	AU-3	Warra	S43.11	E146.90	2

Verification sites: circular with 20 km radius



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## Challenge of Expansion

- Enlarging area of current National Demonstrators  
e.g. add **Sumatra (Indonesia)**
- Adding more countries with commitment as NDs  
e.g. **Peru, Colombia, D.R. of Congo**  
**→ double the ND area by end of 2010**
- **Full satellite coverage** of the UN-REDD and Worldbank's FCPF countries by end 2011
- Deepen current progress towards integration  
e.g. move from **remote sensing products to emissions products** by integration of in-situ and remote sensing observations with carbon and emissions models



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## EO Data Acquisition



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## Optical Satellites

Satellite	Spectral Bands	Geometric Resolution	Swath Width	Repeat Cycle
Landsat 5, 7	VNIR, SWIR, TIR	30 m / 120 m (TIR)	185 km	16 days
IRS: AWiFS	VNIR, SWIR	56 m	740 km	4 days
IRS: LISS-III	VNIR, SWIR	23 m	140 km	24 days
CBERS 2b: CCD	VNIR	20 m	114 km	26 days
AVNIR-2	VNIR	10 m	70 km	46 days
SPOT 4, 5	VNIR, SWIR	20 m / 10 m	60 km	26 days
Kompsat-2	VNIR	1 m / 4 m	15 km	28 days



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## Requirements for Optical Satellites

- Acquisition preferably close to nadir
- Cloud free observations (< 20% cloud coverage for individual scenes – total cloud removal by multiple scenes)
- All available spectral bands
- Time window – yearly during dry season
- Level-1 processing



GLS 2005: 423 TM Scenes in USGS Archive



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## Requirements for Optical Satellites

- Preferred time window: July/Aug – but window open the whole year to mitigate cloud cover impact and acquire during **dry season**

National Demonstrator	Dry Seasons
Brazil	none in the Amazon basin, June - September in the Brazilian Plateau
Guyana	February - March and August - November
Mexico	November - April
Cameroon	November - March and additionally in the South from June - August
Tanzania	June - October
Borneo	June - September, but strong variations over the island
Tasmania	June - November (cool temperate climate)

Based on precipitation tables

- Objective: Annual minimum-cloud composite coverage of all ND
- Defined in detail in **2010 Data Requirement document v1.0 [Dec. 2009]**



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## SAR Satellites

Satellite	Frequency / Polarisation	Geometric Resolution	Swath Width	Repeat Cycle
ALOS PALSAR	L-band (23.6 cm) / full pol	7 m – 154 m	30 – 360 km	46 days
RADARSAT-1	C-band (5.6 cm) / HH	9 m – 100 m	45 - 500 km	24 days
RADARSAT-2	C-band (5.6 cm) / full pol	3 m – 100 m	20 - 500 km	24 days
ENVISAT ASAR	C-band (5.6 cm) / dual pol	30 m – 150 m	56 - 400 km	35 days
TerraSAR-X	X-band (3.1 cm) / full pol	1 m – 16 m	5 - 100 km	11 days
COSMO-SkyMed	C-band (3.1 cm) / full pol	1 m – 100 m	10 - 100 km	16 days

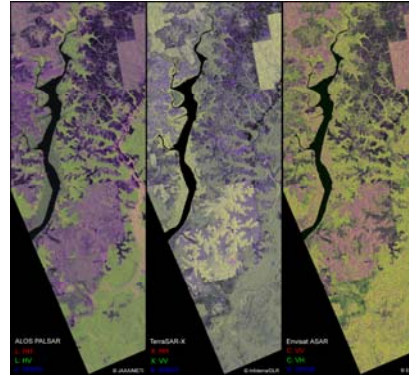


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## Requirements for SAR Data

- Spatial and temporal consistency
- Fixed single observation mode
- Level-1 processing (calibrated)
  - SLC
  - Multi-look



Polarimetric composites in L-, X- and C-band by ALOS PALSAR, TerraSAR-X and Envisat ASAR



## Summary of EO Data Acquisitions over NDs in 2009

Sensor	Brazil	Guyana	Mexico	Cameroon	Tanzania	Borneo	Tasmania
ALOS PALSAR	4541	159	375	116	405	507	86
RADARSAT-2	126	41	243	acquisition by ENVISAT	acquisition by ENVISAT	161	24
ENVISAT ASAR	303	67	acquisition by RADARSAT	107	182	acquisition by RADARSAT	25
Landsat 5 & 7	1665 (+ 3500 INPE)	107 (+ 88 INPE)	484	115	115	173	41
CBERS-2B: CCD	3500	80	N/A	N/A	N/A	N/A	N/A



Area	Brazil (parts)	Guyana	Mexico	Cameroon	Tanzania	Borneo	Tasmania	<p><b>Summary Table of Acquisitions in 2010 over NDs and VS</b></p>					
ALOS - PALSAR	3977	120	1391	265	776	884	118						
Radarsat-2	368	72	641	acquisitions by Envisat	acquisitions by Envisat	132	65						
Envisat ASAR	704	17	405	71	151	50	21						
COSMO - Skymed	not planed	24	not planed	42	not planed	101	16						
TerraSAR-X	54	18	72	21	24	30	24						
Landsat	2443	173	1732	230	253	320	129						
SPOT	TPM by ESA, but restrictions related to repatriation			Congo Basin 2010 - 15	TPM by ESA, but restrictions related to repatriation				<table border="1"> <tr> <td>o.k.</td> <td>not feasible</td> </tr> <tr> <td>some restrictions</td> <td>under discussion</td> </tr> </table>	o.k.	not feasible	some restrictions	under discussion
o.k.	not feasible												
some restrictions	under discussion												
CBERS	full coverage	full coverage						<p><b>Status:</b> 31 March 2010</p>					
IRS	acquired at INPE	acquired at INPE											



## Product Development – First Results





## Status – Product Development Teams

ND	ND Product Development team lead	Organisation	PD team contributing organisations	ND authority
Brazil	Dalton Valeriano	INPE	INPE, NSC, WHRC, IPAM	INPE
Guyana	Dirk Hoekman	Wageningen Univ.	WAU, CI, NSC	GFC
Mexico	Michael Schmidt / Sergio Ojeda	CONABIO / INEGI	CONAFOR, CONABIO, INEGI, SAGARPA, CONANP, PMC, USGS, CSA, FSU-Jena, DLR-DFD, NRCan	SEMARNAT
Cameroon	Frank Martin Seifert/ Gernot Ramminger	ESA / GAF	ESA, GAF, Joanneum Research	MINEF
Tanzania	Jan Petter Pedersen	KSAT	NSC, KSAT	MNRT
Borneo	Dirk Hoekman	Wageningen Univ.	LAPAN, WAU, CSIRO, CRC-SI, JAXA/NIES	LAPAN
Tasmania	Anthony Milne	UNSW	CSIRO, CRC-SI	DCC



## What does “product development team lead” mean?

- Interfacing with space agencies to coordinate satellite data acquisition;
- Advise space agencies what the specifications should be for satellite data to be recorded;
- Help to define the international standard for methods and procedures;
- Specific focus on specialized radar knowledge, to be integrated with work of experts in optical remote sensing
- Help to development optimal procedures for using data from multiple satellite sensors;
- Collaboration with other country product development teams to ensure consistent results adhering to international standards are being produced;
- Coordinate the generation and validation of prototype MRVS mapping products: at two scales:
  1. Entire country ('wall-to-wall')
  2. Local validation sites (20km circle areas)





## Examples from SDS TBD



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## Events and Future



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## Past FCT Events

- 1st GEO Forest Monitoring Symposium, Iguazu Oct 08
- CEOS SIT 23 (NOAA), Cocoa Beach Mar 09
- Side Event at ISRSE 33, Stresa May 09
- 1<sup>st</sup> FCT SAR Data Coordination Meeting (ESRIN) June 09
- 2<sup>nd</sup> GEO Forest Monitoring Symposium, Chiang Rai July 09
- 2nd FCT SAR Data Coordination Meeting, Tsukuba Aug 09
- CEOS SIT 24 (EUMETSAT), Darmstadt Sep 09
- FCT Strategy Meeting PoW, London Oct 09
- FCT Planning Meeting Google, London Oct 09
- CEOS Plenary, Phuket Nov 09
- GEO Plenary, Washington Nov 09
- UNFCCC COP-15, Copenhagen Dec 09
- CEOS SIT 25 (JAXA) Tokyo Apr 10



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## FCT Events in Summer 2010

- **First FCT Science and Data Summit**, Woods Hole (USA), 11-12 May 2010
- **3rd FCT Space Data Coordination Meeting**, Woods Hole (USA), 13-14 May 2010
- **GEO FCT Information Meeting**, Geneva (CH), 1<sup>st</sup> June 2010
- **FCT Side Event at UNFCCC SBSTA**, Bonn (Germany), 3<sup>rd</sup> June 2010
- **MRV Workshop by NFC / UN-REDD / GEO**, Guadalajara, Jalisco, México, 22-24 June 2010
- **FCT session at ESA's Living Planet Symposium**, Bergen, Norway, 28 June 2010



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## Cooperations

- **UN-REDD** with 9 pilot countries
  - UN-REDD/GEO Symposium in Mexico
- World bank's **Forest Carbon Partnership Facility (FCPF)** with 37 REDD country participants
  - Future FCT expansion countries
  - Challenge to cover all of them from end 2011 onwards ...



## FCT EO Data Considerations

- Currently FCT deals with a **magnitude** of different data agreements – suboptimal and time consuming!
- FCT takes **aging** of satellites (e.g. Landsat, Envisat, Spot, ...) into account for **long term strategy**
- GEO FCT encourages **free and open data policy**
- Data grants to FCT should be **without restrictions** – today they are not!
- Need for **VHR data for validation** – mainly from commercial providers





## Future Data Contribution Models

### Free and open data policy

- National / international missions e.g. Landsat (USGS), CBERS (INPE), future Sentinels (ESA), ...  
→ **most likely the work horses**

### Commercial data provision

- Private companies and PPP missions e.g. Spot (Spotimage), TerraSAR-X (DLR/Infoterra), Radarsat-2 (CSA/MDA), ...  
→ **bulk data order by governments/donors** e.g. France with Spot coverage over the Congo Basin



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## Progress today ...

- **Satellite data** are being acquired systematically over the National Demonstrators in two acquisition periods starting June 2009;
- Satellite data processing mechanisms have been established with the **Product Development Teams** and data processing has started;
- Preparation of various **documentation**;
- Several **FCT events** have been organised.



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**Thank you for your attention!**



## **Task Outputs/Deliverables**

- Regional reference test-sites established in consultation with national governments, NGO's and expert teams
- Optical + SAR data acquisition strategy agreed and established via CEOS agencies
- Forest change data (Optical + SAR) products agreed and being routinely produced, by national/regional programs
- Establish guidelines for annual, mid-resolution global forest-change monitoring program
- Satellite data processing, accuracy assessment and correction methods widely agreed and documented
- Consistent field measurement guidelines and protocols implemented across national demonstrators
- Provision of in-country access to observations, datasets, tools and expertise and associated capacity building activities.

