esa

Global Monitoring for Environment and Security

GSE

Forest Monitoring

Partners:

Service Strategy Group

Core User Group

Operational Service Providers

System Developers

Research Partners

Expert Consultants

Stage 1 - Service Consolidation Actions of the Earthwatch GMES Services Element

Data Needs and Availability Prospectus C12

Doc. No: GAF-GSE-FM-A-T3-C12-Ph2-03-033
Issue/Rev.: 2.0

Date: August 06, 2004

Lead Company

GAF AG Arnulfstr. 197
D-80634 Munich

Phone: + 49 (0) 89 121528-0
Fax: + 49 (0) 89 121528-79
info@gaf.de
http://www.gaf.de

GSE Forest Monitoring

Data Needs and Availability Prospectus C12

ESRIN/Contract No. 17063/03/I-LG

Document No.: **GAF-GSE-FM-A-T3-C12-Ph2-03-033**

Date: **August 06, 2004**

Summary: **This document describes identifies all EO and in-situ observations that will be needed to deliver products and services from the GSE FM service portfolio.**
It establishes a programme of data acquisitions that is consistent with the Strategic Plan and the Service Prospectus and which covers time scales of 0-2, 2-5, 5-10 years.

	Affiliation/Function	Name	Date	Signature
Prepared	German Aerospace Center DLR	Günter Strunz	27/07/04	
Reviewed	German Aerospace Center/ Quality Control	Erhard Diedrich	02/08/04	
Approved	German Aerospace Center DLR / Task Manager	Günter Strunz	04/08/04	
Authorized	GAF AG/ Prime Project Manager	Thomas Häusler	xxxxxx	
Accepted	ESA/ Project Manager	Espen Volden		

The document is accepted under the assumption that all verification activities were carried out correctly and any discrepancies are documented properly in compliance matrices or else.

Signatures

	Name	Date	Signature
Signature of authorisation and overall approval	Thomas Häusler		
Signature of acceptance by ESA	Espen Volden		

Distribution

Affiliation	Name	Address	Copies
ESRIN	Espen Volden	Via G. Galilei Frascati (Rome), Italy.	electronic copy
	GSE Consortium members	See list on webpage www.gmes-forest.info	electronic copy

Document Contributions

Chapter	Affiliation	Name
Chapters 3.3, 4.2	European Forest Institute EFI	Jo van Brusselen
Chapters 3.4, 4.3	Infoterra ITD	Marek Tinz

Document Status Sheet

Issue	Date	Details
0.1	20/10/03	First Document Issue
0.2	11/11/03	With contributions from Infoterra and EFI
0.3	13/11/03	Integration of inputs, executive summary
1.0	14/11/03	First Issue to ESA
1.1	27/07/04	Version 2: Draft
2.0	06/08/04	First Issue of Final Version 2 to ESA
		New in version 2: updated data acquisition needs according to new operational service scenarios

Document Change Record

#	Date	Request	Location	Details

Executive Summary

This document *"Data Needs and Availability Prospectus (C12)"* identifies all EO and in-situ observations that will be needed as inputs to generate the GSE FM service portfolio.

This analysis is done in accordance with the *"Operational Services Scenario (C11)"*. It is consistent with the *"Strategic Plan (S1)"* and the *"Service Prospectus (S3)"* and it is based on the analysis registered in the *"Data Sources Inventory (C10)"*. The results of this document provide the technical basis to establish the *"Service Level Agreements (C7)"* for service provision.

On the basis of the *"Data Sources Inventory (C10)"* the input data sources are analysed, which are required for the GSE FM portfolio. These more than 90 input data sources have been grouped according to the categories (1) space-based, (2) in-situ observation data sources, and (3) ancillary data sources. The analysis and development of a data acquisition programme for each of the data sources is done according to a systematic approach.

The main results and conclusions of the *"Data Needs and Availability Prospectus"* are:

(1) Space-based EO data:

The EO data needs for GSE FM services for the time scale 2-5 years and 5-10 years are summarized in the following tables:

Year		**2005**	**2006**	**2007**
National GHG Reporting				
Mapping area	(Mio sqkm)	0.27	0.49	0.71
No. of scenes	Optical data	132	239	347
	SAR data	10	16	24
Clean Development Mechanism				
Mapping area	(Mio sqkm)	0.03	0.05	0.07
No. of scenes	Optical data	15	24	34
	SAR data	2	2	2
Mapping and Monitoring of Disturbances				
Mapping area	(Mio sqkm)	0.270	0.520	0.770
No. of scenes	Optical data	132	254	376
	SAR data	9	17	26
Sub-national Forest Information				

Mapping area	(Mio sqkm)	0.02	0.03	0.05
No. of scenes	Optical data	13	19	31
	SAR data	0	0	0
Land Cover and Forest Indicators				
Mapping area	(Mio sqkm)	0.26	0.52	0.77
No. of scenes	Optical data	127	254	376
	SAR data	9	17	26

Year		**2008**	**2009**	**2010**	**2011**	**2012**
National GHG Reporting						
Mapping area	(Mio sqkm)	0.75	0.96	1.18	1.39	1.60
No.of scenes	Optical data	284	363	447	526	605
	SAR data	50	64	79	93	107
Clean Development Mechanism						
Mapping area	(Mio sqkm)	0.07	0.08	0.10	0.11	0.13
No. of scenes	Optical data	26	30	38	42	49
	SAR data	5	5	7	7	9
Mapping of Disturbances						
Mapping area	(Mio sqkm)	0.910	1.060	1.200	1.350	1.500
No. of scenes	Optical data	344	401	454	511	568
	SAR data	61	71	80	90	100
Sub-National Forest Information						
Mapping Area	(Mio sqkm)	0.15	0.26	0.37	0.48	0.59
No. of scenes	Optical data	94	163	233	302	371
	SAR data	0	0	0	0	0
Land Cover and Forest Indicators		2008	2009	2010	2011	2012
Mapping area	(Mio sqkm)	0.84	1.11	1.37	1.64	1.90
No. of scenes	Optical data	318	420	518	621	719
	SAR data	56	74	91	109	127

With respect to capacity, availability and reliability of space-based EO data sources the analysis revealed the following main open issues and problems: long-term continuity of EO satellite missions, timeliness and sufficient EO observation frequency, and redundancy and backup capability of EO missions.

- Long term continuity of EO satellite missions: The GSE FM services require a long term perspective of EO data provision to justify the adaptation of the users infrastructure to using EO services. The long term continuity of the EO data as main data source for the GSE services must be guaranteed. GMES is totally depending on the maintenance of EO systems and on their upgrade and/or replacement over time. Follow-on missions and upgrading of sensors have to be planned within long term continuing satellite programs.

- The planned sentinel missions of ESA, especially the realisation of the envisaged super-spectral mission (continuity of Landsat data type), are of great importance for the GSE FM services.

- Long-term continuity also requires the setting up of institutional and commercial funding mechanisms, which means that the funding for these operational systems has to be shifted from the research and development domain to budget lines in the institutional or commercial funding framework.

- Lack of timeliness and insufficient frequency of EO observations with optical sensors: The critical problem for optical data is the availability of cloud-free data over a certain region at a defined time period. Due to cloud coverage, it is necessary to have a more frequent coverage with EO data by increasing the revisit frequency. This could be done by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration which integrates several satellites into a harmonised system and/or (c) satellites with high spatial resolution and much higher swath width to increase revisit time considerably.

- Redundancy and backup capability of EO missions: The current severe problems with Landsat 7 clearly show the urgent requirement that EO missions need redundancy and backup capabilities. For operational service provision it must be ensured that in case of technical problems with a single satellite or even the loss of satellites this data gap can be compensated without any time delay.

- European EO capacities: To compensate the current problems with Landsat 7 as soon as possible it is necessary that Europe either builds own capacities of multi-spectral imagery at a Landsat compatible geometric and spectral resolution (“European Landsat“) and/or closely cooperates with U.S. agencies NASA and USGS for the implementation of the Landsat Continuity Mission.

- There is a strong demand for a European “Integrated Ground Segment”. The European data acquisition is not harmonised; for each satellite system different organisations are responsible. Thus, the data acquisition policies are ruled by quite heterogeneous goals. A harmonised data supply is desirable from the viewpoint of the GSE service portfolio.

(2) In-situ observation data sources:

For the time period 0-2 years:

- In the short-term most required in-situ data sources will be available from finished or on-going national and regional forest inventories. The availability of national and regional forest inventory data is not assumed to phase out.

- The quality of biomass expansion factors, carbon conversion factors and soil carbon data is expected to increase through the contribution of coordinated pan-European research projects. Activities in this field of research are expected to continue their importance and thus funding is not expected to phase out in the short-to-mid term.

For the time period 2-5 years:

- EU15 and NAS countries have well-established forest inventory schemes, which record data on forest area, wood volume, tree species and other variables, which would also allow for forest type discrimination and stratification. Inventory activities are not expected to phase-out.

- Methodology for the monitoring of CDM projects, including data-acquisition, has to be approved by the Executive Board of the Clean Development Mechanism.

For the time period 5-10 years:

- In the event that the Kyoto Protocol would not be ratified, the global attention for monitoring in the framework of CDM/JI may loose significance. The same faith could then be for (an assumed) increased support for the inventorying of forests in developing countries.

The main problems and necessary improvements for the in-situ data observations are as follows:

For the time period 0-2 years:

- It is not expected that national/regional forest inventories will phase out. In the short term, the quality of biomass expansion factors, carbon conversion factors and soil carbon data is expected to increase through the contribution of coordinated pan-European research projects. Expansion of services may suffer time-delays and will go accompanied with significant increases in cost in territories not sufficiently covered with in-situ data collection. The incorporation of EO in inventory methodology for such territories may have a positive effect on the overall cost of the inventory operation.

For the time period 2-5 years:

- It is not expected that national/regional forest inventories will phase out, even in the long-term future. In the run-up to the start of the first commitment period of the Kyoto Protocol, still a lot of research will be focusing on improving biomass

expansion factors, carbon conversion factors and on the collection of soil carbon data. Data-collection methodologies, definitions and concepts may change throughout time and such changes need be taken into account in the service methodology.

- At preparation of detailed land/forest cover maps prior to a customer agreement has been made for a particular area coverage, problems may arise with ownership of data and protection of private interest. Such situation must be anticipated with good data access agreements between GSE Forest Monitoring and the custodian of the data, likely being the national/regional forest authority or relevant ministry.

For the time period 5-10 years:

- It is not expected that national/regional forest inventories will phase out, even in the long-term future. It is expected that the monitoring schemes ICP Forests and Forest Focus will continue their in-situ data collection activities.

Summarizing, for in-situ data sources the analysis revealed the following open issues and problems: definitional differences; lack of in-situ data outside Europe; lack of country-wide forest GIS outside Europe; and difficult access to forest management plans.

(3) Model and other data sources:

- Digital Elevation Models (DEM) are basic data sources needed in most of the service packages. The required resolution is 1-3 arc seconds (25 m to 75 m). Common DEM sources are national survey agencies (cover only the relevant country), MONA Pro DEM (covers 22 countries within Europe), SRTM-XSAR (global coverage, but with gaps), and in near-future SRTM-C (global coverage). Therefore, the availability of DEM data is ensured in future.

- Topographical Maps are provided by regional, federal or state agencies. They are in general available in European countries with comparable specifications. Maps at scale 1: 50,000 are available in all of Europe, but global coverage and availability is not assured.

- Land cover/land use data are needed for some of the services. CORINE Land Cover is based on homogeneous class definitions and is available all over Europe for the reference year 1990 (CLC1990) and in near future also for 2000 (CLC2000). Forest cover maps and other forest related data sources (e.g. forest management plans) are specific to the local or regional situation and mostly provided by users. The global coverage and availability is not ensured. Nevertheless, the lack of spatial thematic data in an appropriate quality can be compensated by field surveys in combination with EO data (e.g. SPOT for DTM production). However, this will obviously increase the total effort for the service providers and, thus, the cost of the services.

At the same time it can contribute to the improvement of the overall business by offering additional services for land cover and topographic mapping.

- Regarding model and ancillary data sources in Europe a large variety of systems exists with different levels of details, formats and update rates. Here, for each new country / customer an analysis is required to assess the state-of-the-art and the accessibility of the data. Beyond Europe, in many cases the availability even of basic digital information with acceptable topicality and quality is not assured.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ASAR	Advanced Synthetic Aperture Radar
CLC	CORINE Land Cover
CLRTAP	Convention on Long-Range Transboundary Atmospheric Pollution
COST E21	European Cooperation in the Field of Scientific and Technical Research; E21: Contribution of Forests and Forestry to Mitigate Greenhouse Effects
DEM	Digital Elevation Model
DOP	Digital Ortho Photo
EC	Commission of the European Communities
ENVISAT	ENVIronment SATellite
EU15	European Union of the fifteen Member States
EO	Earth Observation
ERS	European Remote Sensing Satellite
ETM+	Enhanced Thematic Mapper
EU	European Union
FIMCI	Forest Intensive Monitoring Co-ordinating Institute
GCP	Ground Control Point
GIS	Geo-Information System
GMES	Global Monitoring for Environment and Security
GPS	Global Positioning System
GSE	Global Monitoring for Environment and Security - Service Element
GSE FM	Global Monitoring for Environment and Security - Service Element Forest Monitoring
ICP Forests	International Cooperative Programme on assessment and monitoring of air-pollution effects on forests operating under UNECE
HI	SPOT-5 Multispectral data with 10m resolution (includes MIR band)
HRG	SPOT-5 Sensor
HRV	SPOT 1-3 Sensor
HRVIR	SPOT-4 Sensor
IRS	Indian Remote Sensing Satellite
JERS	Japanese Earth Resources Satellite
LC / LU	Land Cover/ Land Use

LISS	Line Imaging Spectrometer Sampler
LU	Land Use
LUC	Land-Use Change
LUCAS	Land Use and Cover Areal Survey
MIR	Middle Infra Red (1.5µm band)
MS	Multi-spectral
NAS	Newly Associated States
NCC	National Coordinating Centre
NFC	National Focal Centre
NFI	National Forest Inventory
NIR	Near Infra Red
PAN	Panchromatic
PCC	Programme Co-ordinating Centre
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
TBFRA	Temperate and Boreal Forest Resources Assess
TM	Landsat Thematic Mapper
XI	SPOT 4 Multi-spectral data (includes MIR band)
XS	SPOT 2-4 multi-spectral data
UN	United Nations

1. Objective and Scope

This document identifies all EO and in-situ observations that will be needed as inputs to generate the GSE FM service portfolio.

This analysis is done in accordance with the "*Operational Services Scenario (C11)"*. It is consistent with the "*Strategic Plan (S1)"* and the "*Service Prospectus (S3)"* and it is based on the analysis registered in the "*Data Sources Inventory (C10)"*.

The results of this document provide the technical basis to establish the *"Service Level Agreements (C7)"* for service provision.

2. Method of Description

On the basis of the "*Data Sources Inventory (C10)"* the input data sources are analysed that are required for the GSE FM portfolio. The data sources are then grouped into the three main categories: space-based data sources, in-situ observation data sources, and model and other data sources.

Based on the "*Operational Services Scenario (C11)"* the mapping areas are estimated, for which the services will be provided presently and in the future. From these areas the amount of EO satellite scenes, in-situ measurements or ancillary data sets (e.g. map sheets, digital elevation models etc.) are calculated. From this calculations a concept for data acquisitions is derived which covers the time scales 0-2 years, 2-5 years, and 5-10 years.

3. Data Acquisition Needs

In the document *"Service Portfolio Specifications (S5) – Version 2"* the GSE FM products are aggregated to 5 services:

- Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting
- Forest Monitoring Inputs for CDM Projects
- Sub-National Forest Information Updates
- Mapping and Monitoring of Disturbances (Clear Cuts, Forest Fires, etc)
- Land Cover & Forest Indicators

Based on this new structure of the GSE FM services and on the new growth paths of GSE FM services, which are described in the Version 2 document of the *"Operational Service Scenarios (C11)"*, the data needs and availability prospectus are analysed in this chapter.

3.1. Basic Assumptions

3.1.1. Mapping Area

The mapping areas for the 5 services are given in the following tables (taken from document C11 Version 2):

Tab. 1: Mapping area per period (Mio sqkm)

	2003-04	2005-07	2008-12
National Greenhouse Gas (GHG) Reporting	0.141	1.46	5.89
Clean Development Mechanism (CDM) Projects	0.024	0.16	0.49
Mapping and Monitoring of Disturbances	0.035	1.55	6.02
Sub-National Forest Information	0.016	0.10	1.83
Land Cover and Forest Indicators	0.040	1.55	6.86

Tab. 2: Mapping area per year (Mio sqkm)

	2005	2006	2007	2008	2009	2010	2011	2012
National Greenhouse Gas (GHG) Reporting	0.27	0.49	0.71	0.75	0.96	1.18	1.39	1.60
Clean Development Mechanism (CDM) Projects	0.03	0.05	0.07	0.07	0.08	0.10	0.11	0.13
Mapping and Monitoring of Disturbances	0.27	0.52	0.77	0.91	1.06	1.20	1.35	1.50
Sub-National Forest Information	0.02	0.03	0.05	0.15	0.26	0.37	0.48	0.59
Land Cover and Forest Indicators	0.26	0.52	0.77	0.84	1.11	1.37	1.64	1.90

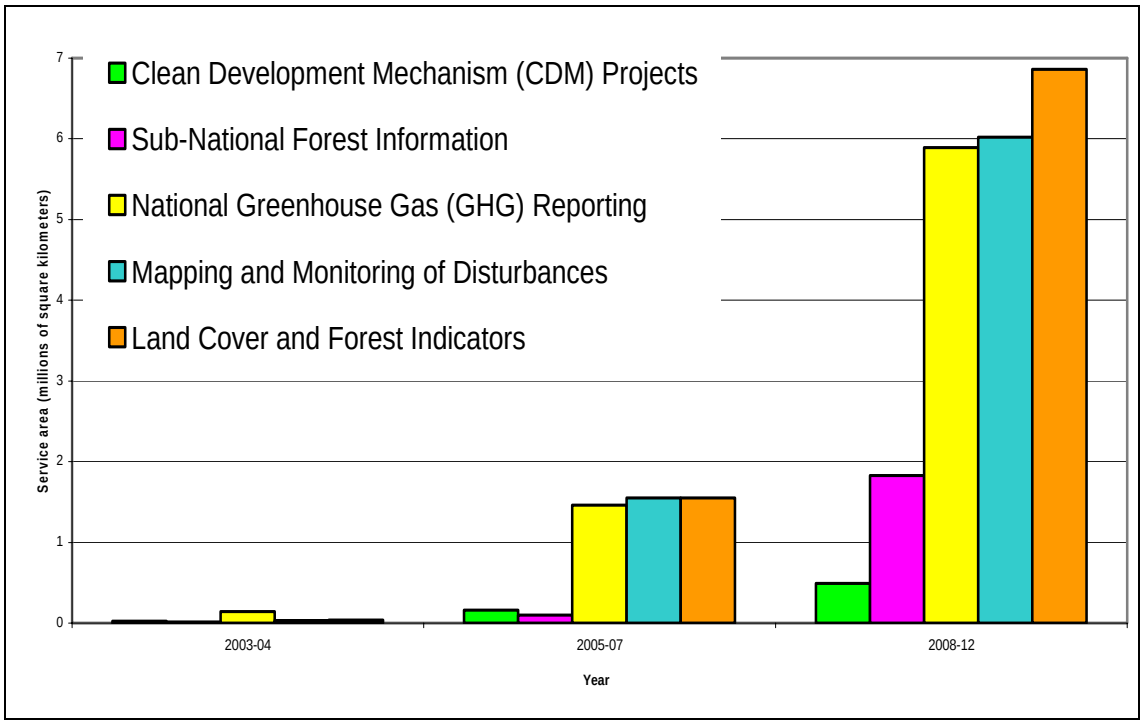

Fig. 1: Mapping area per period (Mio sqkm)

3.1.2. Data Requirements

The data requirements for the 5 services are as follows (taken from Document S5 Version 2):

1. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting:

   - EO data source: Landsat 5/7, SPOT XS, IRS 1C LISS/Pan and equivalent, alternatively SAR sensors, e.g. ERS/Envisat ASAR in cloudy regions.
   - In-situ data needs: reference data are essential; depending on the availability of existing data in some countries additional reference data acquisition is necessary.
   - Other data: topographic maps and DEM.

2. Forest Monitoring Inputs for CDM Projects:

   - EO data source: Landsat 5/7 or SPOT 5 and equivalent, alternatively SAR sensors, e.g. ERS/Envisat ASAR in cloudy regions (see product specifications).

- In-situ data needs: reference data are essential, use of existing data or additional data acquisition.
- Other data: topographic maps and DEM.

3. Sub-National Forest Information Updates

   - EO data source: preferably SPOT 5 or equivalent , alternatively Landsat 5/7 or equivalent
   - In-situ data needs: existing user data (Forest GIS)
   - Other data: topographic maps and DEM.

4. Mapping and Monitoring of Disturbances (Clear Cuts, Forest Fires, etc.)

   - EO data source: preferably SPOT 5 or equivalent , alternatively Landsat 5/7 or equivalent
   - In-situ data needs: existing forest management maps and data
   - Other data: topographic maps and DEM.
   - EO data source for historical clear-cut mapping normally Landsat 5 or SPOT 1-4. Depending on availability in archive.

5. Land Cover & Forest Indicators

   - EO data source: Landsat 5/7 and equivalent
   - In-situ data needs: reference data are essential, use of existing data or additional data acquisition
   - Other data: topographic maps and DEM.

3.2. Earth Observation Data Sources

3.2.1. Basic Assumptions

Based on the mapping areas in the consolidation phase, which are given in the "*Service Portfolio Specifications (S5)"*, the numbers of required EO data (scenes) are calculated. Due to the overlap of adjacent scenes, which is e.g. about 30-40 % for Landsat scenes in central Europe, the net growth in area by an adjacent scene has to be reduced accordingly for the calculation of scenes. Moreover, due to the fixed paths of most of the EO satellite, the scenes are not perfectly covering the region of interest. Therefore, the simplified assumption is made, that the relevant area is about 60% of the nominal area covered by a satellite scene. The following table gives an overview on the estimated areas.

Tab. 3: Estimation of relevant areas covered by the satellite scenes

EO Sensor	**Scene Area**	**Relevant Area of Satellite Scene (see explanation in the text)**
Current missions:		
Landsat 1-5, Landsat 7	~ 32.400 sqkm (180 km * 180 km)	~ 20.000 sqkm
SPOT 2-5	~ 3.600 sqkm (60 km * 60 km)	~ 2.200 sqkm
IRS-1C/D (Multispectral)	~ 19.600 sqkm (140 km * 140 km)	~ 12.000 sqkm
IRS-1C/D (Pan)	~ 4.900 sqkm (70 km * 70 km)	~ 3.000 sqkm
ERS-1/2 SAR	~ 10.000 sqkm (100 km * 100 km)	~ 6.000 sqkm
ENVISAT ASAR	~ 10.000 sqkm (100 km * 100 km)	~ 6.000 sqkm
Future missions, e.g.:		
TerraSAR-X	~ 10.000 sqkm (100 km * 100 km) in ScanSAR mode	~ 6.000 sqkm
Landsat Data Continuity Mission	~ 32.400 sqkm (180 km * 180 km)	~ 20.000 sqkm

3.2.2. Specific EO Data Needs for each GSE FM Service

In the following chapters the EO data needs are estimated for each of the GSE FM services. The EO data are categorized into “HR optical” (high resolution optical data) and “HR SAR” (high resolution SAR data).

3.2.2.1. GSE FM Inputs for National Greenhouse Gas (GHG) Reporting

EO data needs per mapping cycle as percentage of the overall mapping area:

.		2005-07		2008-12	
HR optical	SPOT 5& follow on	100%	40%	100%	50%
	SPOT 1-4		10%		
	IRS PAN & follow on		20%		
	IRS LISS & follow on		20%		
	Landsat 7 & follow on		30%		50%
HR SAR	ERS 1 / 2	5%		10%	
	Envisat ASAR		2,5%		
	TerraSAR-X / Cosmo Skymed / Radarsat 2 & follow on		2,5%		10%

Number of scenes per geographic area per cycle:

HR optical 1.5

HR SAR 4

HR optical: Where feasible to increase the accuracy dual coverage per area is foreseen. Average: 1.5 scenes per cycle per geographic area.

Repetition cycle: up to 5 years (Scenario assumption: 5 years)

Data needs in the first cycle to cover the reference mapping (year 1990):

		2005-07		2008-12	
HR optical	SPOT 1-4	100%	20%		
	IRS PAN				
	IRS LISS				
	Landsat 5		80%		
HR SAR	ERS 1 / 2	5%	5%		

Number of scenes per geographic area per cycle:

HR optical 1.5

HR SAR 5

3.2.2.2. Forest Monitoring Inputs for CDM Projects

Data need for optical data identical to service “Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting”. HR SAR data are not used in this service.

Repetition cycle: up to 5 years (Scenario assumption: 5 years)

3.2.2.3. Mapping and Monitoring of Disturbances

Data need for actual HR data identical to service “Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting”.

Repetition cycle: 1 to 2 years (Scenario assumption: 2 years)

Data need for reference mapping (historical data): data of at least one year before initial start of the service of the same sensor as for actual mapping.

Data needs for Level 1 Mapping:

		2005-2007	2008-2012
MR optical Type (250m – 1km)	AVHRR	100%	
	Envisat Meris		
	Terra/Aqua – MODIS		100%
	SPOT Vegetation		

3.2.2.4. Sub-National Forest Information Service

EO data needs per mapping cycle as percentage of the overall mapping area:

		2005-2007		2008-2012	
HR optical	SPOT 5& follow on	100%	50%	100%	50%
	SPOT 1-4				
	IRS PAN & follow on		50%		50%
	IRS LISS & follow on				
	Landsat 7 & follow on		50%		50%

Repetition cycle: up to 5 years (Scenario assumption: 5 years)

Number of scenes per geographic area per cycle: 1.5

3.2.2.5. Land Cover and Forest Indicators

EO data needs for HR data identical to service “Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting”.

Repetition cycle: 5 years

3.2.3. Time Period 0-2 Years (End of 2004)

For the time period 0-2 years the mapping areas are specified in the GSE FM project plan. The EO data needs are given in the following table.

Tab. 4: EO data needs for the time scale 0-2 years

GSE-FM product	Primary Data Source	Alternative Data Sources	Mapping Area in 2004 [km^2]	Number of EO Scenes	Open Issues and Problems (see explanation below)

OM-1-1	Landsat 7	IRS-1C/D SPOT 2-5	71.000	4	P1)
FA-1-2	Landsat 7	IRS-1C/D SPOT 2-5	30.000	2	P1)
FT-1-3	Landsat 7	IRS-1C/D SPOT 2-5	30.000	2	P1)
FAC-1-4	Landsat 7	IRS-1C/D SPOT 2-5	30.000	2	P1)
CS-1-5	Landsat 7	IRS-1C/D SPOT 2-5	30.000	2	P1)
FEI-2-1	Landsat 7	IRS-1C/D SPOT 2-5	30.000	2	P1)
FA-3-1	IRS-1C/D (Pan)	Landsat 7 or SPOT 2-5	16.000	6	
	Landsat 7 (MS)	SPOT 2-5 (MS)	16.000	1	P1)
FA-3-2	IRS-1C/D (Pan)	Landsat 7 or SPOT 2-5	16.000	6	
	Landsat 7 (MS)	SPOT 2-5 (MS)	16.000	1	P1)
LUC-4-1	Landsat 7	SPOT 2-5	16.000	1	P1)
FAC-5-1	ERS SAR	JERS-1 SAR	90.000	30 (2 coverages)	P2)
	Envisat ASAR	--- (optical EO)	90.000	30 (2 coverages)	P2)
OM-6-1	Landsat 1-5	SPOT 1-3	14.000	1	
	SPOT 2-5 (pan)	---	14.000	7	
	Landsat 7	SPOT 2-5	14.000	1	P1)
FA-6-2	Landsat 1-5	SPOT 1-3	14.000	1	
	Landsat 7	SPOT 2-5	14.000	1	P1)
LU-6-3	Landsat 1-5	SPOT 1-3	14.000	1	
	Landsat 7	SPOT 2-5	14.000	1	P1)
OM-7-1	Landsat 1-5	SPOT 1-3	25.000	2	
CC-7-2	Landsat 1-5	SPOT 1-3	25.000	2	
	Landsat 7	SPOT 2-5	25.000	2	P1)
CC-7-3	Spot 5	SPOT 4 Landsat 7	25.000	13	
	Landsat 7	SPOT 4	25.000	2	P1)
CC-7-4	Spot 5	SPOT 4 Landsat 7	25.000	13	
	Landsat 5	SPOT 1-3	25.000	2	

3.2.3.1. Open Issues and Problems

- 1) Landsat 7 technical problems:

  Landsat 7 ETM+ is one of the most important EO data sources for the service. On May 31, 2003, Landsat 7 experienced an anomaly causing the Scan Line Corrector (SLC) to stop functioning normally. The non-functioning SLC causes individual scan lines to alternately overlap and then leave large gaps at the edges of the image. Landsat 7 ETM+ has been reactivated on October 22, 2003, however with significantly reduced image quality due to the faulty SLC. These anomalies in the resulting data massively limit the usefulness of Landsat 7 data for the GSE FM services in the future. Although the precursor satellite Landsat 5 has been reactivated in July 2003, due to its age it is uncertain if Landsat 5 can provide EO data coverage for the time period until the launch of a follow-on satellite for the defective Landsat 7 ETM+.

- 2) Envisat ASAR and ERS SAR acquisition capacity:

  The necessary EO data needs for the generation of the relevant service products currently exceed the data acquisition capacities provided by Envisat ASAR. This problem is also due to the ASAR unavailability in May 2003 because of a faulty on-board sub-system. This problem has been fixed since June 2003 and it is expected that the necessary amount of ASAR data will be available within 2004.

  Moreover, the amount of available ERS-1/2 SAR data from the archives did not fully satisfy the needs of the service provider, because the number of available archived scenes did not provide the required coverage with SAR scenes. However, it is expected that this deficiency will be overcome within 2004.

Despite of the above mentioned open issues and problems the necessary capacities for the generation of the GSE FM services in the 0-2 years consolidation phase can be provided by the currently available EO data sources.

3.2.4. Time Period 2-5 Years (End of 2007)

It is expected that during this time period IRS-1C/D will replaced or supplemented by the IRS P5 / P6 missions. Moreover, until the end of 2007 it is assumed that Landsat 7 will be replaced by the Landsat Data Continuity Mission (LDCM) and “ENVISAT ASAR” will be supplemented by “TerraSAR-X”.

3.2.4.1. EO Data Needs

In the following tables the EO data needs are estimated for each of the GSE FM services.

Tab. 5: EO data needs for the time scale 2-5 years: National GHG Reporting

Year		2005	2006	2007
Mapping area (Mio sqkm)		0.27	0.49	0.71
EO data needs (Mio sqkm)	Spot 5	0.162	0.294	0.426
	Spot 1-4	0.041	0.074	0.107
	IRS Pan	0.081	0.147	0.213
	IRS LISS	0.081	0.147	0.213
	Landsat 7 & LDCM	0.122	0.221	0.320
	ERS SAR	0.000	0.000	0.000
	Envisat ASAR	0.027	0.049	0.071
	TerraSAR	0.027	0.049	0.071
No of scenes	Spot 5	74	134	194
	Spot 1-4	18	33	48
	IRS Pan	27	49	71
	IRS LISS	7	12	18
	Landsat 7 & LDCM	6	11	16
	ERS SAR	0	0	0
	Envisat ASAR	5	8	12
	TerraSAR	5	8	12
Sum	Optical data	132	239	347
	SAR data	10	16	24

Tab. 6: EO data needs for the time scale 2-5 years: Clean Development Mechanism

Year		2005	2006	2007
Mapping area (Mio sqkm)		0.03	0.05	0.07
EO data needs (Mio sqkm)	Spot 5	0.018	0.030	0.042
	Spot 1-4	0.005	0.008	0.011
	IRS Pan	0.009	0.015	0.021
	IRS LISS	0.009	0.015	0.021
	Landsat 7 & LDCM	0.014	0.023	0.032
	ERS SAR	0.000	0.000	0.000
	Envisat ASAR	0.003	0.005	0.007
	TerraSAR	0.003	0.005	0.007
No of scenes	Spot 5	8	14	19

	Spot 1-4	2	3	5
	IRS Pan	3	5	7
	IRS LISS	1	1	2
	Landsat 7	1	1	2
	ERS SAR	0	0	0
	Envisat ASAR	1	1	1
	TerraSAR	1	1	1
Sum	Optical data	15	24	34
Sum	SAR data	2	2	2

Tab. 7: EO data needs for the time scale 2-5 years: Mapping and Monitoring of Disturbances

Year		2005	2006	2007
Mapping area (Mio sqkm)		0.270	0.520	0.770
EO data needs (Mio sqkm)	Spot 5	0.162	0.312	0.462
	Spot 1-4	0.041	0.078	0.116
	IRS Pan	0.081	0.156	0.231
	IRS LISS	0.081	0.156	0.231
	Landsat 7 & LDCM	0.122	0.234	0.347
	ERS SAR	0.000	0.000	0.000
	Envisat ASAR	0.027	0.052	0.077
	TerraSAR	0.027	0.052	0.077
No of scenes	Spot 5	74	142	210
	Spot 1-4	18	35	53
	IRS Pan	27	52	77
	IRS LISS	7	13	19
	Landsat 7 & LDCM	6	12	17
	ERS SAR	0	0	0
	Envisat ASAR	5	9	13
	TerraSAR	5	9	13
Sum	Optical data	132	254	376
Sum	SAR data	9	17	26

Tab. 8: EO data needs for the time scale 2-5 years: Sub-National Forest Information

Year		2005	2006	2007
Mapping area (Mio sqkm)		0.02	0.03	0.05
EO data needs (Mio sqkm)	Spot 5	0.015	0.023	0.038
	Spot 1-4	0.000	0.000	0.000
	IRS Pan	0.015	0.023	0.038
	IRS LISS	0.000	0.000	0.000
	Landsat 7 & LDCM	0.015	0.023	0.038
	ERS SAR	0.000	0.000	0.000
	Envisat ASAR	0.000	0.000	0.000
	TerraSAR	0.000	0.000	0.000
No of scenes	Spot 5	7	10	17
	Spot 1-4	0	0	0
	IRS Pan	5	8	13
	IRS LISS	0	0	0
	Landsat 7 & LDCM	1	1	2
	ERS SAR	0	0	0
	Envisat ASAR	0	0	0
	TerraSAR	0	0	0
Sum	Optical data	13	19	31
Sum	SAR data	0	0	0

Tab. 9: EO data needs for the time scale 2-5 years: Land Cover and Forest Indicators

Year		2005	2006	2007
Mapping area (Mio sqkm)		0.26	0.52	0.77
EO data needs (Mio sqkm)	Spot 5	0.156	0.312	0.462
	Spot 1-4	0.039	0.078	0.116
	IRS Pan	0.078	0.156	0.231
	IRS LISS	0.078	0.156	0.231
	Landsat 7	0.117	0.234	0.347
	ERS SAR	0.000	0.000	0.000
	Envisat ASAR	0.026	0.052	0.077
	TerraSAR	0.026	0.052	0.077
No of scenes	Spot 5	71	142	210
	Spot 1-4	18	35	53
	IRS Pan	26	52	77
	IRS LISS	7	13	19
	Landsat 7	6	12	17

	ERS SAR	0	0	0
	Envisat ASAR	4	9	13
	TerraSAR	4	9	13
Sum	Optical data	127	254	376
Sum	SAR data	9	17	26

Tab. 10: EO data needs for the time scale 2-5 years: Summary table

Year		**2005**	**2006**	**2007**
National GHG Reporting				
Mapping area	(Mio sqkm)	0.27	0.49	0.71
No. of scenes	Optical data	132	239	347
	SAR data	10	16	24
Clean Development Mechanism				
Mapping area	(Mio sqkm)	0.03	0.05	0.07
No. of scenes	Optical data	15	24	34
	SAR data	2	2	2
Mapping and Monitoring of Disturbances				
Mapping area	(Mio sqkm)	0.270	0.520	0.770
No. of scenes	Optical data	132	254	376
	SAR data	9	17	26
Sub-national Forest Information				
Mapping area	(Mio sqkm)	0.02	0.03	0.05
No. of scenes	Optical data	13	19	31
	SAR data	0	0	0
Land Cover and Forest Indicators				
Mapping area	(Mio sqkm)	0.26	0.52	0.77
No. of scenes	Optical data	127	254	376
	SAR data	9	17	26

3.2.4.2. Open Issues and Problems

- Landsat 7 technical problems:

  Landsat 7 ETM+ is one of the most important EO data sources for the service. On May 31, 2003, Landsat 7 experienced an anomaly causing the Scan Line Corrector (SLC) to stop functioning normally. The non-functioning SLC causes individual scan lines to alternately overlap and then leave large gaps at the edges of the image. Landsat 7 ETM+ has been reactivated on October 22, 2003, however with significantly reduced image quality due to the faulty SLC. These anomalies in the resulting data massively limit the usefulness of Landsat 7 data or even make it unusable for the GSE FM services in the future. Although the precursor satellite Landsat 5 has been reactivated in July 2003, due to its age it is uncertain if Landsat 5 can provide EO data coverage for the time period until the launch of a follow-on satellite for the defective Landsat 7 ETM+.

- Timeliness and frequency of optical EO data:

  The frequency of optical EO observations is too low. Due to the frequent cloud coverage, especially in northern and central European states, it is necessary to have a more frequent coverage with EO data by increasing the "revisit frequency". This could be done by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration which integrates several satellites into a harmonised system and/or (c) satellites with high spatial resolution and much higher swath width to increase revisit time considerably.

This issue on timeliness and insufficient frequency of observations is a very critical one. It is not the capacity of the EO infrastructure, which is the bottleneck for the generation of the GSE FM services in the 2-5 years period. Compared to the amount of data, which e.g. are received at the ESA Earthnet stations, the required number of scenes can be provided by the currently available EO infrastructure. The critical issue is to get cloud free scenes for the requested period. The total number of Landsat 7 scenes received at the 4 ESA station is about 17.200 scenes in the year 2002 (see "*Precursor systems Inventory S9"* document).

3.2.5. Time Period 5-10 Years (End of 2012)

It is expected that during this time period at least two new missions with optical and/or SAR sensors (and with a geometric resolution relevant for GSE FM) will be available, e.g. the Pleiades System and COSMO SkyMed. Moreover, additional missions are likely to be available, e.g. ALOS, Radarsat-2, RapidEye.

Therefore, in the following table the terms have to be read as follows:

- Landsat 7 -> optical sensor system(s) "Landsat type" (a)

- IRS-1C/D -> optical sensor system(s) “IRS type” (b)
- SPOT-5 -> optical sensor system(s) “SPOT type” (c)
- ENVISAT ASAR -> SAR sensor system(s) “C-/X-/L-SAR” (d)

Explanations:

(a): spectral bands similar to Landsat 7, geometric resolution 10-30 m

(b): spectral bands similar to IRS-1C/D, IRS-P5/6, geometric resolution 5-20 m

(c): spectral bands similar to SPOT 5, Pleiades: geometric resolution 1-10 m

(d): SAR system in C-Band (ASAR), X-Band (TerraSAR-X), L-Band (ALOS)

3.2.5.1. EO Data Needs

In the following tables the EO data needs are estimated for each of the GSE FM services.

Tab. 11: EO data needs for the time scale 5-10 years: National GHG Reporting

Year		2008	2009	2010	2011	2012
Mapping area (Mio sqkm)		0.75	0.96	1.18	1.39	1.60
EO data needs (Mio sqkm)	Spot 5	0.563	0.720	0.885	1.043	1.200
	Spot 1-4	0.000	0.000	0.000	0.000	0.000
	IRS Pan	0.000	0.000	0.000	0.000	0.000
	IRS LISS	0.000	0.000	0.000	0.000	0.000
	Landsat 7	0.563	0.720	0.885	1.043	1.200
	ERS SAR	0.000	0.000	0.000	0.000	0.000
	Envisat ASAR	0.000	0.000	0.000	0.000	0.000
	TerraSAR	0.300	0.384	0.472	0.556	0.640
No of scenes	Spot 5	256	327	402	474	545
	Spot 1-4	0	0	0	0	0
	IRS Pan	0	0	0	0	0
	IRS LISS	0	0	0	0	0
	Landsat 7	28	36	44	52	60
	ERS SAR	0	0	0	0	0
	Envisat ASAR	0	0	0	0	0
	TerraSAR	50	64	79	93	107
Sum	Optical data	284	363	447	526	605
	SAR data	50	64	79	93	107

Tab. 12: EO data needs for the time scale 5-10 years: Clean Development Mechanism

Year		**2008**	**2009**	**2010**	**2011**	**2012**
Mapping area (Mio sqkm)		0.07	0.08	0.10	0.11	0.13
EO data needs (Mio sqkm)	Spot 5	0.053	0.060	0.075	0.083	0.098
	Spot 1-4	0.000	0.000	0.000	0.000	0.000
	IRS Pan	0.000	0.000	0.000	0.000	0.000
	IRS LISS	0.000	0.000	0.000	0.000	0.000
	Landsat 7	0.053	0.060	0.075	0.083	0.098
	ERS SAR	0.000	0.000	0.000	0.000	0.000
	Envisat ASAR	0.000	0.000	0.000	0.000	0.000
	TerraSAR	0.028	0.032	0.040	0.044	0.052
No of scenes	Spot 5	24	27	34	38	44
	Spot 1-4	0	0	0	0	0
	IRS Pan	0	0	0	0	0
	IRS LISS	0	0	0	0	0
	Landsat 7	3	3	4	4	5
	ERS SAR	0	0	0	0	0
	Envisat ASAR	0	0	0	0	0
	TerraSAR	5	5	7	7	9
Sum	Optical data	26	30	38	42	49
	SAR data	5	5	7	7	9

Tab. 13: EO data needs for the time scale 5-10 years: Mapping and Monitoring of Disturbances

Year		2008	2009	2010	2011	2012
Mapping area (Mio sqkm)		0.910	1.060	1.200	1.350	1.500
EO data needs (Mio sqkm)	Spot 5	0.683	0.795	0.900	1.013	1.125
	Spot 1-4	0.000	0.000	0.000	0.000	0.000
	IRS Pan	0.000	0.000	0.000	0.000	0.000
	IRS LISS	0.000	0.000	0.000	0.000	0.000
	Landsat 7	0.683	0.795	0.900	1.013	1.125
	ERS SAR	0.000	0.000	0.000	0.000	0.000
	Envisat ASAR	0.000	0.000	0.000	0.000	0.000
	TerraSAR	0.364	0.424	0.480	0.540	0.600
No of scenes	Spot 5	310	361	409	460	511
	Spot 1-4	0	0	0	0	0
	IRS Pan	0	0	0	0	0
	IRS LISS	0	0	0	0	0

	Landsat 7	34	40	45	51	56
	ERS SAR	0	0	0	0	0
	Envisat ASAR	0	0	0	0	0
	TerraSAR	61	71	80	90	100
Sum	Optical data	344	401	454	511	568
	SAR data	61	71	80	90	100

Tab. 14: EO data needs for the time scale 5-10 years: Sub-National Forest Information

Year		2008	2009	2010	2011	2012
Mapping Area (Mio sqkm)		0.15	0.26	0.37	0.48	0.59
EO data needs (Mio sqkm)	Spot 5	0.113	0.195	0.278	0.360	0.443
	Spot 1-4	0.000	0.000	0.000	0.000	0.000
	IRS Pan	0.113	0.195	0.278	0.360	0.443
	IRS LISS	0.000	0.000	0.000	0.000	0.000
	Landsat 7	0.113	0.195	0.278	0.360	0.443
	ERSSAR	0.000	0.000	0.000	0.000	0.000
	Envisat ASAR	0.000	0.000	0.000	0.000	0.000
	TerraSAR	0.000	0.000	0.000	0.000	0.000
No of scenes	Spot 5	51	89	126	164	201
	Spot 1-4	0	0	0	0	0
	IRS Pan	38	65	93	120	148
	IRS LISS	0	0	0	0	0
	Landsat 7	6	10	14	18	22
	ERS SAR	0	0	0	0	0
	Envisat ASAR	0	0	0	0	0
	TerraSAR	0	0	0	0	0
Sum	Optical data	94	163	233	302	371
	SAR data	0	0	0	0	0

Tab. 15: EO data needs for the time scale 5-10 years: Land Cover and Forest Indicators

Year		2008	2009	2010	2011	2012
Mapping area (Mio sqkm)		0.84	1.11	1.37	1.64	1.90
EO data needs (Mio sqkm)	Spot 5	0.630	0.833	1.028	1.230	1.425
	Spot 1-4	0.000	0.000	0.000	0.000	0.000
	IRS Pan	0.000	0.000	0.000	0.000	0.000
	IRS LISS	0.000	0.000	0.000	0.000	0.000
	Landsat 7	0.630	0.833	1.028	1.230	1.425
	ERS SAR	0.000	0.000	0.000	0.000	0.000

	Envisat ASAR	0.000	0.000	0.000	0.000	0.000
	TerraSAR	0.336	0.444	0.548	0.656	0.760
No of scenes	Spot 5	286	378	467	559	648
	Spot 1-4	0	0	0	0	0
	IRS Pan	0	0	0	0	0
	IRS LISS	0	0	0	0	0
	Landsat 7	32	42	51	62	71
	ERS SAR	0	0	0	0	0
	Envisat ASAR	0	0	0	0	0
	TerraSAR	56	74	91	109	127
Sum	Optical data	318	420	518	621	719
	SAR data	56	74	91	109	127

Tab. 16: EO data needs for the time scale 5-10 years: Summary table

Year		**2008**	**2009**	**2010**	**2011**	**2012**
National GHG Reporting						
Mapping area	(Mio sqkm)	0.75	0.96	1.18	1.39	1.60
No.of scenes	Optical data	284	363	447	526	605
	SAR data	50	64	79	93	107
Clean Development Mechanism						
Mapping area	(Mio sqkm)	0.07	0.08	0.10	0.11	0.13
No. of scenes	Optical data	26	30	38	42	49
	SAR data	5	5	7	7	9
Mapping of Disturbances						
Mapping area	(Mio sqkm)	0.910	1.060	1.200	1.350	1.500
No. of scenes	Optical data	344	401	454	511	568
	SAR data	61	71	80	90	100
Sub-National Forest Information						
Mapping Area	(Mio sqkm)	0.15	0.26	0.37	0.48	0.59
No. of scenes	Optical data	94	163	233	302	371
	SAR data	0	0	0	0	0
Land Cover and Forest Indicators		2008	2009	2010	2011	2012

Mapping area	(Mio sqkm)	0.84	1.11	1.37	1.64	1.90
No. of scenes	Optical data	318	420	518	621	719
	SAR data	56	74	91	109	127

3.2.5.2. Open Issues and Problems

- Timeliness and frequency of optical EO data:

  The frequency of optical EO observations is too low. Due to the frequent cloud coverage, especially in northern and central European states, it is necessary to have a more frequent coverage with EO data by increasing the "revisit frequency". This could be done by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration which integrates several satellites into a harmonised system and/or (c) satellites with high spatial resolution and much higher swath width to increase revisit time considerably.

- Continuity of missions:

  The long term continuity of EO sensors must be ensured. The GSE FM services require a long term perspective of EO data provision to justify the adaptation of the users infrastructure to using EO services. Therefore, continuity should be guaranteed.

This issue on EO continuity is a very critical one. Long-term continuity requires the setting up of institutional and commercial funding frameworks and transferring the funding to budget lines outside the research and development framework. Moreover, the problem of timeliness and insufficient frequency of observations is also growing.

3.3. In-situ Observation Data Sources

3.3.1. Time Period 0-2 years (End of 2004)

In the short-term most required in-situ data sources will be available from finished or on-going national and regional forest inventories in the European region. The availability of national and regional forest inventory data is not assumed to phase out.

Co-ordinates of inventory plots are recorded in most inventories for at least part of the plots. No information has yet been reviewed however on the accuracy of such plot co-ordinates.

In the short term, the quality of biomass expansion factors, carbon conversion factors and soil carbon data is expected to increase through the contribution of coordinated pan-European research projects. Activities in this field of research are expected to continue and funding is not expected to phase out in the short-to-mid term.

Concerning the reliability of data sources, there is inversely proportional to the number of samples that have been taken per unit of area. The correlation between variance and forest type, or the effect of forest parameters on the variance at the plot level and its contribution to error propagation has not been reviewed thus far. Nevertheless, the quality standards that apply to the collection of data for a national/regional forest inventory (as well as for ICP Forests) are high and the data are the best available. It may be appropriate to repeat the importance of the benefit of a standardized data collection methodology for information collection over a large area.

Tab. 17: In-situ data needs for the time scale 0-2 years

GSE-FM product	Data Type	Primary Data Source	Alternative Data Sources	Mapping Area in 2004 [km^2]	Amount of Data	Open Issues and Problems
					See text	See text
CS-1-5	O	Forest Stratification for volume, biomass and carbon stock estimation	----	30.000		
CS-1-5	O	Tree data (from NFI)	In-situ survey	30.000		
CS-1-5	O	Volume function	Single tree volume figures from NFI	30.000		
CS-1-5	O	Biomass expansion factors	Single tree biomass from NFI	30.000		
CS-1-5	O	Carbon conversion factors	Single tree carbon content from NFI	30.000		

CS-1-5	O	Soil carbon	Total storage of carbon in soil from other sources	30.000		
CS-1-6	O	Forest Stratification for volume, biomass and carbon stock estimation	----	30.000		
CS-1-6	O	Tree data (from NFI)	In-situ survey	30.000		
CS-1-6	O	Volume function	Single tree volume figures from NFI	30.000		
CS-1-6	O	Biomass expansion factors	Single tree biomass from NFI	30.000		
CS-1-6	O	Carbon conversion factors	Single tree carbon content from NFI	30.000		
CS-1-6	O	Soil carbon	Total storage of carbon in soil from other sources	30.000		
FA-3-2	IS	In-situ data	Existing and update GIS data	16.000		
OM-6-1	IS	Ground control points	---	14.000		
FA-6-2	IS	Ground verification data	---	14.000		
LU-6-3	IS	Ground verification data	---	14.000		

3.3.2. Time Period 2-5 Years (End of 2007)

European countries have well-established forest inventory schemes, which record data on forest area, wood volume, tree species and other variables, which would also allow for forest type discrimination and stratification. Inventory activities are not expected to phase-out. In the Russian Federation there exist regional differences in the methodology, intensity and quality of in-situ forestry data collection.

Availability of (in-situ) national forestry data is a problem for many countries in economically less developed regions (Africa, Western Asia and Asia and the Pacific and South America and the Caribbean). Existing forest monitoring exercises are largely based on expert estimates, general and detailed mapping.

Upon expansion of services outside Europe, the availability of accurate biomass expansion factors, carbon conversion factors and soil data may become a problem.

Methodology for the monitoring of CDM projects, including data-acquisition, has to be approved by the Executive Board of the Clean Development Mechanism. Ground control points may not be as abundant in developing compared to developed nations.

Tab. 18: In-situ data needs for the time scale 2-5 years

GSE-FM product	**Data Type**	**Primary Data Source**	**Alternative Data Sources**	**Mapping Area in 2007 [km^2] (conservative scenario)**	**Amount of Data**	**Open Issues and Problems**
					See text	See text
CS-1-5	O	Forest Stratification for volume, biomass and carbon stock estimation	----	260.000		
CS-1-5	O	Tree data (from NFI)	In-situ survey	260.000		
CS-1-5	O	Volume function	Single tree volume figures from NFI	260.000		
CS-1-5	O	Biomass expansion factors	Single tree biomass from NFI	260.000		
CS-1-5	O	Carbon conversion factors	Single tree carbon content from NFI	260.000		
CS-1-5	O	Soil carbon	Total storage of carbon in soil from other sources	260.000		
CS-1-6	O	Forest Stratification for volume, biomass and carbon stock estimation	----	260.000		
CS-1-6	O	Tree data (from NFI)	In-situ survey	260.000		
CS-1-6	O	Volume function	Single tree volume figures from NFI	260.000		
CS-1-6	O	Biomass expansion factors	Single tree biomass from NFI	260.000		
CS-1-6	O	Carbon conversion factors	Single tree carbon content from NFI	260.000		
CS-1-6	O	Soil carbon	Total storage of carbon in soil from other sources	260.000		
FA-3-2	IS	In-situ data	Existing and update GIS data	260.000		

OM-6-1	IS	Ground control points	---	260.000		
FA-6-2	IS	Ground verification data	---	260.000		
LU-6-3	IS	Ground verification data	---	100.000		

3.3.3. Time Period 5-10 Years (End of 2012)

In the event that the Kyoto Protocol would not be ratified, the global attention for monitoring of projects in the framework of the Clean Development Mechanism (afforestation and reforestation) or Joint Implementation (afforestation, reforestation and forest management) may loose significance. The same faith could then be for (an assumed) increased support for the inventorying of forests in developing countries. However, there are strong signs that the Kyoto Protocol will be ratified by the end of the year 2004.

Methodology for the monitoring of CDM projects, including data-acquisition, has to be approved by the Executive Board of the Clean Development Mechanism.

Tab. 19: In-situ data needs for the time scale 5-10 years

GSE-FM Product	Data Type	Primary Data Source	Alternative Data Sources	Mapping Area in 2012 [km^2] (conservative scenario)	Amount of Data	Open Issues and Problems
CS-1-5	O	Forest Stratification for volume, biomass and carbon stock estimation	----	1.180.000		
CS-1-5	O	Tree data (from NFI)	In-situ survey	1.180.000		
CS-1-5	O	Volume function	Single tree volume figures from NFI	1.180.000		
CS-1-5	O	Biomass expansion factors	Single tree biomass from NFI	1.180.000		
CS-1-5	O	Carbon conversion factors	Single tree carbon content from NFI	1.180.000		
CS-1-5	O	Soil carbon	Total storage of carbon in soil from other sources	1.180.000		
CS-1-6	O	Forest Stratification for volume, biomass and carbon stock estimation	----	1.180.000		

CS-1-6	O	Tree data (from NFI)	In-situ survey	1.180.000		
CS-1-6	O	Volume function	Single tree volume figures from NFI	1.180.000		
CS-1-6	O	Biomass expansion factors	Single tree biomass from NFI	1.180.000		
CS-1-6	O	Carbon conversion factors	Single tree carbon content from NFI	1.180.000		
CS-1-6	O	Soil carbon	Total storage of carbon in soil from other sources	1.180.000		
FA-3-2	IS	In-situ data	Existing and update GIS data	580.000		
OM-6-1	IS	Ground control points	---	580.000		
FA-6-2	IS	Ground verification data	---	580.000		
LU-6-3	IS	Ground verification data	---	220.000		

3.3.4. Conclusions

The following groups of in-situ data are essential for successful implementation of the GSE-FM services in an area:

- Reference data; depending on the availability of existing data in some countries additional reference data acquisition is necessary.
- Forest GIS
- Existing forest management maps and data

3.4. Model and Ancillary Data Sources

3.4.1. Data Needs Prospectus

The following table gives an overview of the data needs prospectus considering the mapping area per year needed for service provision according to the Operational Scenarios (C11 V2, table 19) for the 0-2 y years 2005, 2-5 years 2008 and 2012. (conservative scenario) and 5-10 years (conservative scenario).

Tab. 20: Model and ancillary data needs prospectus – mapping area [Mio km²] per year in 2005, 2008, 2012

GSE-FM product	Data Type	Primary Data Source	Alternative Data Sources	Mapping Area in 2005	Mapping Area in 2008	Mapping Area in 2012
Nat. GHG	GIS	DEM (MONA)	DEM SRTM-X Other DEMs	0.27	0.75	1.60
	GIS	TopoMap 25.000	TopoMap 50.000, Satellite Map, Aerial Ortho images	0.27	0.75	1.60
	GIS	Large scale forest map	TopoMap, Satellite Map, Aerial Ortho images	0.27	0.75	1.60
	GIS	Administrative borders (various NUTS levels)	Other border types	0.27	0.75	1.60
	GIS	Forest / Non-forest map (Output from GSE-FM-LFM-FA)		0.27	0.75	1.60
	GIS	NDVI (Output from GSE-FM-LFM-FA)		0.27	0.75	1.60
	GIS	DEM		0.27	0.75	1.60
	GIS	Forest stand polygon data or sample plot data	Large scale aerial photos	0.27	0.75	1.60
	GIS	CORINE Land Cover		0.27	0.75	1.60
	GIS	FOREST 2000	Management plans	0.27	0.75	1.60
	GIS	Land Use / Cover Map 1990		0.27	0.75	1.60
	GIS	Land Use / Cover Map – current year		0.27	0.75	1.60
CDM	GIS	Forest Stand Polygon data	Sample plot data	0.03	0.07	0.13
Disturb.	GIS	DEM		0.27	0.91	1.50
	GIS	Forest mask (raster format)	Forest mask (vector format)	0.27	0.91	1.50

	GIS	Cloud mask		0.27	0.91	1.50
	GIS	Clear cut areas characterisation	Attribute data	0.27	0.91	1.50
Sub-Nat,	GIS	DEM	DEM 50 m raster	0.02	0.15	0.59
	GIS	Forest Cover Map (Output from GSE-FM-LFM-FA)	Other forest cover maps	0.02	0.15	0.59
LC&FI	GIS	Forest cover map Forest Type map	Forest / Non-forest map	0.26	0.84	1.90

3.4.2. Data Availability Prospectus

Constrains for the availability of the above mentioned model and ancillary data-sets are mainly:

- Are the data sets required for service provision existing in the specific service area? General distinction can be made between availability in the country of the precursor service and other regions (EU, NAS, global).
- Are the data sets required up-to-date to assure the quality of services? According the thematic content of input data-sets, different refresh-periods can be considered.
- Are the data sets required accessible? Conditions of access and restrictions of use have to be considered.

In addition, alternatives have to be considered to assure the service provision, if preferred data-sets are not available.

Tab. 21: Data availability prospectus

Data Source	Prec. Service Dependency	Availability in country of precursor	Availability in other regions	Update rate needed	Last Update	Access conditions
SRTM X DEM	High	High	High	Low	2000	Commercial
MONA Pro	Alternative	High	High	Low		Commercial
DEM public survey agency	Alternative	High	Low	Low	1985-90	Commercial
DEM Thuringia	High	Low	Low	Low		Restricted - provision by user
DEM VTT	High	High	?	Low		

DEM Greece	High	High	Low	Low	1999	Specific access conditions (Hellenic Army)
Topo Maps (used in Saxonia onlyGermany, Russia)	High	High	Middle	Middle	Under permanent revision	Commercial
Topo Maps (Germany, France, Finland, Greece, Russia)	High	High	Middle	Middle	Under permanent revision	Commercial or specific access conditions (e.g. Greece)
Topo Maps (Russia)	High	High	High	Middle		Commercial
Topo Maps (Russia)	High	High	High	Middle		Commercial
Local Scale Forest Maps	High	Middle	Low	High		Restricted - provision by user
Forest Cover Maps (Germany)	High	Middle	Low	High		
Forest Cover Maps (Greece),	High	Middle	Low	High	1965-80	Specific access conditions
Forest stand polygon data Finland	High	Middle	Low	High		Restricted - provision by user
Forest Database Russia	High	Middle	Low	High	1999	non information available
CORINE	Middle	High	High	Middle	1991(partly : 2000)	Freely available for non-commercial use
Forest Management Plans (Greece)	High	Middle	Low	High	1970-today	Restricted - provision by user
Administrative Boundaries	Low	High	High	Low		Commercial

(NUTS) Aerial Ortho-Photos	Alternative	High	Low	High		Commercial or restricted provision by user

3.4.3. Conclusions

The following conclusions can be drawn with respect to ancillary data sources. Except of globally available models and ancillary data sources, the availability of these data-sets has to be assessed per country or region. The following table (taken from document C11 - Operational Service Scenarios) gives an overview of the country groups for the scenario development for GSE FM services.

Tab. 22: Country groups for scenario development per service – Definition of groups

Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting	
1	Annex 1, European (including Russia), non EU+
2	Annex 1, Non European
3	Non Annex 1, European, non EU+
4	Non Annex 1 & outside Europe
5	Annex 1, EU+
Forest Monitoring Inputs for CDM Projects	
1	Non Annex 1 & with high afforestation potential
2	Non Annex 1 & with high conditional afforestation potential (where presently project establishment is too risky due to political and economic instability)
3	Non Annex 1 & with low afforestation potential
Mapping and Monitoring of Disturbances (Clear Cuts, Forest Fires and other Disturbances)	
1	EU+,. conifer-dominated countries
2	non EU+, conifer-dominated countries
3	SE Asian countries
4	Non EU+, other countries with considerable forest area
5	EU+, other countries with considerable forest area
Sub-National Forest Information Update	
1	EU+ with advanced Forest GIS
2	Other European Countries (including Russia), with advanced Forest GIS
3	All Non European countries, with advanced Forest GIS
4	EU+ without ~
5	Other European Countries (including Russia), without ~
6	All Non European countries, without ~
Land Cover & Forest Indicators	
1	EU+
2	All other countries

EU+: EU member countries in 2003, new member states in 2004 and countries with applicant status in 2004.

Although in most European countries e.g. topographic maps are available and updated outside Europe the situation is quite different. The following tables gives an impression on the present status and demand for topographic maps.

Tab. 23: Status of Topographic Mapping (Konecny, 2002)

Continent Scale	Africa	Asia	Australia & Oceania	Europe	former USSR	North America	South America	World
1:200 000	89.1 %	100 %	100 %	90.9 %	100 %	99.2 %	84.4 %	90.2 %
1:100 000	21.7 %	66.4 %	54.4 %	87.5 %	100 %	37.3 %	57.9 %	58.9 %
1: 50 000	41.1 %	84 %	24.3 %	96.2 %	100 %	77.7 %	33 %	56.1 %
1:25 000	2.9 %	15.2 %	18.3 %	86.9 %	100 %	45.1 %	7 %	33.3 %

The summary states that about 100 % of the land area of the world is covered by maps 1:200 000 for global requirements, about 2/3 by maps 1:50 000 for local needs. Unfortunately, especially for sub-national forest information updates the existence of large mapping scales and level of details, respectively, are high.

Some of these mapping systems are in the process of vector or at least raster digitization. But most of the map material does exist in analogue paper format. Due to often unfavorable storage conditions, the map quality will continuously decrease. The crucial truth is that most of the map information is not up-to-date. The most up-to-date topographic maps worldwide on the average are 20 years old. The current updating procedures by aerial photogrammetry or ground surveys and the digitization of existing analogue maps are in many cases too expensive to permit an up-to-date coverage of digital map information. As opposed to Europe and the industrialized countries of the world this constitutes a serious problem especially for developing countries.

Regarding to forest GIS data even in Europe a large variety of systems exists with different levels of details, formats and update rates. Here, for each new country / customer an analysis is required to assess the state-of-the-art and the accessibility of the data.

4. Problems and Necessary Improvements

4.1. Earth Observation Data Sources

Based on the analysis of the data needs and their availability prospectus the following main issues have been identified with respect to the EO data sources.

4.1.1. Continuity of EO missions

There is a strong need that the long term continuity of EO satellite missions must be ensured. The GSE FM services require a long term perspective of EO data provision to justify the adaptation of the users' infrastructure to using EO services. Therefore, the long term continuity of the main data source for the GSE services, i.e. the EO data, must be guaranteed. GMES is totally depending on the maintenance of EO systems and on their upgrade and/or replacement over time.

Because EO missions typically have lifetimes of about 5-7 years, this means that instead of single (one satellite) missions, stable satellite programs with a long term series of satellites are needed. Follow-on missions and upgrading of sensors have to be planned within this long term satellite programs, which shall cover planning periods of at least 10-20 years from now on.

The planned sentinel missions of ESA, especially the realisation of the envisaged super-spectral mission (continuity of Landsat data type), are of great importance for the GSE FM services.

Long-term continuity also requires the setting up of institutional and commercial funding mechanisms, which means that the funding for these operational systems has to be shifted from the research and development domain to budget lines in the institutional or commercial funding framework. The Eumetsat constellation, where national meteorological agencies fund the Meteosat program with a series of operational satellites and where Eumetsat is the operating agency for the satellites, is an excellent example how to ensure operational long term continuity of observations.

4.1.2. Timeliness and Sufficient EO Observation Frequency

One of the most important drawbacks for EO with optical sensors is the lack of timeliness and the insufficient frequency of observations. Due to cloud coverage, which is especially a problem in northern and central European states (if focussing on Europe), it is necessary to have a more frequent coverage with EO data by increasing the "revisit frequency". This could be done by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration which integrates several satellites into a harmonised system and/or (c) satellites with high spatial resolution and much higher swath width to increase revisit time considerably.

To illustrate this problem, the experiences made in the project "CORINE Land Cover 2000 (CLC2000)" will be shortly described. The objectives and the main elements of the project are described in the "*Precursor Systems Inventory (S9)*".

4.1.2.1. Cloud Coverage Analysis Based on "CORINE Land Cover 2000"

The experiences from CORINE Land Cover 2000 clearly show the problems to get cloud free coverage of data from only one satellite system. The data source is Landsat 7 ETM+ and the task is to get cloud free data within the vegetation period of about May – September 2000. The area that has to be covered is given in **Error! Reference source not found.**.

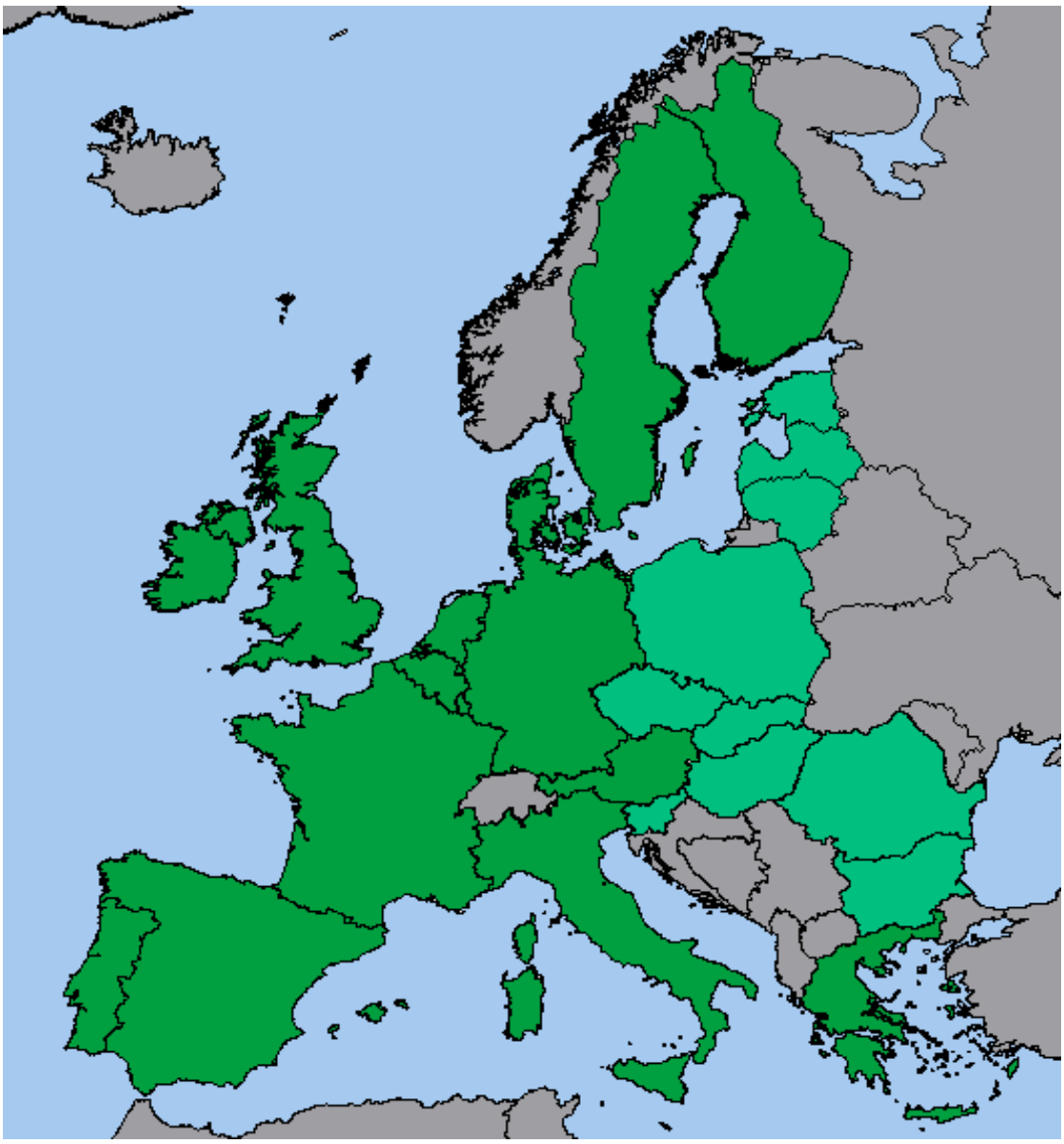

Fig. 2: Area to be covered (in green) by Landsat 7 scenes

The image selection is based on the following criteria and priorities:

- cloud free images (i.e. 0 % or, in difficult regions <5 % cloud coverage)
- acquired within the year 2000
- of an appropriate date (restricted window, then extended).

For the reference year 2000, cloud free images acquired within restricted time window should be selected as a first priority (see **Error! Reference source not found.**). When no cloud free images are available for this year/window, the selection will search successively:

- in extended acquisition window for year 2000
- in restricted acquisition window for year 1999
- in extended acquisition window for year 1999.

When no cloud free images are available on the campaigns 1999 and 2000, the search will be continued in 2001, in restricted, then in extended acquisition windows

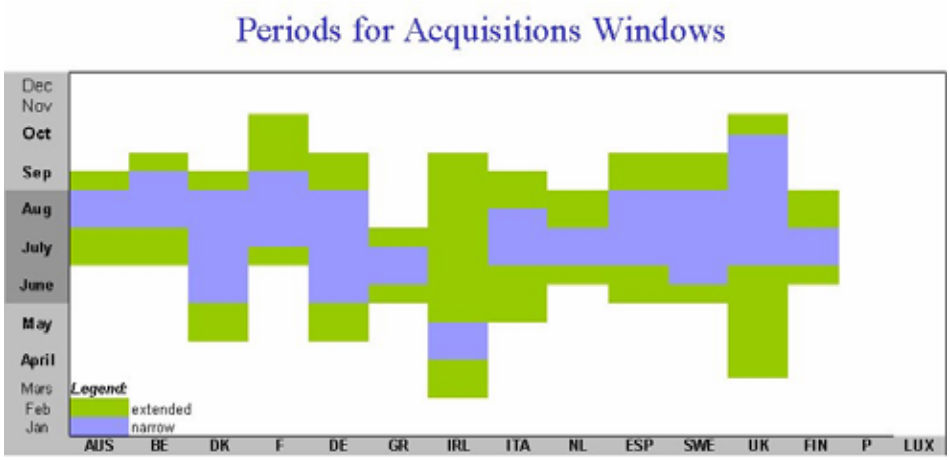

Fig. 3: Acquisition windows for Landsat 7 during vegetation period (http://image2000.jrc.it/i2000)

The number of images needed for full cloud free coverage is listed in **Error! Reference source not found.**, which results in 328 Landsat 7 ETM+ scenes.

With a repetition cycle of 16 days for Landsat 7 it is theoretically possible to acquire about 10 scenes within a 5-6 months vegetation period. However, due to cloud coverage in reality it was not possible to get cloud free coverage for the year 2000, for some countries even not within a three years period 1999-2001. **Error! Reference source not found.** shows the availability of cloud-free images for each of the participating countries for 1999-2001.

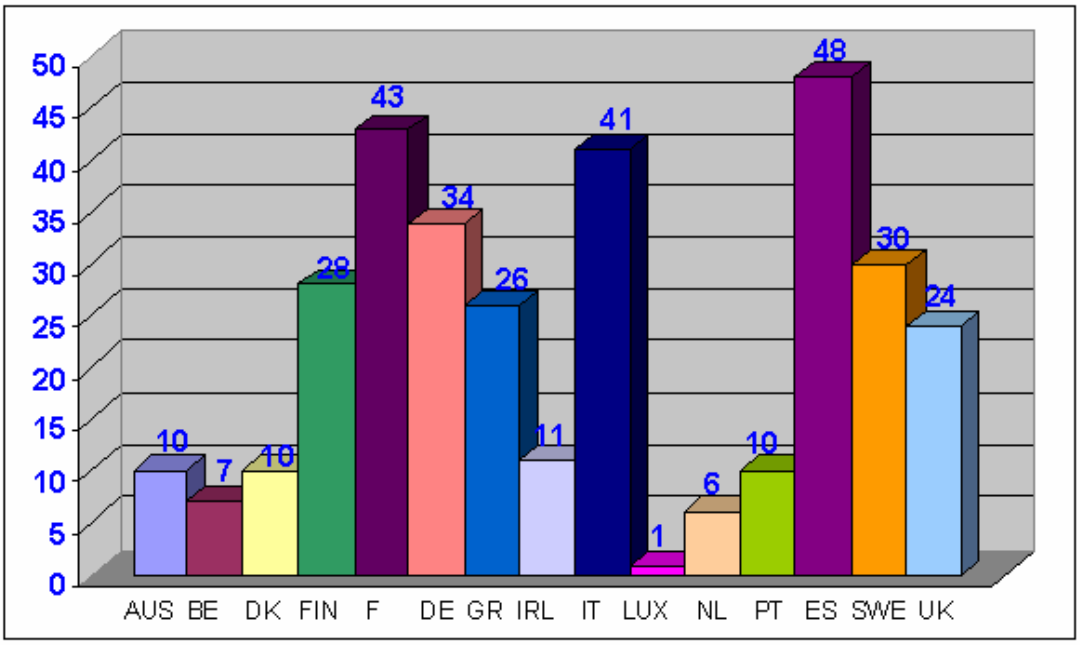

Fig. 4: Number of Landsat 7 ETM+ scenes needed for full coverage (http://image2000.jrc.it/i2000)

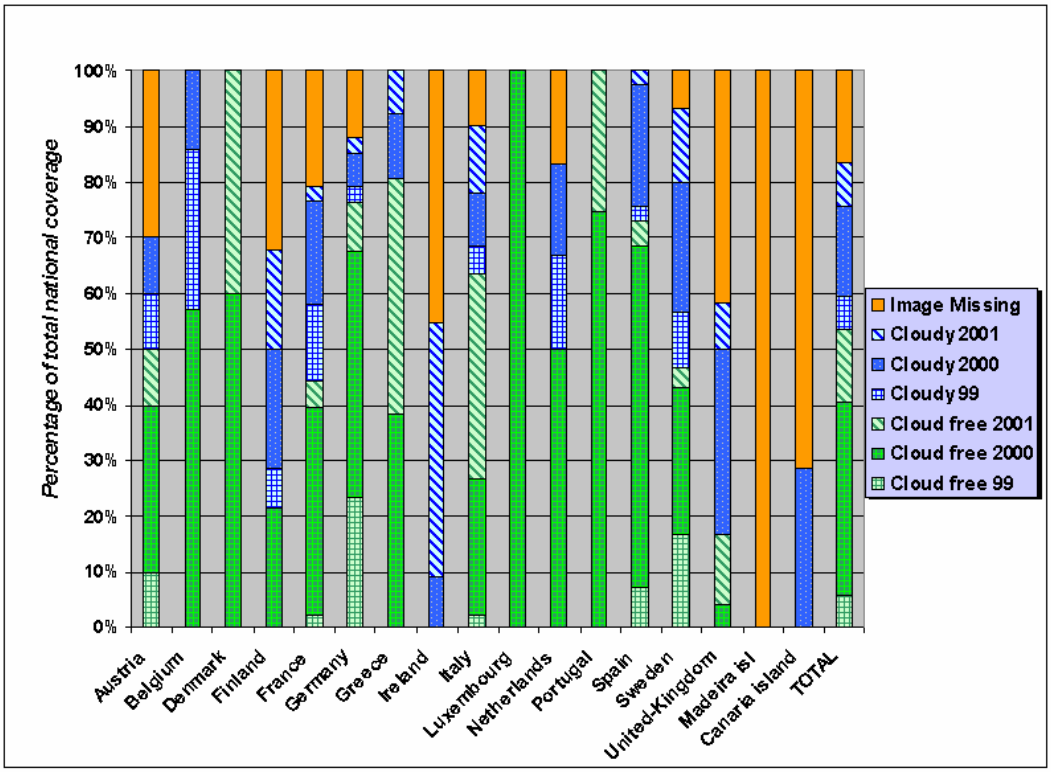

Fig. 5: Availability of cloud-free Landsat 7 images 1999-2001 (http://image2000.jrc.it/i2000)

In **Error! Reference source not found.** the data selection for Germany is listed, which show that only about 50% of the data could be acquired from the year 2000.

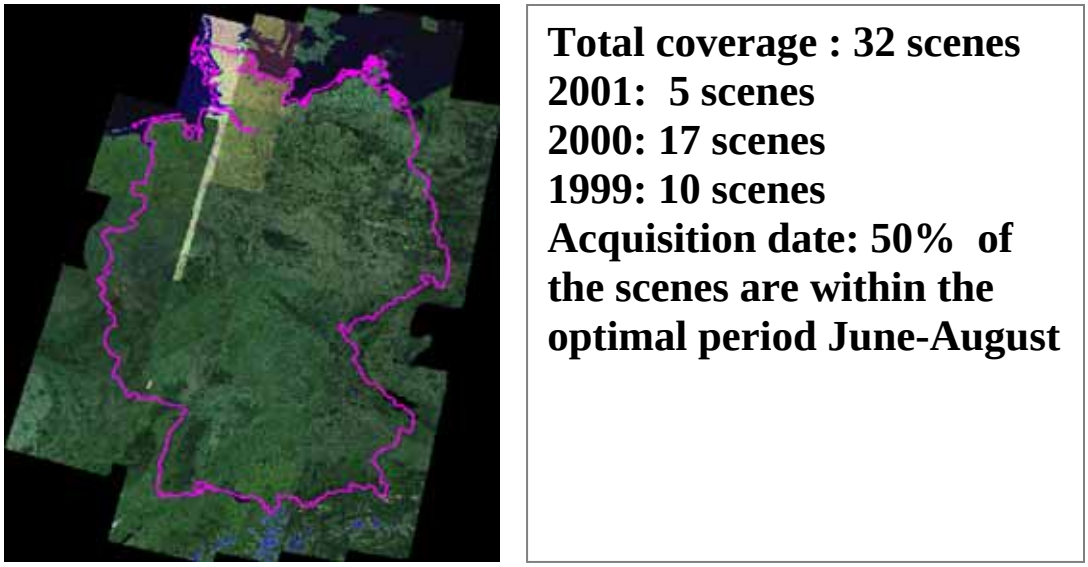

Fig. 6: Data selection in Germany (http://image2000.jrc.it/i2000)

Summarizing, the experiences from CORINE Land Cover 2000 illustrate the practical problems to get cloud free coverage of data from only one satellite system for large cover product generation.

4.1.3. Redundancy and Backup Capability of EO Missions

The current problems with Landsat 7 clearly show the need that EO missions need redundancy and backup capabilities. For operational service provision it must be ensured that in case of technical problems with a single satellite or even the loss of satellites this data gap can be compensated without any time delay. This could be realised by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration of identical or similar sensors which integrates several satellites into a harmonised system.

In case of Landsat 7 it was decided in October 2003 by USGS to generate products based on the faulty Scan Line Corrector (SLC-off). These products seem to be suitable for the Landsat global archive (Long Term Acquisition Plan, see document GSE-FM-C10). However, for the GSE FM services these anomalies in the SLC-off data massively limit the usefulness of Landsat 7 data or even make these data unsuitable for the GSE FM services in the future. **Error! Reference source not found.** gives an impression of the faulty data sets and the gaps in the Landsat 7 SLC-off products. In Europe ESA/Eurimage has not yet decided, whether they will adapt their processors to generate Landsat 7 SLC-off products.

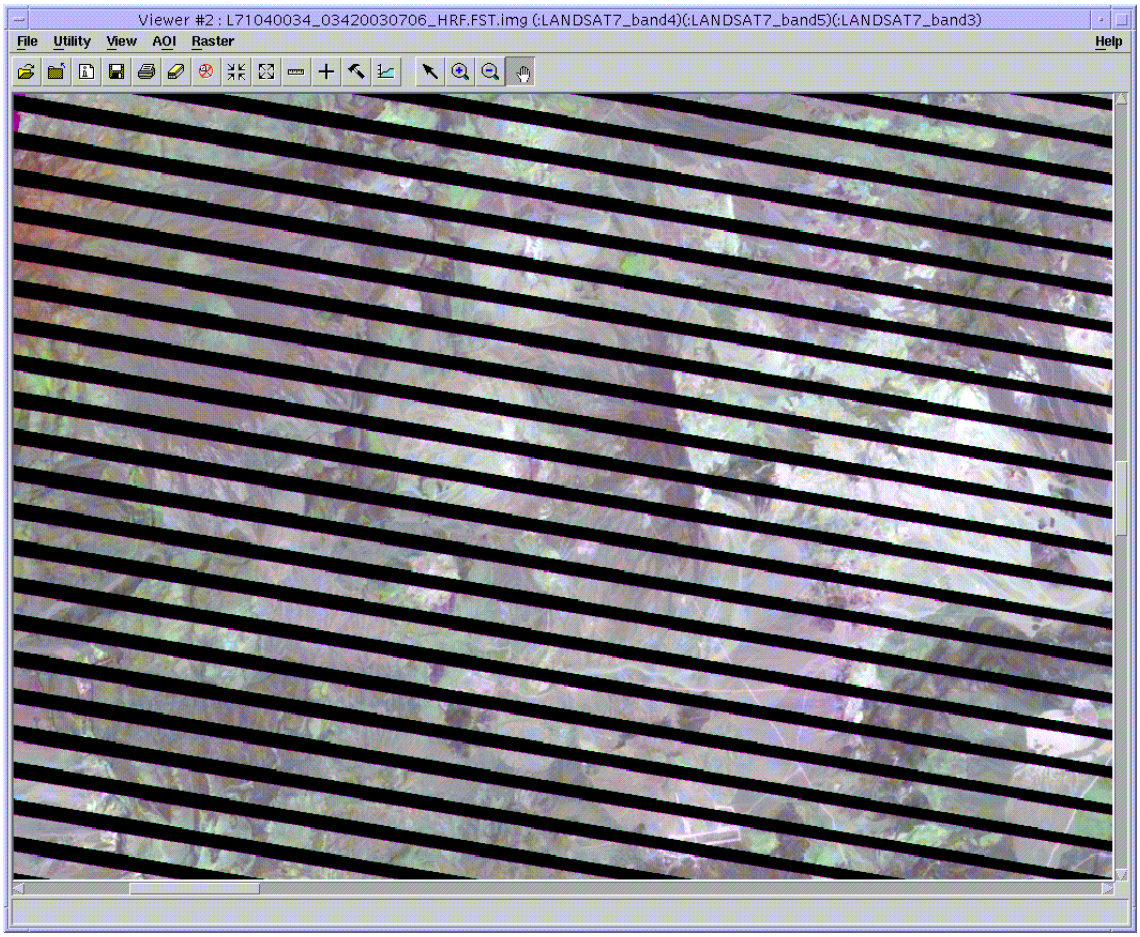

Fig. 7: Landsat 7 data (SLC-off)

Summarizing, to compensate the current problems with Landsat 7 as soon as possible, it is necessary that by Europe either (a) builds more own capacities of multispectral imagery at a Landsat compatible geometric and spectral resolution ("European Landsat") and/or (a) closely cooperates with U.S. agencies NASA and USGS for the implementation of the Landsat Continuity Mission.

4.2. In-situ Observation Data Sources

4.2.1. Time Period 0-2 Years (End of 2004)

Concerning the European service region, it is not expected that national/regional forest inventories will phase out. In the short term, the quality of biomass expansion factors, carbon conversion factors and soil carbon data is expected to increase through the contribution of coordinated pan-European research projects. Most European countries maintain GIS-based forestry information systems. Forest management plans, maps and data are also available in most European countries. No information is available on whether management plans and regional GIS systems are interoperable and if the information can be easily integrated in country-wide databases.

Expansion of services may suffer time-delays and will go accompanied with significant increases in cost in territories, especially outside Europe, which are not sufficiently covered with in-situ data collection. To anticipate a lack of in-situ data, guidance needs to be developed with specifications of requirements towards needed in-situ data collection and related infrastructure. The incorporation of EO in inventory methodology for such territories may have a positive effect on the overall cost of the inventory operation and vice-versa, the inclusion of extensive in-situ data would increase the accuracy of the EO products.

GIS-based input information for GSE-FM services is most likely less developed outside the European area. E.g. in Western Asia only 46 % and in Africa only 17 % of the region's forests are covered by country-wide GIS-based soil information systems which should also include information on forests. Also detailed management plans may be lacking or not easily accessible through centralised systems. (For more detailed regional and country-wise information on the implementation of GIS-based soil information systems, please refer to Annex A of the GSE-FM document 'Key User Segment Profiles'.) Management plans, preferably integrated with geographical information in GIS, are becoming more and more prerequisites for enabling to keep an overview on sustainable management of territories. The development of such systems has been called for in numerous international forums. Technical and financial aid should be given to those countries that find themselves not in the possibility to establish the needed infrastructure and data collection.

4.2.2. Time Period 2-5 Years (End of 2007)

It is not expected that national/regional forest inventories will phase out, even in the long-term future. In the run-up to the start of the first commitment period of the Kyoto Protocol, still a lot of research will be focusing on improving biomass expansion factors, carbon conversion factors and on the collection of soil carbon data. Data-collection methodologies, definitions and concepts may change throughout time and such changes need be taken into account in the service methodology. Expansion of services may suffer time-delays and will go accompanied with significant increases in cost in territories not sufficiently covered with in-situ data collection.

At preparation of detailed land/forest cover maps prior to a customer agreement has been made for a particular area coverage, problems may arise with ownership of data and protection of private interest. Such situation must be anticipated with good data access agreements between GSE Forest Monitoring and the custodian of the data – likely being the national/regional forest authority or relevant ministry.

Presently on-going processes under the Collaborative Partnership for Forests under the United Nations Forum on Forests and also the Global Forest Information Service under the International Union of Forest Research Organisations may result in increased transparency and accessibility of forestry information. In Europe, the new COST Action E43 on National Forest Inventories in Europe (ENFIN) has as one of its objectives to bring about the convergence of forest inventory definitions and methods. ENFIN will also discuss the issue of accessibility of (geo-referenced forest inventory plot) data, what could lead to improved access to data.

4.2.3. Time Period 5-10 Years (End of 2012)

It is not expected that national/regional forest inventories will phase out, even in the long-term future. It is expected that the monitoring schemes ICP Forests and Forest Focus will continue their in-situ data collection activities upon reviewing the effectiveness of the scheme in order to provide a basis for any decisions on the continuation of these activities after 2006. Data-collection methodologies, definitions and concepts may change throughout time. Expansion of services may suffer time-delays and will go accompanied with significant increases in cost in territories not sufficiently covered with in-situ data collection. Data-collection methodologies, definitions and concepts may change throughout time and such changes need be taken into account in the service methodology.

4.3. Model and Ancillary Data Sources

The following table summarizes the problems identified and necessary improvements of model and ancillary data sources with respect to the data sources needs prospectus.

Tab. 24: Problems and necessary improvements of model and ancillary data sources

Data Source	Problems and necessary improvements
SRTM X DEM	Global coverage between 60 deg. North and 58 deg south. Problems: incomplete coverage, gaps have to be filled with additional digital elevation information. Update not foreseen, but uncritical; Commercially available, costs have to be considered within CBA
MONA Pro	MONA Pro covers 22 countries within Europe; no global coverage; update-rate needed: low – uncritical; Commercially available, costs have to be considered within CBA
DEM public survey agency	Coverage and quality/resolution specific to public survey agency; high amount of work for generating cross-border mosaics based on various DEMs public survey agencies; update-rate needed: low – uncritical; Commercially available, costs have to be considered within CBA
DEM Thuringia	Coverage limited to Thuringia; provided by user; access restricted to precursor service; further access conditions for operational use need to be determined.
DEM Greece	DEM covering Greek territory; access restricted by Hellenic Army; further access conditions for operational service provision need to be determined.
Topo Maps 1:25,000 (used in Saxonia only Germany, Russia)	Topographic Maps 1: 25,000 available in many areas of Europe, at least in printed form; global coverage not assured; differing update-status, e.g. 1960-today; commercial access, in most cases via public survey agencies.
Topo Maps 1:50,000 (Germany, France, Finland, Greece, Russia)	Topographic Maps 1: 50,000 available in all of Europe, at least in printed form; global coverage not assured.
Local Scale Forest Maps - FOGIS	Area limited to Germany, final status not yet completed, mapping still in progress; covering only public forest areas; 10 year update cycle required legally; access conditions for operational use need to be determined.
Forest Cover Maps (Greece),	Area limited to Greece; update-status within 1965-1980; restricted access; access conditions for operational use need to be determined.

Forest stand polygon data Finland & France	'Coverage limited to specific areas in Finland and France; access restricted; access conditions for operational use need to be determined.
Forest Database Russia	Access conditions and use for operational service provision have to be clarified. Work-flow of data access will have to be improved
CORINE	CORINE land cover available in all EU member states (edition: 1991); update (CLC 2000) in progress and partly available; The data-set is only freely available for non-commercial use. Access conditions for operational use need to be determined.
Forest Management Plans (Greece)	Coverage: specific forest areas in Greece; update-status: 1970-today; access restricted; lack of price policy, access conditions for operational use need to be determined.
Administrative Boundaries (NUTS)	NUTS is available for all EU member states and all / most accession countries (SABE database of Eurogeographics); under strict copyright protection, but can be purchased for commercial use (for a rather high cost).
Aerial Ortho-Photos	Coverage of Aerial Remote Sensing data varies in Europe, e.g. availability of ortho-photos in Germany assured, update-rate: 5 years; CIR ortho-photos only partly available; commercially available.

5. Synthesis and Outlook

This "Data Needs and Availability Prospectus" identifies and analyses all EO, in-situ and ancillary data sources that will be needed to deliver products and services from the GSE FM portfolio.

(1) For space-based EO data sources, the analysis with respect to the capacity, availability and reliability revealed the following open issues and problems: long-term continuity of EO satellite missions, timeliness and sufficient EO observation frequency, and redundancy and backup capability of EO missions.

There is a strong need that the long term continuity of EO satellite missions must be ensured. The GSE FM services require a long term perspective of EO data provision to justify the adaptation of the users' infrastructure to using EO services. Therefore, the long term continuity of the main data source for the GSE services, i.e. the EO data, must be guaranteed. GMES is totally depending on the maintenance of EO systems and on their upgrade and/or replacement over time. Because EO missions typically have lifetimes of about 5-7 years, this means that instead of single (one satellite) missions, stable satellite programs with a long term series of satellites are needed. Follow-on missions and upgrading of sensors have to be planned within this long term satellite programs, which shall cover planning periods of at least 10-20 years from now on. Long-term continuity also requires the setting up of institutional and commercial funding mechanisms, which means that the funding for these operational systems has to be shifted from the research and development domain to budget lines in the institutional or commercial funding framework. The Eumetsat constellation, where national meteorological agencies fund the Meteosat program with a series of operational satellites and where Eumetsat is the operating agency for the satellites, is an excellent example how to ensure operational long term continuity of observations.

The lack of timeliness and the insufficient frequency of EO observations is one of the most important drawbacks for EO with optical sensors. Due to cloud coverage, which is especially a problem in northern and central European states (if focussing on Europe), it is necessary to have a more frequent coverage with EO data by increasing the "revisit frequency". This could be done by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration which integrates several satellites into a harmonised system and/or (c) satellites with high spatial resolution and much higher swath width to increase revisit time considerably.

The current problems with Landsat 7 clearly show the need that EO missions need redundancy and backup capabilities. For operational service provision it must be ensured that in case of technical problems with a single satellite or even the loss of satellites this data gap can be compensated without any time delay. This could be realised by either (a) a satellite configuration with several identical satellites on the same orbit or (b) a satellite configuration of identical or similar sensors which integrates several satellites into a harmonised system.

In particular, to compensate the current problems with Landsat 7 as soon as possible it is necessary that Europe either builds own capacities of multi-spectral imagery at a

Landsat compatible geometric and spectral resolution ("European Landsat") and/or closely cooperates with U.S. agencies NASA and USGS for the implementation of the Landsat Continuity Mission.

Finally, there is a strong demand for a European "Integrated Ground Segment". The European data acquisition is not harmonised; for each satellite system different organisations are responsible. Thus, the data acquisition policies are ruled by quite heterogeneous goals. A harmonised data supply is desirable from the viewpoint of the GSE service portfolio. This is also in complete accordance with the Oxygen initiative.

(2) For in-situ data sources, the analysis with respect to the capacity, availability and reliability revealed the following open issues and problems: definitional differences; lack of in-situ data outside Europe; lack of country-wide forest GIS outside Europe; difficult access to forest management plans.

Definitions (and also methodologies) applied by national forest inventories are similar but not the same across Europe. This does not prevent successful implementation of GSE-FM services, but reduces chances for comparability of results. EO products could address multiple definitions to bridge national differences and to increase comparability of country information. Processes are currently on-going that will help to converge definitions or to at least lead to better comparability and understanding.

Country-wide collection of forestry data with systematic sampling is mainly applied in EU15 countries. Country forest information in most Eastern European countries is based on stand inventories for which tree data are usually lacking. The forest inventory data of economically less developed regions outside Europe is for largest part based on expert estimates, general and detailed mapping. A lack of in-situ data obliges to extensive data collection in the field (and also production of standard guidelines, training of field workers, support of infrastructure) at additional cost.

Country-wide GIS-based information systems that cover also forestry are implemented in most European countries. Outside the European region, such systems may be lacking, especially in Africa and Western Asia.

Forest management plans exist for most European forests however as they operate on the smallest management scale, the information may not be easily accessible. Systems may not be interoperable between regions. Private forest owners' plans may not be available from centralised (governmental or non-governmental) organisations. Similar and worse problems may be expected for other regions.

(3) For model and ancillary data sources in Europe there exists a large variety of systems with different levels of details, formats and update rates. Here, for each new country / customer an analysis is required to assess the state-of-the-art and the accessibility of the data. Beyond Europe, in many cases the availability even of topographic maps in larger scales and with acceptable topicality and quality is not

assured. Nevertheless, the lack of spatial topographic and thematic data in an appropriate quality can be compensated by field surveys in combination with EO data (e.g. SPOT for DTM production). However, this will obviously increase the total effort for the service providers and, thus, the cost of the services. At the same time it can contribute to the improvement of the overall business by offering additional services for land cover and topographic mapping.

Even if data sources are available the access to and the terms of use of these data-sets is very fragmented due to the great variety of data providers on local to national/international level. These problems make it difficult to identify, access and use data that is available. In addition, the easy access to data sources, the authentication and authorisation of the user (service provider) is not supported by a harmonized infrastructure approach. At least in Europe, the INSPIRE initiative intending to trigger the creation of an European spatial information infrastructure is seen as a key element to overcome this obstacle. Similar activities on a global level cannot be identified. Thus, as a worst case scenario, the data access issues will have to be clarified on a case by case basis.