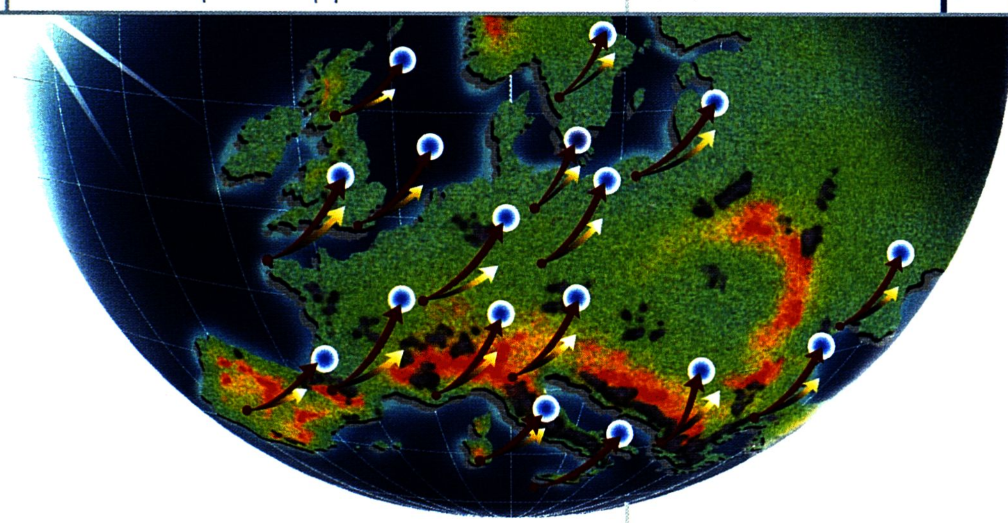
Space Applications Institute

Spatial Reference Systems for Europe

A joint initiative of Megrin and the Space Applications Institute

Workshop



Proceedings & Recommendations

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EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

megrin

2000

EUR 19575 EN

Mission

Space
Applications
Institute

The primary mission of SAI is to develop anc promote the use of space derived data and geo-spatial data from other sources in the service of EU policies, especially those relatin(to agriculture, fisheries, transport and anti-fraud SAI also seeks to make the best use of information from space systems, to maximise the return from European investments in spac and to help the Union reinforce its role in international action on the environment and sustainable development.

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Proceedings & Recommendations

Edited by:
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and Claude Luzet**
*Joint Research Centre
**Megrin

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Editorial

Geographic Information (GI) helps governments and EU institutions make informed decisions in a wide range of areas from environmental protection to spatial and urban planning. As European integration advances, also businesses, public organisations and citizens are taking a more European view of their activities.

Base data is fundamental information regarding the territory such as boundaries, height, rivers and transport infrastructure which is needed by many applications yet is specific to none. It is therefore important to ensure that such data is available and is compatible across Europe. Presently the data exists at national level but it is a complex, tedious and sometimes impossible task to combine this information at the European level. Europe is composed of more than 30 countries (currently 15 of them are part of the European Union). Each Country uses different "types" of national geodetic coordinates, distributed in adjacent or overlapping spatial, and/or temporal, and/or resolution domains. As a consequence it is relatively difficult to build relatively simple seamless data... To overcome these barriers we need both to develop European GI policies (and to converge national GI policies) and to address/solve the technical problems related to the different cultures and traditions in collecting and maintaining GI data at national level.

A common reference system for geographic information is needed as a first step to ensure that data is compatible across Europe.
In its Fifth Framework Programme for Research and Development, the Space Applications Institute (SAI) of the Joint Research Centre (JRC) has defined and is now implementing a project called "GI/GIS: Harmonisation and Interoperability", the objectives of which support the policy, data related, and technical initiatives necessary for the integrated assessment of EU policies. The activities of MEGRIN which represents the interests of the European National Mapping Agencies are complementary to those of SAI. With these considerations in mind, SAI and MEGRIN organised this workshop on Spatial Reference System for Europe, giving a clear indication of the priority attached by both organisations to this topic.

The workshop established that a suitable candidate as European Spatial Reference System already exists: ETRS89 . There is consensus amongst the experts that this is the system to adopt at the European level, and several countries have already done so. It is not realistic to require all existing data in the Member States to be transformed into this new system - not even in the medium term.

However, it could be required for all new data collected and for updates to existing data. In addition there is also a need for Mapping Agencies to make public the transformation algorithms and parameters for converting the data between national systems and ETRS89.

Alessandro Annoni
Joint Research Centre
Space Applications Institute

Content

Editorial ... 2

Content ... 3

The Workshop Summary - *Claude Luzet* ... 4

Executive Summary ... 4
Represented bodies and organisations ... 6
Introduction ... 12
European co-ordinate reference system ... 12
Relationship with National Co-ordinate Reference Systems ... 13
European map projections ... 14
Results dissemination ... 14
Notes: 'co-ordinate reference systems' for the layman ... 14
What is ETRS89 ? ... 16

The EC Requirements related to Spatial Reference Systems
Alessandro Annoni ... 18

The objectives of the GI&GIS project ... 18
Why are harmonisation and interoperability important ? ... 18
On going activities in the EC ... 20
On going EC relevant projects for the ESRS ... 21
Conclusions ... 22

GI2000: towards an European Policy Framework for Geographic Information - *Martin Littlejohn* ... 23

Political role of the Commission for GI ... 23
The Commission as a stimulator of the market ... 24
The Commission as a user of GI ... 24
Conclusion ... 25

The GISCO Database and Spatial Reference System
Torbiörn Carlquist ... 26

Current situation ... 26
Advantages of switching to a common spatial reference system ... 26
Problems with changing the projection ... 26
Statistical grids ... 27

CLC2000 - Emerging Needs for a Standard European Reference System - *Chris Steenmans, Vanda Perdigao* ... 29

Aim of the CLC2000 project ... 29
CLC2000 overall production ... 29
Outputs of CLC2000 ... 31

Civil Aviation Requirements for Data in a Common Reference System - *Paul Dunkley* ... 32

Aeronautical Information Dependencies ... 32
Aviation Safety Requirement ... 33
Geodetic and Charting Issues ... 34
Summary ... 34

Appendix A. Navigation Strategy for ECAC 35
Appendix B. Future Air Navigation Programme 37
Appendix C. Issues to address 38

Spatial Reference Systems: The OGC's Efforts and Concepts of Measurement Based GIS - *Martin Staudinger* 40

OpenGIS and Europe 40
OGC activities 40
Spatial Reference Systems and Interoperability 41
Measurement based GIS 44
Conclusions 45

LaClef - a Geodetic Service Provider - *T. Hancock, C. Luzet, B. Farrell* 46

MEGRIN and Metadata 46
LaClef and Geodesy 47
Proposals for LaClef 49

The European Vertical GPS Reference Network (EUVN) 50

Initial Objectives 50
Project Objectives 50
EUVN Design 51
Connection levellings to UELN95 and Sea Level Observations 53

How to make Optimal Use of the Conventional European Reference System ETRS89 - *Erich Gubler* 55

Old national reference systems 55
The new European Reference System ETRS89 55
The European continent 56
Transforming GIS data 56

Spatial Reference by Coordinates for GIS (concepts and status of relevant standards - ISO & CEN) - *Johannes Ihde* 57

Overview - CEN/TC 287, ISO/TC 211, OGC 57
Concept of ISO/TC 211, WI 11 (ISO 19111) 60
What we shall do for European GIS users 65

The Internet Collection of Map Projections and Reference Systems for Europe - *Stefan A. Voser* 66

Spatial Reference and Coordinate Reference Systems 66
Georeferencing Processes 68
Applications of Coordinate Reference Systems 69
The MapRef Web Pages 69
How to specify a map projection 70
How to specify a geodetic reference system 71
Meta-Information about the MapRef Pages 72
Conclusion and final remarks 72

Executive Summary

The Spatial Reference workshop was organised by MEGRIN following a request from the European Commission. Its objective, to be achieved by discussion amongst leading experts from the field of European geodesy and Geographic Information, was to examine the options and issues related to a European Reference System for spatial data.

By its acceptance and support of the defined system the European Commission would promote widespread use of the de facto standard for future pan-European data products and services.

Summary of Recommendations

The Workshop recommends that the European Commission:

European Geodetic Datum

- Adopts ETRS[1]89 as the geodetic datum for the geo-referenced coordinates of its own data;
- Promotes the wider use of ETRS89 within all member states.

Geographical co-ordinate system

- Normally expresses positions related to ETRS89 datum in ellipsoidal type co-ordinates.

European map projections

- Defines its various needs for map projection(s)/obtains further expert advice to determine the appropriate projections.

European Vertical Datum

- Adopts the results of the EUVN[2]/UELN[3] initiatives when available, as definitions of vertical datum and gravity-related heights;
- Promotes the wider use of the European vertical reference system within all member states.

Results dissemination

- Disseminates widely the results of the meeting and follow-up activities to the GIS industry, standards authorities, and potential users.

The Workshop recommends to the European National Mapping Agencies that:

Relationship with National Co-ordinate Reference Systems

- National transformation parameters and algorithms to and from ETRS89 providing co-ordinates of an accuracy at the 1~2m level should be placed in the public domain. The availability of more accurate transformations should also be indicated (with the achievable accuracy) and the official source of information.

The Workshop further recommends that the Technical Working Group of EUREF[4]:

- Manages the collection of the relevant transformation data, and its publication, in year 2000. Issues a progress report for the November 2000 meeting of the EUROSTAT working group on GIS, with NMA[5]'s and NSI[6]'s.

[1] ITRS: IERS Terrestrial Reference System (IERS; International Earth Rotation Service)
[2] EUVN: EUropean Vertical reference Network
[3] UELN: United European Levelling Network
[4] EUREF: European Reference Frame
[5] NMA: National Mapping Agency
[6] NSI: National Statistical Institute

Day 1: presentations and discussions

Organisation	*Person's Name*	*Topic or Presentation*
Chair	Jean Meyer-Roux	Opening
Host/organiser	Claude Luzet	Format and objectives of the workshop
EC/JRC/SAI	Alessandro Annoni	The EC requirement in terms of Spatial Reference Systems
EC/DGInfo Society	Martin Littlejohn	GI2000 and the political role of the Commission
EC/EUROSTAT	Torbiörn Carlquist	The GISCO perspective
EEA	Chris Steenmans	Status of CLC2000 and other Environmental Projects
EUROCONTROL	Paul Dunkley	Civil Aviation requirements for data in a common reference system
OGC/GIPSIE	Martin Staudinger	Spatial Reference Systems, the OGC's efforts: issues, objectives, status, work-plan
MEGRIN	Bernard Farrell	Spatial Reference Systems and pan-European meta-data services: issues for the LaClef project
EUREF	Claude Boucher	EUREF contributions to the knowledge of Spatial Reference Systems used in Europe, and the relations between them. The International Terrestrial Reference System and WGS84
BKG	Georg Weber	The EUREF GPS permanent station network: description, availability of data and services, future evolution
CERCO WG8	Erich Gübler	Optimal use of the conventional European reference system ETRS
ISO-TC211	Johannes Ihde	Spatial reference by coordinates for GIS (concepts and status of relevant standards - ISO & CEN)
BFL	Stefan Voser	MapRef: the Internet collection of Map Projections and Reference Systems for Europe
OGC/EPSG	Roger Lott	The perspective of the Oil Industry

Day 2: Brain-storming

Drafting of recommendations.

Represented Bodies and Organisations

Leading experts from the field of European geodesy and Geographic Information were invited to the workshop. They well represent standardisation organisations, GIS industry, users of European data, European data providers, ...

SAI, the Space Applications Institute

The Joint Research Centre (JRC) is the European Union's scientific and technical research laboratory and an integral part of the European Commission. The JRC is a Directorate General, providing the scientific advice and technical know-how to support EU policies. Its status as a Commission service guarantees the independence from private or national interests, which is crucial for pursuing its mission.
SAI is one of the eight specialised institutes of JRC. It is the largest European institution working in the domain of space applications. Its mission is to develop and promote the use of space derived data and geo-spatial data from other sources in the service of EU policies. SAI also seeks to make the best use of information from space systems, to maximise the return from European investments in space and to help the Union reinforce its role in international action on the environment and sustainable development.
The 'GI & GIS Project' of SAI, has the mission to facilitate "GI harmonisation and interoperability".

Directorate General Information Society

Previously DGXIII, it focuses on "Telecommunication, Markets, Technology, Innovations and Expolitation of Research".
The objective of the Directorate-General for the Information Society is to implement the Commission's policy with regard to the Information Society. Its main tasks are as follows:

- To assist the College and the Member of the Commission with special responsibility for the Information Society with the formulation of a policy concerning the Information Society in the European Union;
- To implement Community policy with regard to the Information Society in accordance with the guidelines set by the College and instructions given by the Member of the Commission with special responsibility for the Information Society.

DGXIII has been one key partner to the GI community, through its involvement in the GI2000 initiative, and programmes such as INFO2000.

EUROSTAT

The statistical office of the Commission has for mission "to provide the European Union with a high-quality statistical information service. More specifically, this consists of:

- Providing the European institutions with statistical information for devising, managing and assessing common policies;
- Setting up a European statistical system using a common language linking the national statistical systems;
- Supplying the general public with statistical information, including the use of new electronic media;
- Offering technical cooperation with the rest of the world".

GISCO (GIS for the COmmission), is the Office of EUROSTAT responsible for maintaining a core GI database for the Commission, and supports its use within the Commission services.

The European Union (EU) launched the European Environment Agency (EEA) in 1993 with a mandate to orchestrate, crosscheck and put to strategic use information of relevance to the protection and improvement of Europe's environment. Current membership includes all 15 EU states, as well as Iceland, Liechtenstein and Norway.
Mission statement: "The EEA aims to support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy making agents and the public".

EEA, the European Environment Agency

EUROCONTROL, the European Organisation for the Safety of Air Navigation, has 28 Member States. Founded in 1960 for overseeing air traffic control in the upper airspace of Member States, EUROCONTROL today has as its most important goal the development of a coherent and coordinated air traffic control system in Europe. Its primary objectives are to:

- Manage the implementation of the European Air Traffic Management Programme (EATMP), on behalf of States belonging to the European Civil Aviation Conference (ECAC);
- Manage the development and implementation of the ATM 2000+ Strategy which will provide effective ATM in Europe up to the year 2015;
- Operate the Central Flow Management Unit (CFMU) so as to make optimum use of European airspace and to prevent air traffic congestion;
- Iplement short-term and medium-term action to improve the coordination of air traffic control systems throughout Europe;
- Carry out research and development work aimed at increasing air traffic control capacity in Europe.

EUROCONTROL

EUREF (EUropean REference Frame) is the name of a network of geodetic stations as well as the name of the Sub-Commission for Europe (former EUREF and UELN/REUN) of the Commission X of IAG (International Association of Geodesy), created in 1987 as a successor of RETRIG.
The purpose of the IAG Commission X on Global and Regional Geodetic Networks (GRGN) is to focus on the variety of existing control networks (horizontal or vertical, national or continental, global from space techniques) as well as their connections and evolutions.
The Commission X has two types of subdivisions:

1. Subcommissions for large geographical areas: such subcommissions will deal with all types of networks (horizontal, vertical and threedimensional) and all related projects which belong to the geographical area.
2. Working Groups for specific technical topics.

EUREF

CERCO (Comité Européen des Responsables de la Cartographie Officielle) is the group of 37 European National Mapping Agencies (NMAs) represented by their Heads. The mission of CERCO is to help all its members to meet both national and Europe-wide needs for their mapping and geospatial information.
CERCO's principal objective is to ensure that its members have a key role in developing the European geospatial information industry and, thereby, that investments by national governments in their country's mapping are

CERCO WG8

used to the best advantage of the wider European Community. CERCO achieves this through the efforts of its Management Board, Secretariat, Work Groups, MEGRIN, and individual members.
Work Group 8 of CERCO deals with issues related with geodesy.

MEGRIN

MEGRIN was created in 1993 on the initiative of CERCO with the aim of helping the National Mapping Agencies (NMAs) of Europe to meet the increasing demand for cross-border products and services. Since November 1995 MEGRIN has had the legal statute of a GIE (Groupement d'Intérêt Economique, i.e. Economic Grouping of Interest) according to French law. MEGRIN's members, which are also CERCO members, have signed the GIE agreement and pay an annual membership fee to MEGRIN. There are today 20 MEGRIN members and other CERCO members also take part in the life of MEGRIN as observers.
MEGRIN is an acronym of "Multipurpose European Ground Related Information Network", it is a European network of geographical referenced information for use in many diverse applications. MEGRIN's budget is derived primarily from the financial contributions of its members, and from the incomes of its first commercial product SABE (Seamless Administrative Boundaries of Europe). MEGRIN also takes part in several projects partly funded by the European Commission.

OGC: OpenGIS Consortium

OpenGIS is defined as transparent access to heterogeneous geodata and geoprocessing resources in a networked environment. The goal of the OpenGIS Project is to provide a comprehensive suite of open interface specifications that enable developers to write interoperating components that provide these capabilities.
OGC (OpenGIS Consortium) is organized as a tax-exempt "membership corporation" as defined in section 501(c)(6) of the US tax code, whose mission is to promote the development and use of advanced open systems standards and techniques in the area of geoprocessing and related information technologies. OGC is supported by Consortium membership fees and, to a lesser extent, development partnerships and publicly funded cooperative programs.

GIPSIE

The GIPSIE project is funded by the ESPRIT Programme of the European Commission (DG III) to help support the European GIS industry's development of products compliant with OpenGIS specifications. Funding lasts for two years from June 1998 until May 2000.

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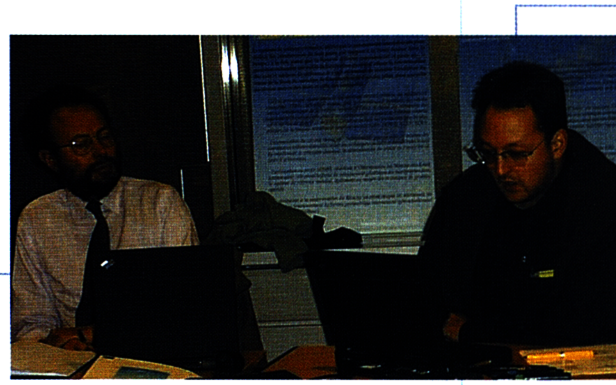

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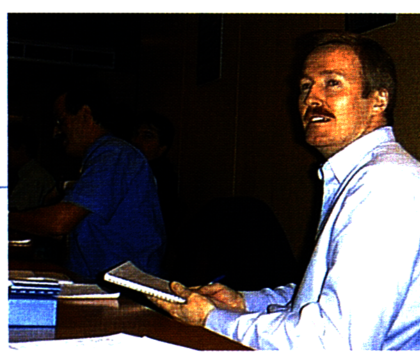

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Introduction

Exact knowledge, understanding, management and subsequent processing of the co-ordinates of any GI dataset is one of the central aspects of cross-border GI interoperability. The Joint Research Centre, on behalf of the European Commission, requested MEGRIN to organise a workshop with a panel of relevant experts, with the objectives:

1. To advise the European Commission on data specification related to spatial referencing systems;
2. To identify and assess, at the European level, the issues involved;
3. To identify the relevant actors for addressing them;
4. To eventually draft an initial action-plan.

Some of the topics that were proposed for further consideration were;

5. A common Spatial Reference System for Europe;
6. A survey/collection of the Spatial Reference Systems used in Europe;
7. Transformations from national co-ordinates to the common system, and reverse;
8. Specification, validation or certification of software embedded transformation modules.

The workshop was very successful due to the participation of a broad range of experts, including institutional cross-border GI users, as well geodesy and standardisation experts. Clear consensus was easily reached on recommendations to the European Commission, and the GI community at large, in regard to the choice and use of geodetic co-ordinates.

The scope of the workshop was restricted by the two following criteria:

- The workshop dealt only with geo-referencing by co-ordinates (direct referencing), and did not address the issues of indirect positioning (e.g. by postcodes, addresses, ...);
- The workshop did not address point 8 (above) related to software specification and certification; however it is expected that software developers will take into consideration the recommendations of the workshop.

European Co-ordinate Reference System

European Geodetic Datum

ETRS[7]89 is recognised by the scientific community as the most appropriate European geodetic datum to be adopted. It is defined to 1cm accuracy, and is consistent with the global ITRS[8]. ETRS89 is now available due to the creation of the EUREF[9] permanent GPS station network and validated EUREF observations. It has been adopted by some European agencies, Civil Aviation, industry, etc. and is already part of the legal framework of some EU member states.

The Workshop recommends that the European Commission:

- **Adopts ETRS89 as the geodetic datum for the geo-referenced co-ordinates of its own data, and includes ETRS89 in the future specifications of the products to be delivered to the EC[10], within projects, contracts, etc;**
- **Promotes the wider use of ETRS89 within all member states, by appropriate means (recommendations, official statement, ..).**

[7] ETRS: European Terrestrial Reference System
[8] ITRS:InternationalTerrestrial Reference System (IERS: International Earth Rotation Service)
[9] EUREF: European Reference Frame
[10] EC:European Commission or Commission for the European Community (CEC)

The following actions are proposed:

Who	*What*	*By*
GISCO	Check implications for the GISCO database, at the 10m level	2nd quarter 2000
COGI	Check with relevant actors the implications for applications at the 1m level, and higher	2nd quarter 2000
COGI	To formulate the recommendation statement, using the EURO CONTROL experience	2nd quarter 2000

Geographical Co-ordinate System

The Workshop recommends to the European Commission that:

- The co-ordinates for expressing positions related to ETRS89 datum will normally be ellipsoidal (geodetic latitude, geodetic longitude, and if appropriate ellipsoidal height).

European Vertical Datur

The IAG[11] sub-commission for Europe (EUREF) is defining a European vertical datum based on the EUVN[12]/UELN[13] initiative. Results will be presented within the year 2000.

The Workshop recommends that the European Commission:

- Adopts the results of the EUVN/UELN initiatives when avail able, as definitions of vertical datum and gravity-related heights;
- Includes the EUVN reference system so defined for the specifications of the products to be delivered to the EC, within projects, contracts, etc.;
- Further promotes the wider use of the European vertical reference system within all member states, by appropriate means (recommendations, official statement,..).

Relationship with National Co-ordin Reference Systems

It is recognised that

- both the ETRS89 and the current national (and local) co-ordinate reference systems for spatial reference and
- both a European vertical datum and the current national height systems for height reference will continue to co-exist for many years to come.

Numerous existing procedures allow transformations of co-ordinates from one system to the other. Some of these transformation programs are freely available, some are embedded in commercial software, yet many are reserved for internal use and not publicly distributed. There is a multitude of user-defined relationships in use. There is an urgent EC business need to implement a single set of officially recognised transformations.

[11] IAG: International Association of Geodesy
[12] EUVN: EUropean Vertical Reference Network
[13] UELN: United European Levelling Network

The Workshop recommends to the NMA[14]s that:

- Transformation parameters and algorithms to and from ETRS89 providing co-ordinates of an accuracy at the 1~2m level should be placed in the public domain;
- The availability of more accurate transformations should also be indicated (with the achievable accuracies) and the official source of information.

The Workshop further recommends that the Technical Working Group of EUREF:

- Manages the collection of the relevant transformation data, and its publication, in year 2000;
- Issues a progress report for the November 2000 meeting of the EUROSTAT working group on GIS, with NMAs and NSI[15]s.

European Map Projections

There are requirements to express the ETRS89 positions converted from ellipsoidal co-ordinates to projected co-ordinates. Different needs will require different types of map projections, capable of being used for both raster and vector data, and at various application scales. It is not therefore possible to adopt a single European map projection for all needs. Issues that have been identified include a Europe-wide projection for statistical data, a Europe-wide projection for raster imagery, and multiple projections for high resolution data.

The Workshop recommends that the European Commission:

- Defines its various needs for map projection(s) (COGI, February 2000);
- Obtains further expert advice to determine the appropriate projections.

Results Dissemination

The Workshop recommends to the European Commission:

- That the results of the meeting and follow-up activities are widely communicated to the GIS industry, standards authorities, and potential users. It is also important to stimulate feedback in order to ensure that EC and other users needs are harmonised.

Notes: 'Co-ordinate Reference Systems' for the Layman

While the summary of the workshop proceedings will hopefully be clear to those working in the field of geodesy some of the concepts and terminology may be complex to those not familiar with the subject. The following notes, while far from comprehensive, are intended to fill some of the gaps and provide some background to help non-specialists to a better understanding of the discussion and results of the workshop.

Co-ordinate Reference System definition:

"Location or position on or near the Earth's surface may be described using co-ordinates. Co-ordinates are unambiguous only when the co-ordinate reference system to which those co-ordinates refer has been fully defined. Each position shall be described by a set of co-ordinates that shall

[14] NMA: National Mapping Agency
[15] NSI: National Statistical Institute

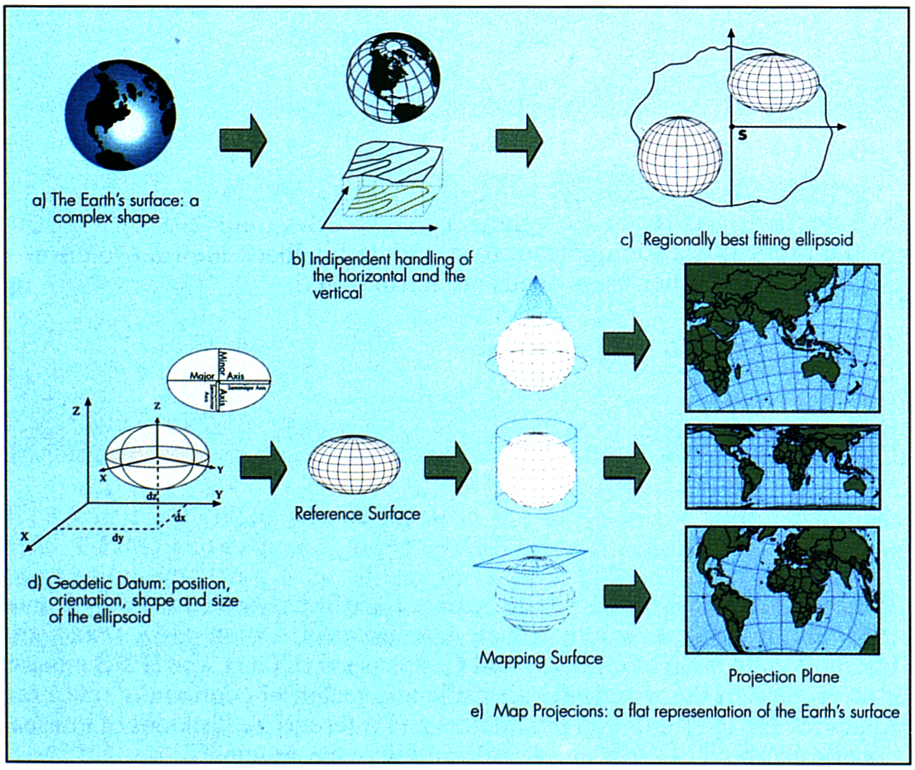
be related to a co-ordinate reference system. A co-ordinate reference system consists of one datum and one co-ordinate system" (ISO 19111).

There exist various co-ordinate reference systems in which a geographic location may be described mathematically by co-ordinates. In each system, the position gets its own co-ordinate values. To understand any set of co-ordinate values, one needs to know without any ambiguity to which 'system' it belongs. We further need to have a complete mathematical description of that 'system'. And finally, particularly if we want to share data belonging to different co-ordinates systems, we need to know the parameters and algorithms that relate that specific 'system' to the others, or preferably to an agreed common co-ordinate reference system.

It is therefore strongly recommended that all co-ordinates must be accompanied by unambiguous identification of the system in which they are expressed.

Defining co-ordinates is a specialist issue that has its own specific terminology. For the layman, there are three main types of co-ordinates:

- *Elevation, or height:* it expresses (or is related to) the 'vertical distance' between a location and a 'horizontal' surface defined as the reference (generally in meters, feet);
- *Geographical co-ordinates:* expresses in terms of longitude and latitude the position of a location on a sphere or an ellipsoid (generally in degrees, minutes, seconds);
- *Cartesian co-ordinates, or map projection:* expresses the position of a location in terms of Easting and Northing on a plane on which the Earth's surface has been projected (generally in kilometres/meters or miles/feet).

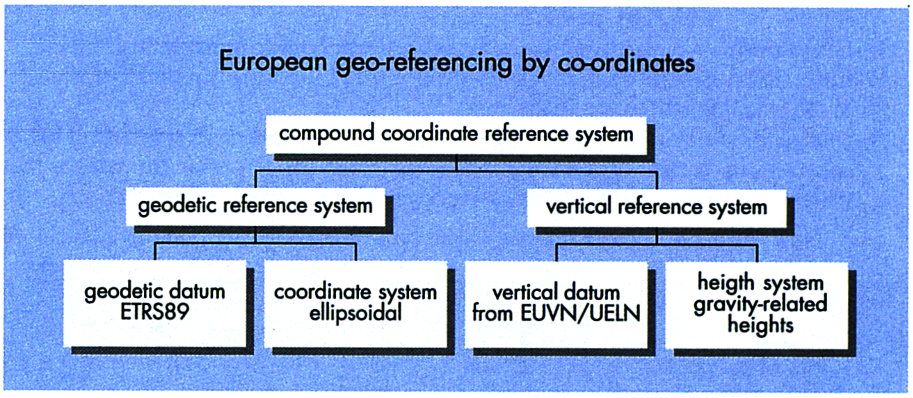


The definition of a geodetic datum will generally include the dimension of an ellipsoid, and its position and orientation relative to 'the Earth'. There is traditionally at least one main datum per country, but often many more. Each country has also its own map projection (Lambert, Mercator, Azimuthal,...) that is basically chosen to minimise the distortions on the national territory.

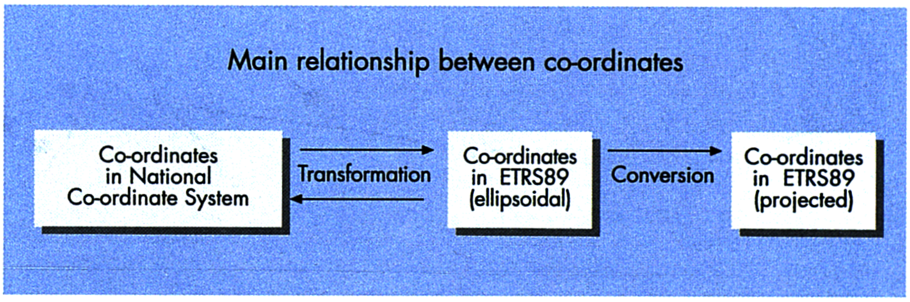
Conversion, within the same datum, from one type of map projection to the other, or to latitude and longitude is a simple matter of applying the pre-defined mathematical formulas, and can be as accurate as one desires. However, transformation from one datum to the other is always an approximation, and is based on empirical formulas and algorithms, deducted from measurements. Typical accuracies vary from 10 centimetres to 100 metres.

Definition of a vertical datum is more delicate, and will not be approached here. Let's say that there is also generally at least one vertical datum per country, and two main families of height. Ellipsoidal height is the third dimension of the location related to an ellipsoid, and is a length. Geoidal height is related to a physical model of the Earth's surface (the geoid), and is a physical component of a location, related to gravity.

This diagram illustrates the components of an unambiguous European geo-reference system.



This diagram indicates the relationship between co-ordinates in a European geo-reference system, a National system, and a European projection.

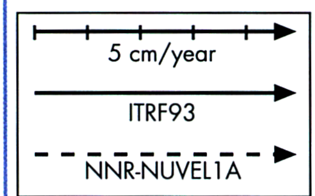


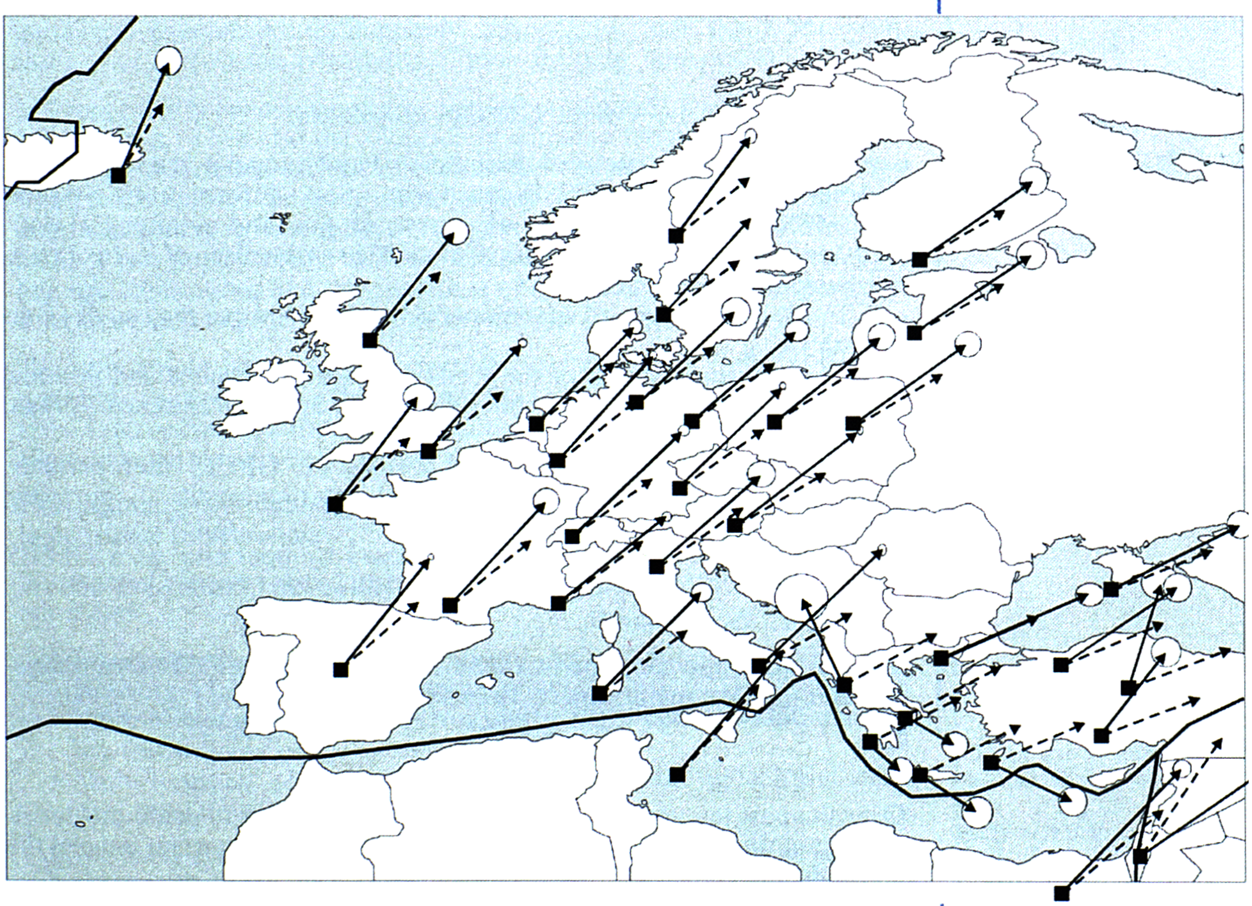
What is ETRS89?

The International Earth Rotation Service (IERS) has been established since 1988 jointly by the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG). The IERS mission is to provide to the worldwide scientific and technical community reference values for Earth orientation parameters and reference realisations of internationally accepted celestial and terrestrial reference systems.

The IERS is in charge to realise, use and promote the International Terrestrial Reference System (ITRS) as defined by the IUGG resolution No 2 adopted in Vienna, 1991. In the geodetic terminology, a reference frame is a set of points with their co-ordinates (in the broad sense) which realise an ideal reference system. The frames produced by IERS as realisations of ITRS are named International Terrestrial Reference Frames (ITRF). Such frames are all (or a part of) the tracking stations and the related monuments which constitute the IERS Network, together with co-ordinates and their time variations.

From the time-series of the IERS results, it has been noted that the European Continental Plate is moving quite uniformly of some 3 cm per year, relatively to the ITRS, at the exception of the south-eastern extreme of Europe (Greece, Turkey). For that reason, in order to have reasonably stable co-ordinates for Europe, the EUREF Sub-commission decided to define a System tied to the European plate. This System (datum) is named





ETRS, or ETRS89, as was identical to the ITRS in the year 1989. Since 1989, ETRS89 co-ordinates, fixed in relation to the European Plate, have regularly shifted from their values expressed in ITRS. However, this shift is well known, monitored by IERS and EUREF, and transformations from one to the other are possible for most part in a 1 cm accuracy.

The EC Requirements related to Spatial Reference Systems

*Alessandro Annoni**

Exact knowledge, understanding, management and subsequent processing of the coordinates of any GI datatset is one of the central aspects of cross-border GI interoperability.

In 1999, the project "GI & GIS: Harmonisation and Interoperability" was conceived as a part of the Joint Research Centre's direct actions in the Fifth Framework Programme. The project supports the actions to create a European Geographic Information Infrastructure (EGII), addressing scientific and technological aspects related to Geographic Information (GI) and Geographic Information Systems (GIS). In particular, the project tries to address, investigate and solve problems related to the collection of GI data coming from different sources and different countries.

This paper shows some problems related to data collection, integration, harmonisation and dissemination, ... that directly affect the EC and describes the EC on-going initiatives contributing or supporting the creation of the European geographic Information Infrastructure, in which the adoption of a common Spatial Reference System has a high priority.

The objectives of the GI&GIS project

The specific objectives of the GI&GIS project are:

- To conceive, create and harmonise Pan-European databases (e.g. NATURA 2000, EUSIS-European Soil Information System, IMAGE2000/CLC2000, ..) relevant to support and monitor EU policies, mainly through the support and co-ordination of networks in various thematic fields;
- To develop integrated spatial models and to improve the use of GI in statistics;
- To assist the creation of the EGII addressing technical and political bottlenecks (e.g. GI data policy, European Spatial Reference System, European cadastres, ..);
- To develop a common European position on GI/GIS interoperability (e.g. Metadata, European Virtual Interoperability Laboratory, OpenGIS, ...) and
- To inform and educate European users by operating as a GI/GIS communications facility (e.g., the new European Commission web site: http://www.ec-gis.org).

The definition and adoption of a common European Spatial Reference system is one of the major aspects to be addressed.

Why are Harmonisation and Interoperability important?

Over the past ten years, the need to develop a strategy to guide the development of the European territory has emerged as an important issue in the policy debate.

As stated in the report on "community policies and spatial planning" in which the European Commission services are seeking to highlight the importance of the territorial dimension in the implementation of Community policies (http://www.inforegio.org/wbdoc/docoffic/official/sdec/sdec4_en.htm):

"it is now required a new unifying conceptual frameworks that make it easier to secure convergence and co-ordination between various sectoral policies. This is where strategic territorial development can play an important role. Territories, though varying greatly throughout Europe, play everywhere

* The opinions expressed in this paper are entirely my own and do not necessarily reflect those of the European Commission

the same roles as (1) the physical base for productive activities, (2) the life support system for people and natural resources, and (3) the place where the impacts of most policies can be seen or felt. The territory, therefore, provides a unique medium for developing a crosscutting, multi-sectoral perspective, for reconciling sometime conflicting objectives, setting mutually compatible targets and ensuring that interventions affecting its organisation, structure and use are coherent. Administrative barriers, sectoral compartmentalisation and territorial fragmentation hamper optimal territorial functionality, optimal allocation of resources and efficient public services".

To overcome such difficulties, it is necessary to develop instruments enabling a reliable analysis of the European territory and its different elements. In particular there is a the need of harmonised and interoperable data, not limited by national boundaries, describing fundamental resources, such as soil type, meteorological information, land cover, demography, protected areas, and so on.

Harmonisation of spatial data mainly concerns the adoption of common guidelines (nomenclature, minimum cartographic unit, geometric precision, ...) or at least the availability of tools for data conversion.

Interoperability concerns not only the use of common standards (metadata, protocols, ..) but also the adoption of common languages, semantic and compliant references such as a common spatial reference system. In fact when two countries are using different vertical reference systems the same point can appear to have different heights in the two systems, making it difficult if not impossible to address trans-national problems (how can we manage applications like the modelling of sea flooding between two countries if the sea level is measured differently?).

To put it simple, harmonisation concerns the "minimum" level of interoperability required to give the opportunity to compare results across countries. Interoperability instead is required to manage trans-national (and more in general trans-boundaries) applications.

European regulations and policies require the creation and management of huge spatial information.

The Spatial aspects related to European policies are investigated at different scales:

- European level (ex. Climate changes, Air pollution, Trans European Network-TEN, Natura2000, Soils,...);
- Multi-National (ex. flooding, transports, water pollution and availability, forest fires,..);
- Multi-Regional or Regional (ex. structural funds, agricultural subsidies, rural development, ..).

Europe is composed of more than 30 countries (currently 15 of them are part of the European Union). Each Country uses different "types" of national geodetic coordinates, distributed in adjacent or overlapping spatial, and/or temporal, and/or resolution domains. As a consequence it is relatively difficult to build relatively simple seamless data as for example: regularly updated Administrative Boundaries (SABE).

The different types of national geodetic coordinates can be sometime described or labelled in different national or regional languages. Interoperability needs an immediate and unambiguous recognition on which "type" a geo-referenced data belongs to (Metadata). Interoperability needs also that any particular "type" of co-ordinates can be transformed/converted to any other type and/or to a set of commonly accepted "global" spatial reference systems (formulas and systems).

On going Activities in the EC

A data policy related to GI is still missing. After the publication of the "Green Paper on Public Sector Information", discussions are on-going to incorporate the topics previously addressed by the draft communication GI2000.

There is a increased awareness in the EC to address the problem related to the lack of reference systems and reference data to better support and define European policies.

A interservice group for Geographic Information (COGI) has been created to co-ordinate the use of geographic information within the Commis-sion services, to improve the efficiency and cost effectiveness of European policy monitoring that require a spatial analysis of the European territory. The mandate is still in discussion and concerns the development of stra-tegies to:

- improve the availability of GI within the Commission services, mainly by proposing joint acquisition of basic GI complying with common specifications and needs;
- improve the level of awareness amongst middle and higher management within the Commission of the power of this technology and how it can contribute to the excellence and increased efficiency of European public service;
- project a coherent image of the Commission's GI activities to the outside world;
- develop a data policy applicable to all Commission services to better share existing in-house GI and facilitate its dissemination to outside users at the lowest possible price thereby stimulating the market for value added services building on this data;
- reduce duplication of effort through better co-ordination between individual activities;
- exchange best practice and experience between departments and thereby contribute to extending and maintaining an in-house expertise and know-how on GI/GIS.

The group will invite participation from the other European institutions and agencies to ensure the widest possible application of its work and will, if necessary, also consult with external organisations in the Member States be they key producers orusers of European GI.

The EEA (European Environment Agency) Management Board decided in July 1999 to establish a Advisory Group on Spatial Analysis to discuss emerging needs from key clients and advise EEA on an appropriate strategy on spatial analysis within its work programme. The proposed action plan on spatial analysis should be considered as a joint common approach shared by the participating institutes of the group, and should be characterised by a pragmatic approach. It should be based on the common needs to support cross-cutting policy areas where the spatial dimension will play a key role in the development, namely:

- the proposed Water Framework directive, which is a multi-purpose instrument interconnected with rural, urban, coastal, mountain and marine areas;

- nature conservation and biodiversity (NATURA2000, Community Biodiversity Strategy, International Conventions, EC Clearing House Mechanism);
- special attention should be given to the forthcoming implementation of the European Spatial Development Perspective action programme.

First examples of the increased collaboration between different Directorates on GI related matter is the joint funding of IMAGE2000/CLC2000 projects and the decision to have a common dissemination approach (the EC-GIS workshop and web site http://www.ec-gis.org).

It should be reminded that it is still difficult to co-ordinate GI aspects embedded in sectoral policies (Agriculture, Transport, Environment, ...).

On going EC relevant Projects for the ESRS

Eurostat-GISCO is in charge to manage the reference data to be used by the various services of the Commission. The GISCO project aims to collect spatial data coming from different activities and to put all them in a common data model and environment. To improve the quality of the data to be collected there is the need to avoid "geometric distortions" introduced by not well defined or not well precise co-ordinate transformations. The GISCO database will great benefit from the adoption of a unique ESRS.

The following EC projects can be used since now to push or to test the adoption of the ESRS.

NATURA 2000 is a European network of areas, proposed under the Birds Directive and the Habitats Directive, where human activity must be compatible with the conservation of sites of natural importance. The NATURA 2000 network comprises two types of areas: i) areas designated directly by the Member States under the Birds Directive; ii) areas proposed by the Member States under the Habitats Directive and then subjected to a Community selection procedure. NATURA 2000 covers large areas of agricultural land. Contrary to a widely held belief in rural areas, the idea behind the NATURA 2000 network is not to set up full nature reserves or freeze all human activity on the proposed sites. This would be both impossible and undesirable since the NATURA 2000 network could eventually cover 12% of the EU territory.

Apart from a few exceptions (intact natural forests and underwater caves), NATURA 2000 sites are managed through productive activity. The development of the Geographic Information System for NATURA 2000 is part of the activities carried out by the JRC under the agreement between DG JRC and the DG Environment. The components of this system will play two key roles - firstly in providing a mechanism for harmonising and validating incoming data from the Member States, each of which has different approaches, and secondly to provide analytical tools to model, monitor, visualise and publish data relating to the NATURA 2000 sites. In order to manage the network the original data (collected in National Projection Systems) should be converted in geographic co-ordinates referred to a ESRS.

During 1999, EEA and ETC/LC discussed with the member countries, DG Environment and other interested Commission services the modalities to update the CORINE land cover database in 2000 and beyond. On that basis, a 3-year project plan, called CLC2000, was drafted by EEA and the ETC/LC describing all steps for a co-ordinated updating of the land cover database, with focus on land cover changes for the reference year 2000.

The power of CLC data has been demonstrated when used with other sources of information (spatial analysis).
The first phase of the CLC2000 project aims to provide a satellite image 'snap shot' of the EU territory and timely information on land cover changes within European coastal zones. The first phase should include the necessary provisions for purchasing satellite images for all member countries for the year 2000 (+/- 1 year). Image2000 can be the temporary used as reference base for Europe until the availability of EU reference data. There is a clear need to identify and use a European Projection System to store IMAGE2000 raster data with a cell size of 25m.

Other different EC needs require different types of map projections, capable of being used for both raster and vector data, and at various application scales. For example the use of a grid for European statistics has been identified as a key problem in the last meeting of the task force NSIs-NMAs (National Statistical Institutes and National Mapping Agencies) leaded by Eurostat-GISCO.

Other projects/activities candidate to follow technical guidelines are:

- Parcel Identification System
- Agricultural Registers
- European Catchments
- European Soils

Conclusions

To improve and to facilitate the use of GI in the EC, strategic technical choices and requirements are needed.
The technical requirements for spatial aspects should include:

- use of advanced technologies;
- better integration of data for fast and better decisions;
- better integration of spatial considerations in EU policies;
- coherence and consistency in technical specifications;
- multi-disciplinarity;
- better sharing, updating and dissemination,...

The adoption of a European Spatial Reference System constitutes a very clear action for a future simplification in data collection and harmonisation. It should be considered as a necessary step:

- to improve the GI multi-disciplinarity enhancing/facilitating data sharing;
- to increase data quality;
- and to guarantee the right execution of trans-boundaries applications.

GI2000: Towards an European Policy Framework for Geographic Information - *Martin Littlejohn**

In relation to geographic information (GI) the Commission acts in three basically ways which all have an impact on GI in Europe. On the one hand the Commission has a political role to "build Europe". Secondly through its various support programmes both inside and outside research the Commission is a stimulator of the market for GI. Thirdly the Commission itself is a major user of pan-European GI. The development of the GI2000 initiative and its follow-up is placed into the context of these three roles.

Political role of the Commission for GI

Commission interest in geographic information (GI) has sprung out of the IMPACT (89-94) and INFO2000 (96-99) programmes to support the European information and multimedia industry respectively. The projects in these programmes faced major difficulties in getting access to the geographic information they needed. This led us to consider how one could organise GI in Europe to improve availability and access.
As Europe becomes more intertwined economically and administratively more an more companies and organisations will be expanding their horizons beyond their own national borders taking a more pan-European view of their activities. Increasingly decisions are being taken on a European basis rather than confined within national borders. As a consequence there going to be a growing need for pan-European GI as decision support, which is one of the most important uses of GI.

Europe has very extensive and comprehensive collections of national GI but it is often difficult to find and access. In addition there is very little seamless homogenised pan-European data available. National data has been collected in accordance with national traditions and culture. The combination of the national data into European data is a highly complex and non-trivial task. GI2000 is about solving these problems. It aims at creating the conditions for a competitive, plentiful, rich and differentiated supply of European GI. The policy must also establish a favourable business environment and improving the functioning of the internal market.

A communication (GI2000) from the Commission to the Council and Parliament was drafted to launch a debate at the political level. The Commission would subsequently develop a detailed action plan on the basis of the reactions of both Member States and Parliament. The GI2000 document has been the subject of numerous consultation meetings over the last years with interested parties both within and outside the Commission. It suggests action under the headings: Leadership & vision, European GI infrastructure, Realising the potential and Global rules. First it proposes to set up a high level working party composed of Commission services and the actors in industry, government and users to develop consensus and to exert the leadership required to drive development forward. EUROGI, the European Umbrella Organisation for GI, their national members, National Mapping Agencies, and research organisations are all strongly in favour of GI2000 although they have different ideas on concrete actions. On the other hand industry support has, unfortunately, not been quite so forthcoming.

Mainly for this reason the previous Commission did not adopt this communication. The new Commission has not yet decided in which context it will deal with it. Rather than sit back and wait I would suggest to progress in the area even without the political legitimacy and visibility such a communication will provide. Luckily this is also possible in the context of a number of other existing or future initiatives.

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One is the Green Paper on Public Sector Information which was published in January 1999. By the deadline for comments on 1 June a total of 180 reactions had been received, hereof 40 from the GI community. Typically, actors suggested the EU to develop an active policy for GI for instance to harmonise pricing policies based on marginal cost and to overcome the fragmented property rights system across Europe. Early next year the Commission intends to issue a follow up communication to the Green Paper summarising the reactions and outlining actions that could be taken at European level. Current ideas include the setting up of a high level working party as a open consensus building forum. Initiatives regarding exploitation of public sector information, metadata or a EU data policy may also be possible.

The Joint Research Centre is running a project called "GI/GIS Harmonisation and Interoperability". As all JRC projects it is designed to support EU policy. It will provide scientific and technological support to policy makers on GI/GIS issues at European level and provide a link to various space activities. In particular it was designed to support the high level working party of GI2000. Moreover it will conceive, create and harmonise a number of pan-European datasets for supporting EU policies. Preparatory GI2000 work can be performed within the scope of this project.

The Commission as a Stimulator of the Market

The second role for the Commission is as a stimulator of the GI market through its various support programmes, such as the Fifth Framework programme and in particular the IST programme. Virtually every key action throughout the research programme has openings for GI related projects (environment, marine science, earth observation, navigation, information for citizens, transport, spatial planning etc). In the Fourth Framework programme we identified over 200 projects where GI played a significant role in terms of money and effort. In total these project received over €200M funding. In the IST programme we are working for a cross programme action for GI to be included in the work-programme possibly in combination with info-mobility actions.

We are also preparing for a follow on programme to the INFO2000 programme from next year on. One of its possible actions is on support to exploitation of public sector information, where GI is explicitly mentioned as an area for support. The current INFO2000 programme has supported 30 GI projects (out of a total of about 140 projects) with about €6 funding.

Both of these programmes contain scope for launching various policy oriented actions such as data policy trials or constructing building blocs for the European Geographic Information Infrastructure.

The Commission as a user of GI

Finally the Commission is itself a major and possibly largest user of pan-European GI. Use of GI began in the mid eighties with the CORINE land cover project for environmental protection purposes but has now expanded to help manage nearly all EU policy areas from regional policy, agriculture, transport to statistics. Here, too, developments are impeded by lack of coherent pan European data. One of the key messages in GI2000 is to encourage the actors to share more data and co-ordinate their activities better. The Commission intends to put this into practice within its own house.

A first step is the setting up of an inter-service group with a mandate to develop an internal co-operation strategy, a common data policy and to jointly purchase the base data needed by the different departments of the Commission services. The first meeting will have taken place just prior to the IST conference.

Conclusion

As shown above there is lots of scope for action at European level in GI even without a dedicated communication. These opportunities have come about, inter alia, because the GI community has been active. I can only recommend that you continue to participate and make proposals for actions at political level as well as on the practical project level.

The GISCO Database and Spatial Reference System

Torbiörn Carlquist

Current Situation

The GISCO database contains a number of coverages from different sources and has been compiled during almost ten years. The software used is ARC/INFO. Most of the coverages are in the scale 1:1,000,000 or smaller. The main exceptions are the SABE data set with commune boundaries from MEGRIN and the CORINE land cover. These are available in the scale 1:100,000 (CORINE LC has been transformed to raster version, though). In the future the main reference data base will consist of coherent data sets in the scale range 1:100,000 to 1:500,000. A data model which shows the relations between themes and layers in the future version has been developed, but the data are lacking so far. Given the accuracy in the data base, it was not so urgent until now to care about the spatial reference system.

The GISCO database is stored in Lambert Azimuthal projection. This projection is only supported on a sphere, not a spheroid. This means that the precision can not be so good. For coverages in a small scale it does not matter, but as the scale increases, problems with precision occurs. The geometric distortion depending on the projection may be as large as 1500 metres. Especially when connecting GISCO datasets with datasets in similar scales from other sources this is apparent.

There is no explicit reference system with the Lambert projection. The projection is centered on 48°N and 9°E and with an earth radius of 6,378,388 metres. No false easting or northing exist. When these parameters are applied in ARC/INFO, numbers occur, but they are not used as a reference system.

Advantages of switching to a Common Spatial Reference System

GISCO provides a reference database to be used by the different services of the Commission for various purposes, including combination with other data sets (national or international). A basic principle for coordinate storage is that the coordinates should be independent from restrictions imposed by projections. The coordinates should be easily convertible in any coordinate system (European or National). The only way to achieve this goal is to store coordinates in Geographic projection and by using a spatial reference system like ETRS89 that can be used to easily transform coordinates between different projections (national or international).

The precision will become better if a projection on a spheroid is used because Lambert Azimuthal is based on a sphere (and has up to 1500 metres errors).

Problems with changing the projection

There might be problems to use existing mapping routines (AMLs) in ARC/INFO after changing the projection. Over the years GISCO has made big investments in a complete system of such mapping routines. These AMLs will have to be adapted to the new storage. Alternatively, a copy of the database or of relevant layers is converted to the current projection, Lambert Azimuthal, and saved as such. Then the AMLs for mapping would be used on this copy.

Grids have to be made anew from original vector data, which first have to be reprojected.

Reprojection for analytic purposes is another issue. Depending on the type of analysis the adequate projection can be selected (area-true for overlaying polygons, distance-true for network-analysis). GISCO has to provide the necessary information on projections and the parameters to apply the projections. This also applies for converting from national projection to European Geographical Grid and vice versa. It could be difficult to project grids on the fly.

Area and perimeter fields will be recalculated and will be of no value anymore. To solve this, add an extra item where area, length calculation from an equal-area projection could be stored. There are no units as meters in Geographical Grid projection. Thus area and length calculations will not be of any value.

Furthermore: spatial analyses as overlays will not work properly. If the area is put in a new attribute item, the values will not be modified according to the overlay. The Geographical Grid is not area-true, so the calculation of the area and length items after an overlay would not be correct anyway.

Before overlaying the data has to be reprojected into an area-true projection. The results, if desired have to be projected in Geographical Grid again. As the data base will be transformed to the proposed new architecture with storage in Oracle spatial and since Arc/INFO 8 will soon replace the current version of Arc/Info, there might be implications for the storage of the data base in a certain projection.

Eurostat aims at adopting ETRS89 for use in the GISCO database. Since there are currently many open questions for the future with regard to implementation of a new data model, medium-resolution pan-European data availability, and storage of geometric data in relational databases a conversion to ETRS will take some time. The GISCO user committee and technical committee will also have to discuss all these issues thoroughly. Availability of data coherent across themes and layers seems to be the most narrow sector; this will probably not be solved before 2-3 years ahead. GISCO will anyway recommend from now on that any development of new geographic data sets should be done on ETRS89.

Statistical Grids

In the Working Group meeting held at Eurostat in Luxembourg 20-21 October 1999, some NSIs (national statistical institutes) expressed needs for a common coordinate reference system to be used when statistical data are presented on regular grids for more than one country. This applies in particular to countries which have georeferenced registers on population, enterprises, and buildings as the base for compilation of statistical data (the Nordic countries, Switzerland, the Netherlands).

An example of cross-border rectifications of statistical data based on grids was made in 1997 by the statistical offices in Finland and Sweden (reported by Tilastokeskus in Research reports 221 "Differences in the Spatial Structure of the Population between Finland and Sweden in 1995"; a poster was also printed). The input data were delivered according to the national coordinate systems in each country.

Since the Finnish grid is based on the International 1909 datum while the Swedish grid is based on the Bessel 1841 ellipsoid, cumbersome recalculations had to be done in order to fit the two data sets where the two country share a land border. Had a European Reference System been put in place, it would have spared this project a lot of efforts.

Another use for grids would be to compile or model statistical data from raster data sets. One example could be to model population densities from CORINE land cover based on assumptions on the relative densities in each land cover class. The results would then be presented according to a pan-European grid with an appropriate resolution.

A third use for grids could be to use them as an intermediate when transforming data between incompatible geographies. For example is it not possible to connect environmental data based on watershed basins directly with socio-economic data based on administrative regions. Both types of data could then be adjusted to a common grid. Following the grid layout, the two types of data could be compared with each other (with some uncertainty).

Eurostat sees a need to define a common European grid which should be made on a pan-European projection and the ETRS89 reference system. The exact procedure for defining the grid has to be discussed further.

CLC2000 - Emerging Needs for a Standard European Reference System - *Chris Steenmans, Vanda Perdigão*

Within the multi-annual workplan 1999-2003 of the European Environment Agency (EEA) there is an emerging need for a standard European reference system for collection of geo-referenced data, GIS data handling as well as map projection. European geo-referenced environmental datasets require storage of vector as well as raster oriented datasets. For the vector data, conversion between national and European reference systems should be available. For the collection and storage of raster data, a standard European grid needs to be considered and it should allow easy overlay of raster based databases (eg. satellite imagery, land cover data, atlas data on species based on a regular grid, etc).

Aim of the CLC2000 Projec

The interest and demand for using land cover as a basic layer for spatial analysis within integrated environmental assessment is strongly increasing in Europe at local, regional and continental level. To respond to these user needs, an update of the European CORINE Land Cover database (called CLC2000) providing European wide consistent information on land changes, has been initiated. Data will be collected from satellite images (called IMAGE2000) which need to be geo-referenced to a common reference system allowing easy conversion between national and European coordinate systems. CLC2000 is a joint project between EEA and the Joint Research Centre (JRC).

Present and future user European needs were examined by EEA before implementation of the project. Following applications will use the European information on land cover changes for integrated assessment to support different European policies such as:

- territorial impact assessment and development of spatial indicators, in support to regional planning (Structural Funds, European Spatial Development Perspective);
- impact of new agricultural policies on the environment;
- strategic environmental assessment of the trans-European transport network;
- ecological assessment of nature sites such as Natura2000;
- study and management of watersheds to support the new Water framework directives;
- new European strategy for integrated coastal zone management;
- spatial impact of enlargement on EU Member States and non-Member States.

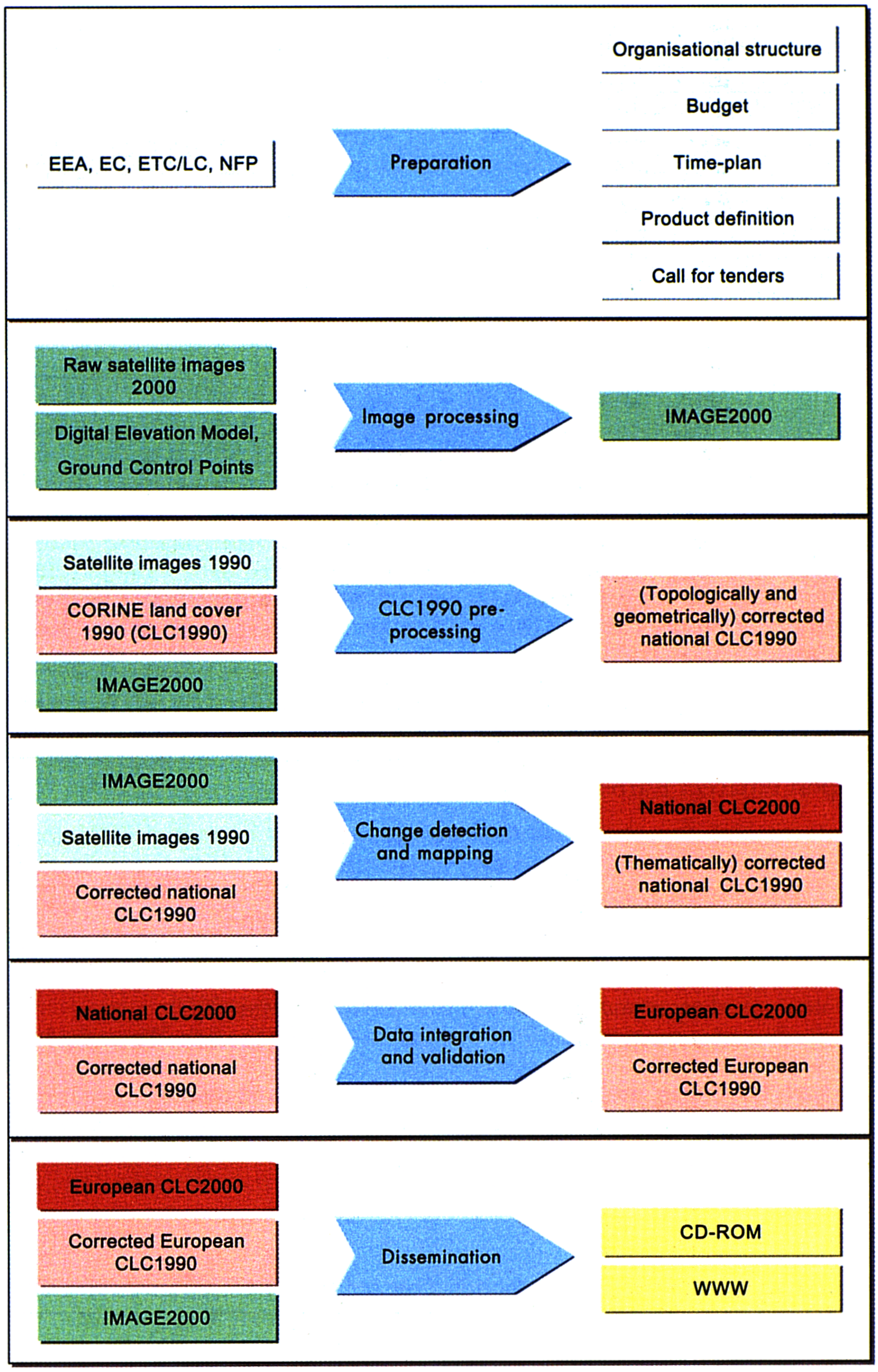
CLC2000 Overall Production

Table 1 shows the overall production flow for the CLC2000 inventory. On the left side are the inputs, whereas the products are on the right side.

The update will be based on an inventory of land cover changes up to 5 ha using the standard European CORINE land cover classes. To obtain coherent and consistent land cover data, specific mapping rules are defined to standardise the land cover mapping procedures. The methodology was developed by the SAI ARIS unit in collaboration with the European Topic Centre on Land Cover and is detailed in the joint publication by JRC and EEA "Technical and Methodological Guide for Updating CORINE Land Cover database", 1997.

CLC2000 - Emerging Needs for a Standard European Reference System

Table 1. Production flow of CLC2000



The satellite images that are the basic input source for updating the land cover database will provide a common reference for national and European needs. Therefore IMAGE2000 consists of a EU wide mosaic of ortho-rectified satellite images dated 2000 with the maximum allowed deviation of one year (1999-2001). Although IMAGE2000 is primarily designed for the CLC2000 production, it can be seen as a multipurpose product that can be used for different topics demanding for spatial information.

Participating countries are extracting the data on land cover changes at national level, to make use as much as possible of local expertise, easy access ancillary data. Integration into a European database on land cover changes as well as validation and dissemination of results is coordinated by a joint EEA/JRC team.

Outputs of CLC2000

The main outputs of CLC2000 are:

- an updated European consistent land cover database for the year 2000, fully compatible with the first CORINE land cover inventory;
- a European database on land cover changes 1990-2000;
- a basic satellite image reference layer for the year 2000 at 25 m ground resolution.

CLC2000 is a European project which will be co-funded by the participating countries, EEA and the European Commission. EEA is investigating together with other EC services the necessary financial resources to include all EEA member countries and Phare countries in this unique project at the turn of the century.

Civil Aviation Requirements for Data in a Common Reference System - *Paul Dunkley*

The growth in air transport seen in the last two decades along with the forecasts, all indicate that air traffic movements in Europe will more than double by 2015 compared with those in 1997. This will maintain a continued pressure to upgrade the capacity of the overall European ATM system, to alleviate congestion on delays.

A Navigation Strategy for the European Civil Aviation Conference (ECAC) Member States has been developed and agreed for the period 2000-2015. This is in line with the International Civil Aviation Organisation (ICAO) Global Air Navigation Plan for Communications-Navigation-Surveillance (CNS) / Air Traffic Management (ATM) systems.
One of the requirements to meet the strategic implementation is the provision of positioning and navigation data at the required performance levels, to support the various applications in the CNS/ATM environment.

This paper looks at the future programme for air navigation along with issues related to geodetic reference systems and geographic co-ordinate data requirements that will need to be addressed.
The first issue involves the availability, consistency and integrity of global terrain and obstacle data, along with the horizontal and vertical reference systems and frames to which they are associated. The second looks at issues of geographic data for GNSS in the Terminal Control Area (TMA), associated with approach, landings and departures along with their relationship to aerodromes, terrain and obstacles data.

Aeronautical Information Dependencies

The role and importance of aeronautical information/data and chart systems has changed significantly with the development of Area Navigation (RNAV) and Required Navigation Performance (RNP) concepts. Aeronautical Information Services (AIS) have become a crucial and critical enabler for the future RNAV implementation in Europe as RNAV performance depends on the quality (accuracy, resolution and integrity) of aeronautical databases. The integrity values defined in the ICAO International Standards and Recommended Practices (SARPS) are required to be raised from the current value of 10^{-3} to 10^{-8} (ICAO Annex 15) to enable the implementation of RNAV in the future environment. The integrity value of 10^{-8} or 10^{-9}, for aeronautical co-ordinate data may be required to support RNP<1 procedures in the terminal area.

For the safe performance of operations, the co-ordinate data has to be published in the common geodetic reference system (WGS-84) as of 1 January 1998 for the horizontal component and 11 November 1998 for selective points of the vertical component. For future developments it is essential that the electronic storage, provision, update and interrogation of aeronautical databases and charts, including terrain and obstacle information, be implemented. Global standardisation of the communication and display of these data are necessary. These improvements will allow on-line, real time, high quality aeronautical information to users.

The loss of frequency protection for Instrument Landing Systems (ILS) and the advent of new technologies have instigated the demand of airspace users to investigate alternatives for instrument approaches and departures. The new technologies also offer advanced TMA operations through the application of curved approaches and continuous descents.

Within the TMA, several different criteria need to be addressed. The horizontal position is related to "WGS 84" co-ordinates. However, the conventional relationship with respect to the aircraft and the aerodrome along with its surrounding terrain and obstacles is currently relative within the TMA. This relationship however is expected to become absolute within the overall CNS/ATM environment, to support future navigation using GNSS.

Aviation Safety Requirement

Terminal (Control) Area - TMA Data

The usage of Global Navigation Satellite Systems requires for the vertical reference frame to be defined at runway thresholds. The initial introduction of Satellite Based Augmentation (EGNOS in Europe) will be on a regional basis and requires a uniform European solution for the provision of height in a common reference frame. Whilst local augmentation system requirements such as GBAS and SBAS are being developed for introduction in the longer term, the initial navigation systems need to be catered for.

GPS geometry provides good horizontal positions but less good height determination. The aviation requirement however is more constrained by the height element. This is not ideal and means that for EGNOS to be used, all error sources have to be minimised. The height of the runway thresholds therefore needs to be known to a higher order of accuracy, at around the decimetre level across Europe. Again consistency and integrity of data are paramount.

Therefore the infrastructure on which the data is based must be defined for long term application. The data associated with this reference frame can be refined, as higher order data becomes available for usage. Traceability of data remains critical to ensure consistent application and confidence in usage.

Terrain and Obstacle Data

The second requirement is for data relative to obstacle and terrain in the Terminal Area (TMA) surrounding aerodromes. This is primarily for the determination and protection of airspace from obstacles and terrain during departure, approach and landing procedures.

Whilst the aviation requirements have yet to be fully determined in terms of data accuracy, precision and resolution, the anticipated accuracy of terrain and obstacle data within the TMA is of the order of 0.5 to 1 meters. For en-route, the accuracy criteria reduces rapidly due to the existence of the requirement for minimum safety altitude, a minimum altitude above ground taking into consideration obstacles and terrain. However data consistency and integrity remain key issues for all data.

The aim is to access geographic data on a global/regional basis, all on a common reference system. Data suppliers must support the data quality requirements. The data accuracy and resolution requirements will vary according to the phase of flight but data consistency and integrity must also be ensured.

As the area of data associated with the TMA is redefined for future navigation applications, the relationship will progress towards one homogeneous surface, managed initially in 2D, then 3D and finally 4D.

Similarly, the future rationalisation of the navigation infrastructure requires the assessment of navigation aid coverage, both from the ground and space based infrastructure. This assessment requires the usage of reliable Digital Terrain Models.

It is therefore anticipated that the usage of terrain and obstacle data will require validation against national data sets to ensure data consistency and accuracy. The issue of timeliness of data must also be managed i.e. ensuring up to date data values.

Civil Aviation Requirements for Data in a Common Reference System

Geodetic and Charting Issues

The implementation of a common horizontal reference frame has been adopted across Europe for navigation facilities. The EUREF network ETRS providing the high quality European solution with Navigation Critical Data having been determined and published for European States.

Terrain and Obstacle data however are still held primarily in the National Mapping System. Whilst transformation parameters may be available to convert this data, this relies upon the availability of the source data in electronic format.
A number of issues need to be evaluated further for the harmonisation of geographic data to take place. These apply to both the horizontal and the vertical reference systems.

With regards to data availability, the following points need to assessed:

- The availability and feasibility of consistent European (Global) digital co-ordinate data sets for Terrain and GIS;
- Co-ordinate system for data;
- Method of interpretation and representation of data models;
- Attribute data related to Terrain (e.g. ground level, height of obstacles including permanent and variables attributes such as trees and snow thickness);
- Transformation parameters between reference systems.;
- Data Quality Management - accuracy, integrity, precision, traceability and timeliness;
- Validation and verification processes;
- Error analysis including error propagation throughout the data process;
- Availability of geoidal models for Europe;
- Data quality risks.

With respect to reference systems and frames, the following points need to be assessed along with their time frames:

- Agreed European and Global Definition of a Unified Vertical Reference System and Frame;
- The European level of adoption of the unified horizontal and vertical reference systems/frames for mapping and terrain data;
- National policy with regards to National Datums and ETRS for National Mapping and GIS data;
- Anticipated migration from the national heighting system (orthometric / normal / normal orthometric heights) to a new reference system;
- Cost benefit considerations.

Summary

The implementation of a common horizontal reference system (WGS84) has been undertaken by civil aviation across Europe for navigation facilities, through the adoption of ETRS89. This has initially been applied to navigation critical data at aerodromes and for navigation aids. The vertical component in a common reference (WGS84) has been recorded through ellipsoidal heights and geoidal undulations at runway thresholds, where future GNSS procedures are anticipated.

There is now a requirement to look at co-ordinate data in a common reference system around the Terminal Area (TMA) of aerodromes, with respect to terrain, obstacles along with Advanced Surface Movement Guidance and Control Systems (A-SMGCS).

The key requirements relate to the need for consistent geographic data, of clearly defined quality (accuracy, precision/resolution, and timeliness) and maintained at a high level of integrity. Any failure provides a safety risk.

In order to assess the feasibility of extending the adoption of a common geodetic reference frame to terrain and obstacle data, there is a need to establish on a Europe wide basis:

1. The extent that the European National Mapping Agencies will adopt ETRS as their National Horizontal Reference System along with intended timeframes;
2. The current and future National co-ordinate systems (Ellipsoid, Datum and Projection) for different mapping data;
3. The availability and constraints on transformation parameters between National Co-ordinate Systems and ETRS or ITRS;
4. An agreed definition of the Unified Vertical Reference System;
5. The extent that it is envisaged that the European National Mapping Agencies will adopt a Unified Vertical Reference System and associated timeframe.

With regards to data:

6. The availability of National, European and Global Digital Mapping, GIS coverages and Terrain/Elevation Data sets along with their associated co-ordinate systems, scales, accuracies and resolutions;
7. The extent that these are linked to ETRS, directly or via National co-ordinate systems;
8. The feasibility of combining / verifying Satellite based Digital Terrain Elevation Data against National Digital Data Sets and the level of harmonisation.

Appendix A. Navigation Strategy for ECAC

The main focus of the Navigation Strategy for the European Civil Aviation Conference (ECAC) Member States looks at cost-effective, customer-orientated evolution of the European Navigation Systems during the period 2000-2015. The evolution of the navigation systems is described in terms of performance, functionality and corresponding infrastructure, taking due account of the principle of global interoperability.
The Strategy supports the operational developments proposed by the ATM 2000+ Strategy and is in line with the implementation of the ICAO Global Air Navigation Plan for CNS/ATM systems.

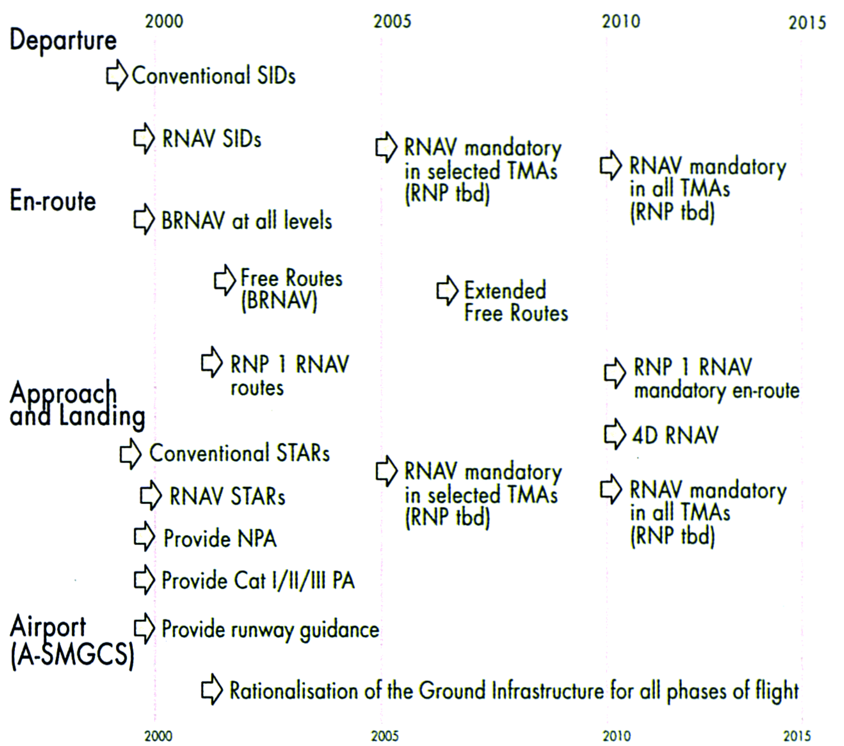
The main strategic streams are:

- Achieving a total Area Navigation (RNAV) environment with defined Required Navigation Performance (RNP) values for all operations ECAC-wide;
- Facilitating the implementation of the 'free routes concept';
- Supporting the continued operations of aircraft with lower capabilities as long as operationally feasible;
- Implementing 4D RNAV operations, to support the transition to a full gate to gate management of flight by 2015;
- Supporting the continued operations of State aircraft, in line with the principles of the overall ATM 2000+ Strategy;
- Providing positioning and navigation data at the required performance levels to support the various applications in the ATM/CNS environment;

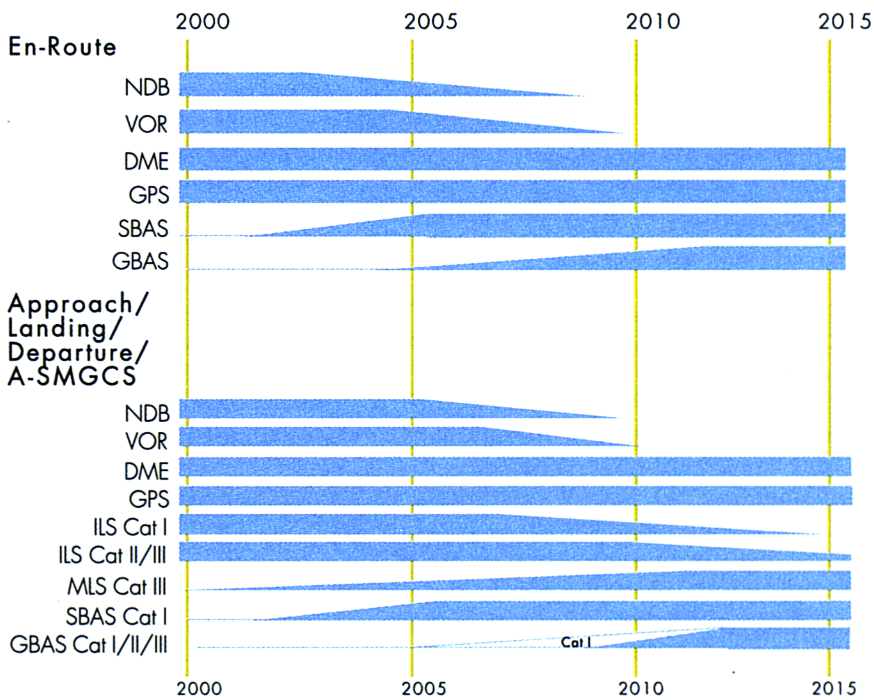
Civil Aviation Requirements for Data in a Common Reference System

- A judicious deployment of the space-based infrastructure and a rationalisation of supporting ground-based infrastructure for all phases of flight, ensuring the transition to GNSS, in line with ICAO recommendations.

Roadmap for Strategic Actions



Rationalisation of the Ground Infrastructure



Appendix B. Future Air Navigation Programme

In order to manage the Navigation Strategy for ECAC, a Navigation Programme is being developed. The navigation application requirements to meet this Navigation Programme can be grouped into four main themes:

1. En-route Improvement
   - Free Routes
   - Precision Area Navigation (PRNAV) and Required Navigation Performance (RNP) 1 RNAV
2. TMA Improvements
   - RNAV and Automated ATM
   - Approach and Landing
3. Surface Movement at airports
4. 4D RNAV (gate to gate).

The Navigation Programme will enable an important element for the future increase in airspace capacity and operational efficiency (with commensurate environmental benefits) through the use of a flexible route structure, and the application of revised Terminal Area (TMA), Standard Instrument Departures (SID), Terminal Standard Instrument Arrival routes (STARs) and Approach Procedures based on the RNAV principles.

This will be achieved through:

- the development and application of RNAV capabilities and associated standards;
- the provision of reduced route spacing based upon the RNAV capability and Air Traffic Control (ATC) environment;
- provision of improved efficiency and/or economy of operation in the TMA by the application of RNAV procedures;
- support to the states for the implementation of RNAV procedures to reduce operating costs, increase airport capacity and reduce environmental impact of aircraft operations.

The provision of Basic Area Navigation (B-RNAV) and Reduced Vertical Separation Minimum (RVSM) are expected to increase en-route airspace capacity by up to 60% in the medium term, therefore the TMA is expected to become the major constraint on capacity and operational efficiency. The Navigation Programme will therefore initially concentrate on the development of RNAV applications that are expected to provide benefits in capacity and efficiency of operation in the Terminal Airspace and Airports.

Previously, the focus was on 2D RNAV. The programme will undertake the work required to validate the benefits to be derived through the application of 3D (providing vertical profile guidance) and ultimately 4D (adding time guidance) RNAV, thereby enabling efficient operations in high density TMAs. This will be extended to surface movement guidance where it can be demonstrated that navigation developments can provide cost effective capacity benefits.

Requirements for new navigation developments need to be provided as far in advance as possible, particularly if modifications to avionics equipment are required. Where there is a need for mandatory equipage then sufficient time must be given for systems to be developed and the fleet equipped, usually a minimum notice of seven years is required. The programme therefore needs to look at a time horizon of at least 9 years ahead and ideally up to 15 years ahead. This will ensure that the short-term developments can be adequately defined whilst at the same time the implications of the longer-term requirements can be evaluated to ensure the successful transition.

Appendix C. Issues to address

Listed below are a number of items that will need to be considered:

1. Requirements relating to integrity, accuracy, resolution, traceability and timeliness of data, from data originators, data integrators, through to system designers to ensure data reaches the users and end-user;
2. Terrain Data Requirements and the various difficulties which are encountered when trying to define the elevation of a point along with the problems of reference which exist for vertical positioning;
3. The types of errors which can affect the accuracy, resolution and timeliness of terrain and obstacle databases
   - National Reference system considerations
     - Horizontal Reference System / Frame
     - Accuracy
     - Vertical Reference System / Frame
     - Accuracy
   - ETRS - Common Reference System considerations
     - Relationship to National Reference System
     - Resolution of multiple horizontal references
     - Resolution of multiple vertical references
     - Geoidal Models
     - Definition of Common vertical Reference frame
   - Terrain Data Requirements
     - Phases of flight
     - GIS coverages.
     - Characterisation of Digital Terrain Elevation Models
     - Representation/Resolution of Characteristics and Methods of Interpolation for Models
     - Terrain attributes
     - Integrity
     - Point Density/ Resolution
     - Level of confidence
     - Update of database issues / timeliness
   - Obstacle data requirements
     - Accuracy
     - Integrity
     - Level of confidence
   - Errors
     - Errors that affect the confidence level of a database
     - Accuracy and Precision
     - Grid spacing and vertical resolution
     - Errors due to the merging of terrain and obstacle data
     - Merging errors

- Validation, Verification and Integrity
  - Quality Management
  - Integrity Management
  - Traceability Requirements
  - Timeliness of Data
- Data Supplier Quality Management.

Spatial Reference Systems: The OGC's Efforts and Concepts of Measurement Based GIS - *Martin Staudinger*

Part one of paper presents the basic ideas of OpenGIS and its role in Europe. Part two runs through the main points of OGC's abstract specification on spatial reference systems, and part three focuses on an alternative conception, namely on the ideas of a measurement based GIS.

OpenGIS and Europe

The OpenGis Consortium

The OpenGIS Consortium (OGC) is a not for profit trade association founded in 1994 to provide the geoprocessing industry with a consensus process for developing interoperability standards and industry relationships that will hasten the commercial success of distributed geoprocessing [1]. As for today (Dec. 1999), OGC has about 190 members worldwide, including, among others, software vendors, system integrators, telecommunication companies, researchers and academic organisations, government agencies, and standards organisations.
OGC envisions the full integration of geospatial data and geoprocessing resources into mainstream computing and the widespread use of interoperable, commercial geoprocessing software throughout the global information infrastructure. OGC's base idea is therefore the development of interoperable geoprocessing technology specifications and to promote distributed geoprocessing to a wide range of user communities.

The GIPSIE project

Among OGC's members, there are about 50 European organisations. When speaking about interoperability, Europe faces special requirements on the one hand, and can offer specialised expertise on the other. As an example, Europe's (natural) languages are not interoperable, and European wide GI applications still have to cross many borders (even if people do not need a passport to do so). Most of the European enterprises are small compared to their U.S. brothers and typically specialised in specific GI niches.
Therefore, the EC established under the Esprit initiative the "GIS Interoperability Project Stimulating the Industry in Europe" (GIPSIE). GIPSIE's duty is both to promote OpenGIS in Europe, and to represent and coordinate European interests within the OGC. GIPSIE, which runs under the coordination of the department of Geoinformation, TU Vienna, wants to create a bridge between the OpenGIS consortium and the European GIS community.

The European special interest group

As one of its output, GIPSIE initiated within OGC a European Special Interest Group (ESIG). ESIG wants to bring together the European GI industry and to establish a communication channel within them. It identifies and organises European interoperability issues and helps to create new business opportunities for its members.

So far, ESIG has prepared a list of nine European topics, which are intended to be brought into the OGC management committee. "Spatial reference systems" is one of them [2].

OGC activities

OGC's relationships to other standards efforts

OGC has a close working relationship with the International Organisation for Standards (ISO) Technical Committee 211 (Geographic information/Geomatics). It has asked ISO/TC 211 to be a voting member of OGC's management committee.
The U.S. Federal Geographic Data Committee (FGDC) has also a voting seat on the OGC Management Committee. The FGDC works to co-ordi-

nate spatial data development and sharing among the U.S.
On the other hand, OGC members are involved in other standard efforts relevant to geoprocessing, among them the GIS standards committee of the American National Standards Institute (ANSI), the Object Management Group (OMG), and other computing standards [1].

Abstract Specification and Implementation Specification

The abstract specification is an OpenGIS document containing a computing technology independent specification for application programming interfaces. It describes an application environment for interoperable geoprocessing and geospatial data products, using object-oriented concepts of the Unified Modelling Language (UML).
The implementation specification on the other hand contains a computing technology dependent specification for application programming interfaces and related technology. It is based on the abstract specification or domain-specific extensions to the abstract specification. As for today, implementation specifications are specified for the Common Object Request Broker (CORBA; Object Management Group OMG), Object Linking and Embedding/Common Object Model (OLE/COM; Microsoft), Distributed Computing Environment (DCE; Open Software Foundation OSF), and Java (Sun).

Status of Spatial Reference Systems Specifications

Within OGC, the co-ordinate transformation work group is involved in the topics "spatial reference systems", "locational geometry structures", and - together with another special interest group - the "image co-ordinate transformation services". The abstract specification about spatial reference systems is now in its fourth version (May 1999).
An request for proposal for co-ordinate transformation services implementation specifications was approved by the technical committee on June 28, with a due date for submissions on November 15. OGC has received one submission and this will be reviewed by the consortium during the forthcoming December meeting. It is scheduled to be voted to approve at the April 2000 meeting.

Spatial Reference Systems and Interoperability

What is "interoperability"?

Sometimes it is easier to start with negative examples. So to begin with, the term database transfer means the moving of entire databases or large portions thereof. Database transfer is typically performed off-line.
Data sharing is a larger term, including for example the use of a common database by different software applications residing on a distributed computer system, or the distribution of the same database to different systems. An example of the latter are map databases on CD-ROMs for in-vehicle navigation systems. Sharing data often means to share not only the data itself but also the internal data structure.

Interoperability (in an OpenGIS point of view) does not mean to transfer data bases, nor to share data in the above sense, or, in particular, to make one's internal data structure available to others. In contrast, interoperability means to share information, which can be achieved by transferring small pieces of data bases, preferable on-line and in real time, and letting the data providers keep their own internal data structure. Interoperability only requires a semantic compatibility on both sides of the link.
"Interoperable geoprocessing" therefore refers to the ability of digital systems to share all kinds of spatial information about the earth and about

objects and phenomena on, above, and below the earth's surface, and to run software capable of manipulating such information [1].

Geoprocessing and Spatial Reference Systems

Geoprocessing needs the location of an object in time and space relative to the surface of the earth. To fix the location of the data - sometimes also referred to as "geopositioning" - is a central aspect of geographic data modelling. Otherwise, entities and phenomena would not be meaningful in a GI context, as geographic data always have the purpose to communicate knowledge about things that have "whereness".
A spatial reference system is then a function which associates those locations in space to geometries of co-ordinate tuples in a mathematical space, usually a co-ordinate vector space. Conversely, a spatial reference system also associates co-ordinate values and geometries to locations in the real world. These two fundamental operations are called "locate" and "survey".
To locate is to find a place on or near the surface of the earth semantically related to a co-ordinate. It is an operation on spatial co-ordinates taking one argument (an instance of co-ordinates) and returning a position.
The second operation is to determine an instance of co-ordinates semantically related to a well-defined place. This operation is called survey. It is an operation on spatial co-ordinates, taking one argument (a position) and returning an instance of co-ordinates.
The above definition of a spatial reference system specifies a co-ordinate vector space as the appropriate mathematical model for locating and surveying. Therefore, the term spatial reference system and co-ordinate reference system are used synonymously in our case.

The Semantics of Spatial Co-ordinates

Spatial co-ordinates are co-ordinates with spatial semantics. To describe spatial semantics, we have to distinguish between three objects: The earth surface object, the mathematical object and the relationship object. The earth surface object describes the "real world" as an aggregation of Euclidian geometric items like points, lines, lengths, surfaces, cones, ellipses, areas, and others.
The mathematical object represents the earth surface object as a set of (mathematical) points. These points are defined on or near a particular ellipsoid and are represented by co-ordinates embedded in a vector space of three or less dimensions.

The relationship object establishes a relationship between the earth surface and the mathematical object. The relationship can be one-to-one or many-to-one, and the relationship object itself is equivalent to the co-ordinate reference system defined above.

Types of Co-ordinate Reference Systems

There is a number of co-ordinate reference system types which can be used. Examples are three-dimensional Cartesian reference systems, either geocentric (origin located at or near the centre of the earth) or topocentric (origin at or near the earth's surface), or ellipsoidal reference systems, where the origin is assumed to be located inside the earth, such that a ellipsoid (with a particular size and shape) approximates the size and shape of the earth or of parts of it in the best way.

Often, we are only interested in the two horizontal position components on this ellipsoid (latitude and longitude) and leave the third component (ellipsoid height) unattended. Never the less, one has to have in mind that for the reference system still three orthogonal co-ordinate axes must be defined.

Another group of reference system types maps the earth's three-dimensional surface on a plane, two-dimensional surface. These plane co-ordinates ("projected co-ordinates") can be derived from the three-dimensional co-ordinates by using a mathematical model that transforms the positions on the earth's surface to positions on the two-dimensional surface and vice versa.
There is a variety of such map projections, and quite a variety of different ellipsoid definitions throughout Europe. Each of them has its own value. Interoperability (as defined above) does not necessarily mean to transform all European-wide data into one specific co-ordinate reference system, but to keep a metadata document with each dataset, including the definition of the reference system and its parameters. There is the need of a "translator", containing all of the information necessary to transform data collections from one system to another, e.g. a description of the projection method, the projection parameters, the projection parameter values in each system, and a set of mathematical operations to establish the transformation.

Metadata of Spatial Reference Systems

Besides the pure mathematical transformation formulae, the translators mentioned above have to include information about the geodetic datum, its validity, information about the expected data quality, and about the units of measure used in the reference system.

Geodetic datum and validity

Each co-ordinate reference system is associated with a local or global datum. Systems with a local datum are useful only in the neighbourhood of its datum. Therefore a domain of validity has to be defined for each reference system.
Every co-ordinate reference system should support an operation that exposes the domain of validity of that system. Only for places within the domain of validity, the relationship between places and co-ordinates can be trusted. Outside the domain of validity, the reference system can not be used.
Places may be located in more than one datum. If the co-ordinates of a place can be represented in two datums, then a mathematical transformation describing the relationship between the co-ordinates on the two datums can be defined. This mathematical transformation is often referred to as a datum transformation, which is to be distinguished from a transformation between two different types of reference systems as previously described.

Data quality

The numerical values of co-ordinates always have limited accuracies. If the accuracies were unknown, the numerical value itself would have little practical value. Besides the fact that the user of the data can interpret and use the data only properly if he knows about their quality, also the accuracy of the transformation between different reference systems will depend, among others, on the accuracy of the co-ordinates (in their respective datums). Therefore, data quality has always to be communicated between the data sender and the recipient.

Units of Measure

Every reference system needs a definition of the units of measure it uses. Length and distances between two entities could, e.g., use the English system (feet) or the metric system (meter). Angles could be measured in a sexagesimal (degrees), a radian, or a grad angle measurement system (gon). The value of accuracy are often given in the appropriate sub-units like millimetres, seconds, or milligon.

Measurement based GIS

Spatial referencing is not tied explicitly to (one-, two- or three-dimensional) co-ordinates but could also be associated with a geographic feature and - based on local measurements - a position definition relative to a fixed point in this geographic feature. As an example, positions on streets are often located by a distance along the street, measured from a junction with another street or any other fixed point (a mile point, e.g.).

Having a closer look to such linear reference systems, one can recognise the following problem: If using mile points, e.g., one measures the distance from the last mile point to the place of interest, and then adds this measured distance to the mileage of the mile point. If it happens that the roadway is realigned, all of the roadway beyond a distinct point will suddenly have different mile points. Two crashes occurring in the real world in exactly the same location but in different years (one before and one after the realignment) are reported, as an example, at point 325.20 km one year and 335.20 km the next year (if the realignment has a length of 10.0 km).
It would be a better approach not to report the accumulated distance but to keep the measured distance in the database and to locate the crash at "200 m from reference post 325" (where 325 is more an ID than a mileage value). When a realignment occurs, the reference posts beyond the realignment remain in their same relative position. Suppose the realignment of our example changes the length of the road before reference post 325. Reference post 325 will then have a different distance from the beginning of the road, but a crash occurring at the same place will still be reported at "200 m from reference post 325".
Whereas this method is quite often used for linear reference systems, it is not common in two- dimensional GI data sets, even if similar problems occur.

Problem: Error analysis

It is a fact that maps and GI databases are constructed from measurements and observations but these data are commonly not retained. Instead, the measurements are used to interpolate between control points of known co-ordinates to get the co-ordinates of the points of interest.
The locations of the points are arranged in a hierarchy: At the top are a small number of locations (control points) that are established with great accuracy by geodetic survey. From these, a much larger number of locations are established by measurements through a process of densification. Since these measurements are usually not as accurate as those used to establish the first order control points, the second locations are also known less accurately. Further measurements using even less accurate instruments are used to register and determine the contents of GI databases.
If the structure of the hierarchy is not known, it is not possible to know how much shared lineage exists between pairs of objects. As there will be a strong correlation in errors between any locations whose lineages share part or all of the tree, it will not be possible to give exact data quality information [3].

Problem: Control Network and Cadastre

GI datasets often have to be linked to a national co-ordinate network. Cadastral information, e.g., is based on the co-ordinates of the boundary points of the parcels, and these co-ordinates are embedded in the national control network. Sometimes it is necessary to re-establish distinct bound-

aries. For lack of the original measurements, this restoring is based on the calculated co-ordinates.
The co-ordinates were prepared in different periods, employing different methods of measurement, calculation and drawing, as well as on different scales. In Austria, e.g., cadastral information sometimes is more than 100 years old. Within that long time period, also the quality of the (hierarchical) base system of control points has changed. As a result, differences are obtained between the co-ordinates of the same boundary points common to two adjacent parcels that were calculated separately according to the measurements from two different control points.

But in a co-ordinate based system, corrections to the positions are impossible, as the geometric conditions defining the shape of the parcel as well as existing relationships between various parcels and boundaries would also change. Even the area of the parcel and the length of its front boundaries would get another value, which surely will not be accepted by the owner of the parcel.
If one keeps the original measurements and stores them in the database, corrections to positions can be appropriately propagated. New information, which is collected often with an improved quality (following the improved quality of new measuring instruments and methods) can easily be integrated. The quality of the whole database can be improved if the quality of the reference system improves. Corrections to positions can be appropriately propagated through the whole database.

Conclusions

Interoperability between two "information communities" does not need two spatial databases embedded in the same reference system, but a "translator" which contains all information necessary to find and translate feature collections from the source to the target system. Therefore, reference systems need to be standardised. Besides common systems like latitude-longitude-systems or plane co-ordinates, the standardisation of reference systems should also include linear and non-coordinative ve reference systems.
For a correct error analysis of GI databases it is necessary to keep also the original measurements and not only the calculated co-ordinates. Within measurements based systems it would also be possible to change the underlying reference system or at least the quality of the reference system.

References

1. OGC, The OpenGIS Guide: Introduction to Interoperable Geoprocessing and the OpenGIS Specification, 1998, Open GIS Consortium: Wayland, Massachusetts.
2. ESIG, European Interoperability Topics - Topic Evaluation Report, 1999, European Special Interest Group (ESIG): Münster, Vienna.
3. Goodchild, M.F. Measurement-Based GIS. in The International Symposium on Spatial Data Quality. 1999. Hong Kong: Department of Land Surveying and Geo-Informatics, The Hong Kong Polytechnic University.

For further information please also look at:

- OpenGIS: http://www.opengis.org
- GIPSIE: http://gipsie.uni-muenster.de
- Author: http://www.geoinfo.tuwien.ac.at

LaClef - a Geodetic Service Provider

T. Hancock, C. Luzet, B. Farrell

MEGRIN and Metadata

Geodesy is an area that, up until now, has not been addressed by MEGRIN. The National Mapping Agencies who MEGRIN represents provide a significant number of members to the two main organisations that deal with European geodetic issues - CERCO WG8 and the EUREF Commission of the International Association of Geodesy (IAG). Hence as MEGRIN begins to consider the provision of new services, Geodesy is one of the areas to carefully consider.

This paper aims to set out the issues relating to geodesy that can be addressed through the development of LaClef and considers the nature of collaboration required with the geodetic bodies.

Geodetic Needs

Europe is a patchwork of more than 30 countries, each using one or more of a number of different national geodetic co-ordinates. These are distributed in adjacent or overlapping spatial, and/or temporal, and/or resolution domains. These systems may also be described in different national or local (province, state) languages. To meet the needs of GPS and other new spatial positioning technologies, most countries have also added modern, global systems (WGS84, ITRS, ETRS89, etc.) to their collections of traditional geodetic systems.

If these systems are to be interoperable, there needs to be an immediate and unambiguous recognition of the systems. In addition, it must be possible for any particular "type" of co-ordinates to be transformed and converted to any other type and/or to a set of commonly accepted "global" spatial reference systems.

From the GDDD to La Clef

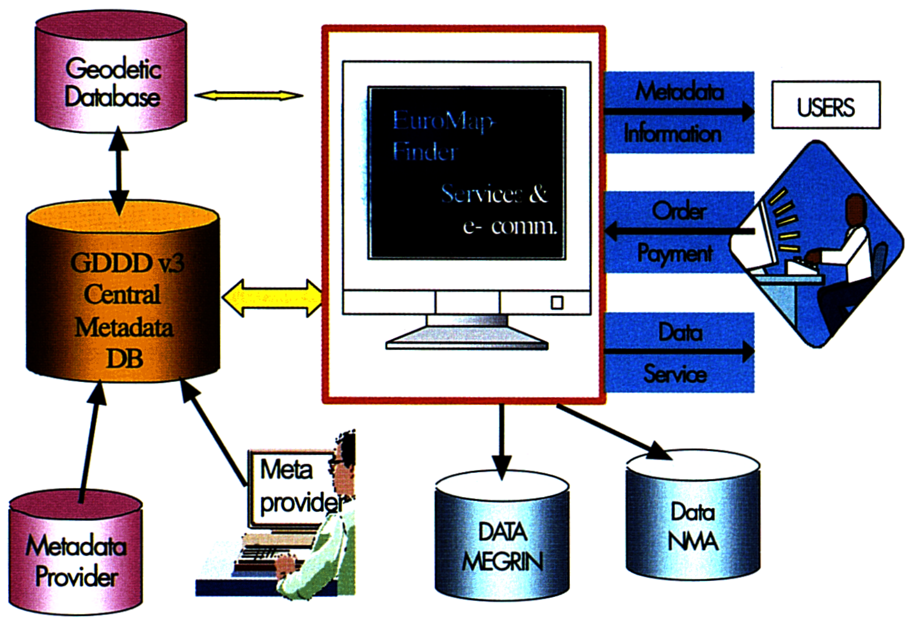
One mission of MEGRIN is of informing and awareness raising.
The GDDD (Geographical Data Description Directory service: http://www.megrin.org/GDDD/Overview.html) is the most visible activity in that domain. The GDDD is a metadata service that provides on the Internet, free of charge, consistent descriptions and commercial contacts for the main digital mapping products of 22 European Mapping Agencies. It was the first implementation of the European standards of CEN/TC287, open to the general public since 1996. Some 3,000 pages of GDDD are consulted every month which prove users' interest for the service provided.

Although an unquestionable success, GDDD had to move with rapidly changing web technology. A follow-up project, named "La Clef" began in January 1999 (http://www.megrin.org/PROJECTS/LACLEF/LaClef.html), co-funded by the EC in the INFO2000 programme, and aims to develop the GDDD in terms of :

- quality and quantity of content, with higher resolution metadata (on the dataset unit or "map-sheet" level), data samples (for viewing or download), and a wider range of products (including aerial photography, paper maps) and possibly related sectors (hydrography, geology, etc.);
- quality of service, essentially with a fully multilingual interface, and geodetic applications;
- commercial application, with the development of an associated e-commerce facility.

This upgrading of the GDDD will have several major impacts on the running of the service.

1. It will obviously offer a much better, more complete service to the users, with more available information, and a facilitated access to the data itself;
2. Consequently, it will serve the interest of the NMAs, by its powerful cross-cultural marketing potential;
3. Finally, it may allow a more concrete measurement of its own usefulness and its possible future direction, with the evaluation of the e-commerce functions and results.



LaClef fundamental architecture

LaClef and Geodesy

Metadata

Up until this point in time, MEGRIN through its GDDD service, has only provided information about different data sets (metadata).

A significant metadata element is the "geographical extent" of a dataset - expressed in terms of bounding co-ordinates. Typically, the source metadata will be expressed in the national co-ordinate system(s). Conversion/ transformation from these to a uniform system will be necessary at some stage in order to allow cross-border search mechanisms.

This conversion/transformation service may be performed in a number of different places:

- by the metadata providers,
- by the metadata authoring tools,
- by automatic maintenance interface, or
- on-the-fly at the time of the user request.

Initial thoughts are that providing this facility will be the responsibility of LaClef as the metadata service provider. In order to perform this task, LaClef will need access to the various parameters for the local co-ordinate systems.

Services

Allied to the conversion of co-ordinates within the metadata is the provision of a general transformation service, Using the same information, such a service would allow for the transformation of a either a single point or a set of points between different systems. Depending on the countries involved and the accuracy requested, this service could be provided free of charge or for a fee.

Requirements

To meet the needs of a transformation service, the following will be needed:

Terminology

There will need to be agreement on the general terms that describe the co-ordinates (datum, projection, etc) and the processes used (transformation, conversion, etc). A multilingual thesaurus with clear definition, based on existing standards (if any) may be necessary. The number of terms should be limited to about 20.

System/datum designation

To allow automatic processing, each co-ordinate system must be uniquely identified. Initially, the national systems should be known only in the national language (an English designation may be also available) and that the designation of the international systems would need to be known only in English.

NB: In some countries (e.g., Greece and some Eastern Europe countries) the use of the national language may cause reading and screen displaying difficulties.

Co-ordinate system parameters

All fixed parameters related to a datum (ellipsoid, dimensions, etc) or to a projection (scale, etc) need to be known.

Transformation parameters

Parameters that allow the transformation or conversion of co-ordinates from one system to another will also be needed. This may involve different types of conversion, (e.g., datum shifts or polynomial transformation) and should be associated with quality criteria (e.g., accuracy and origin).

Algorithms

Algorithms and formulas that describe procedures to transform and convert co-ordinates from one system to another will need to be described. These would be linked to the parameters described in section 0 above and would also include quality criteria.

Control co-ordinate sets

Finally, there is a need for a set(s) of co-ordinates that allow testing of the conversion and transformation procedures.

Confidentiality

The ownership, confidentiality and right of use of the transformation information will need to be carefully addressed. At least two aspects will need to be considered - the strategic military use of such information and the commercial sensitivity of the information.

Issues

Reference and disputes

There is a need for an internationally accepted reference for "geodetic semantics and parameters". The data contained within LaClef could be seen as such as a reference. (Obviously, in this case, there is a need for the information to be validated by appropriate people).

This validated information may bear a "EUREF certification" that would guarantee its quality and "official" acceptance. Risks of possible disputes, mainly on international border definition, must be considered and minimised.

Proposals for LaClef

Geodetic Reference Database

If LaClef is to provide this geodetic information, it will be served from a database for which (initially at least) EUREF would be responsible for creation and maintenance. Tasks to be performed are as follows:

- Definition and specification of the data model and database structure;
- Implementation of the model on a server;
- Collection of the data and population of the database. This task will build on available data and existing network (CERCO/MEGRIN and EUREF). Steps involved include:
  - Recovering questionnaires and data from CERCO WG8
  - Review of the data
    - Preparation of a complementary questionnaire, including the confidentiality aspects
    - Pre-validation of data and populating the database;
- Quality control and validation;
- Definition of the update procedures. Initially the database will need to cover at least
  - Main international systems (EUREF, ED50, WGS84, ...)
  - Main national systems in use
  - Transformation from national systems to international systems

  As second priority, the following items will be covered
  - Reverse transformations
  - Transformations/conversions between national systems
  - More national or local systems in use, and associated transformations

  And as a third priority we may further include
  - Historical systems and associated transformations.

Geodetic Transformation Tools

This will deal with the mechanics of providing the tools with which to perform transformations.

Conversion/transformation modules

Individual modules or components will be created that would convert from "System A" co-ordinates to "System B" co-ordinates. An initial analysis will be necessary to define which modules need to be created and what are their application domains and accuracy requirements.

Conversion/transformation procedures

A typical practical transformation will generally need a combination of components. The architecture of the combinations will be defined. Each procedure will be validated by using:

- Alternative or return path of transformation, and
- Result checking on selected sets of control co-ordinates.

Web interface

Finally, the tools described above will be integrated and provided to users through a web interface. This would involve:

- Metadata conversion for updating of the central GDDD database;
- Conversion for screen displays;
- Development of on-line co-ordinate and geodetic services.

The European Vertical GPS Reference Network (EUVN)

The following are abstracts from articles by J. Ihde, J. Adam, W. Gurtner, B.G. Harsson , W. Schlueter, G. Woeppelmann. The main resource has been published by BKG[18] in the 1999 Report of the June 1998 EUREF Symposium

The European Vertical GPS Reference Network (EUVN) is designed to contribute to the unification of different height systems in Europe. The most important practical and scientific aspects are:

- contribution to a unique European height datum;
- connection of European tide gauge benchmarks as contribution to monitoring absolute sea level variations;
- establishing of fiducial points for the European geoid determination;
- preparation of a European Vertical Kinematic Network.

The EUVN includes 195 points all over Europe, 79 EUREF points, 53 nodal points of the Levelling Networks of Eastern and Western Europe and 63 tide gauges. At every EUVN point three-dimensional co-ordinates in ETRS89 and levelling heights primary in the system of the United European Levelling Network (UELN) have to be derived. In the period of May 21 to 29, 1997, GPS observations at all EUVN stations were carried out simultaneously.

Initial Objectives

1. to provide an integrated vertical reference frame for EUREF/ETRS height values at few centimetres level;
2. to connect different European height datums;
3. to provide fiducial points for the European geoid determination and for future accurate regional geoid computations;
4. to contribute to the realization of an European vertical datum and to connect different sea levels of European oceans in view of work of PSMSL (Permanent Service Mean Sea Level), also in view of anticipated accelerated sea level rise due to global warning;
5. to provide contribution to the determination of absolute world height system;
6. to establish a fundamental network for a further geokinematic height reference system such as UELN 2000 under the special consideration of the Fennoscandian uplift and the uplift in the Carpathian-Balkan region;
7. to provide data for decoupling the land and sea level components of relative sea level variations, as measured by tide gauges;
8. to provide the basis of expressing the results of the regional European tide gauge GPS surveys in the EUREF reference system (ETRS89).

Project Objectives

The initial practical objective of the EUVN project is to unify different European height datums within few centimetres. In addition to the United European Levelling Network (UELN 73) for West and North Europe and the United Precise Levelling Network 1982 (UPLN 82) for Central and Eastern European countries national height systems exist with different kinds of heights and different zero levels. The zero level for the UELN is the tide gauge Amsterdam and for the UPLN it is the tide gauge Kronstadt.

The level difference is about h@amsterdam - h@krostadt = 0,15m.

[18] Bundesamt für Kartographie und Geodäsie

The application of the GPS technique for practical levelling would dramatically ex- tend if the geoid would be known precisely enough in relation to the concerned GPS reference system and the levelling reference system. To derive such a geoid, a European reference geoid is required in the reference system ETRS89 and the reference system of UELN. Up to now there is no precise geoid available for Europe with an accuracy of a few centimetres which fulfils the requirement for the practical applications. This proposal points out a possibility to derive a geoid tailored for the GPS-levelling methods by combining the existing reference network EUREF/ETRS89 with the UELN95.

Independent of a uniform height level for the maritime countries the knowledge of the sea level and, under special conditions, of the variations of the adjacent oceans is vitally important. Tide gauges provide access to a local information which generally results from a combination of sea level changes and vertical movements of the earth crust at the tide gauge site. Therefore, global sea level studies based on tide gauge data require to monitor the vertical crustal velocities at the tide gauge sites with respect to a geocentric reference frame, in order to recover a global geocentric assessment of the sea level variations. In this scope the use of GPS has been recommended by an international group of experts at two occasions (Carter et al., 1989 and Carter, 1994).

The EUVN project contributes to the realization of a European vertical datum and to connect different sea levels of European oceans with respect to the work PSMSL (Permanent Service Mean Sea Level) and of anticipated accelerated sea level rise ïdue to global warning. The project provides a contribution to the determination of an absolute world height system as shown by Balasubramania, 1994.

EUVN is a step to establish a fundamental network for a further geokinematic height reference system such as UELN 2000 under the special consideration of the Fennoscandian uplift and the uplift in the Carpathian-Balkan region (Augath, 1996).

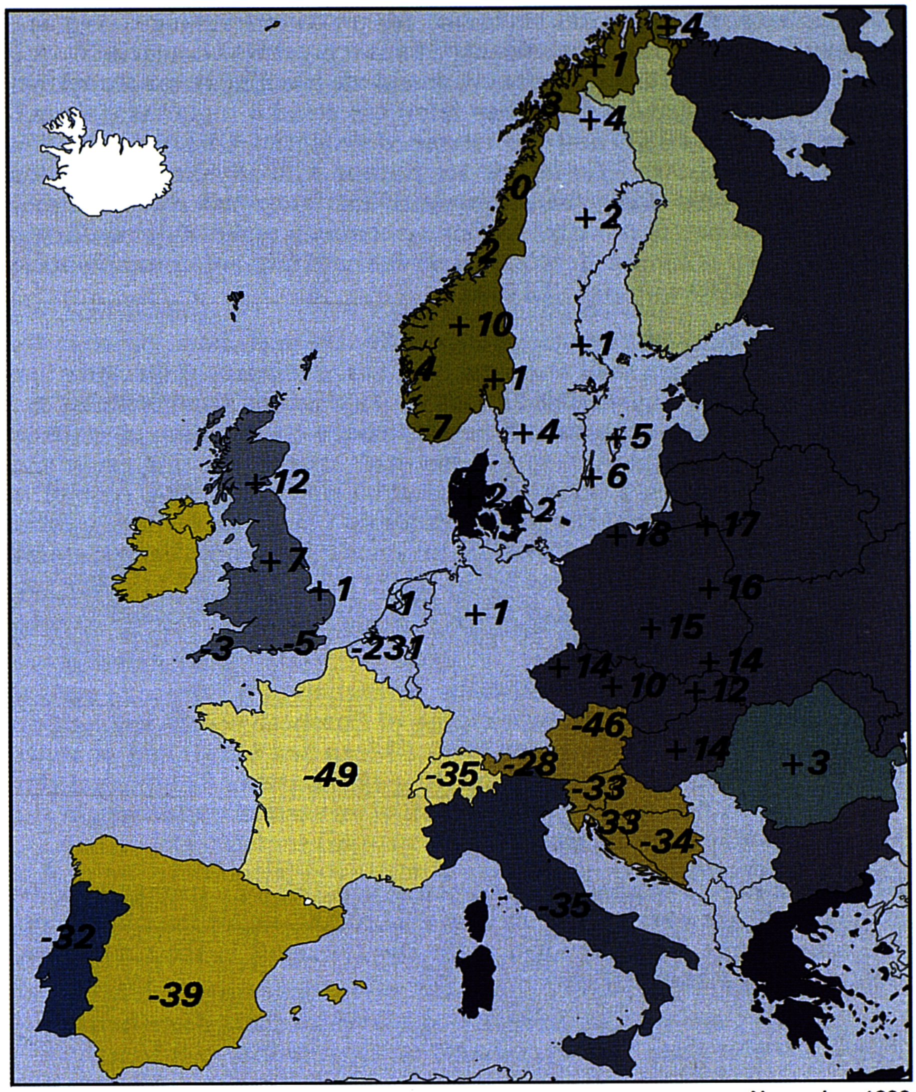
EUVN Design

EUVN connects several kinds of heights and will incorporate the vertical references of the European Reference Systems EUREF, UELN, national height networks and tide gauge sites as well as the European Geoid. The EUVN is designed under consideration of the already existing parts of EUREF and UELN as well as of the planned network of European permanent GPS stations.

EUREF is the realization of the ETRS89 frame for precise applications of GPS techniques in Europe for positioning with an accuracy about 1 em. The height components refer to the reference ellipsoid GRS80.
The UELN provides gravity-related heights with respect to the tide gauge of Amsterdam.
In the Central and Eastern European countries there exists already a United Precise Levelling Network (UPLN) consisting of first order levelling lines through Bulgaria, East Germany, Czech Republic, Slovakia, Poland, Romania, Russia, Georgia, Estonia, Latvia, Lithuania, Belorussia, Hungary, Ukraine and Moldavia. The UPLN was observed in the 50ies and re-measured in the 70ies. The readjustment was completed in 1982. It comprises more than 350 nodal points.

Differences between UELN heights and national heights in Europe (in cm)

bkg



November 1999

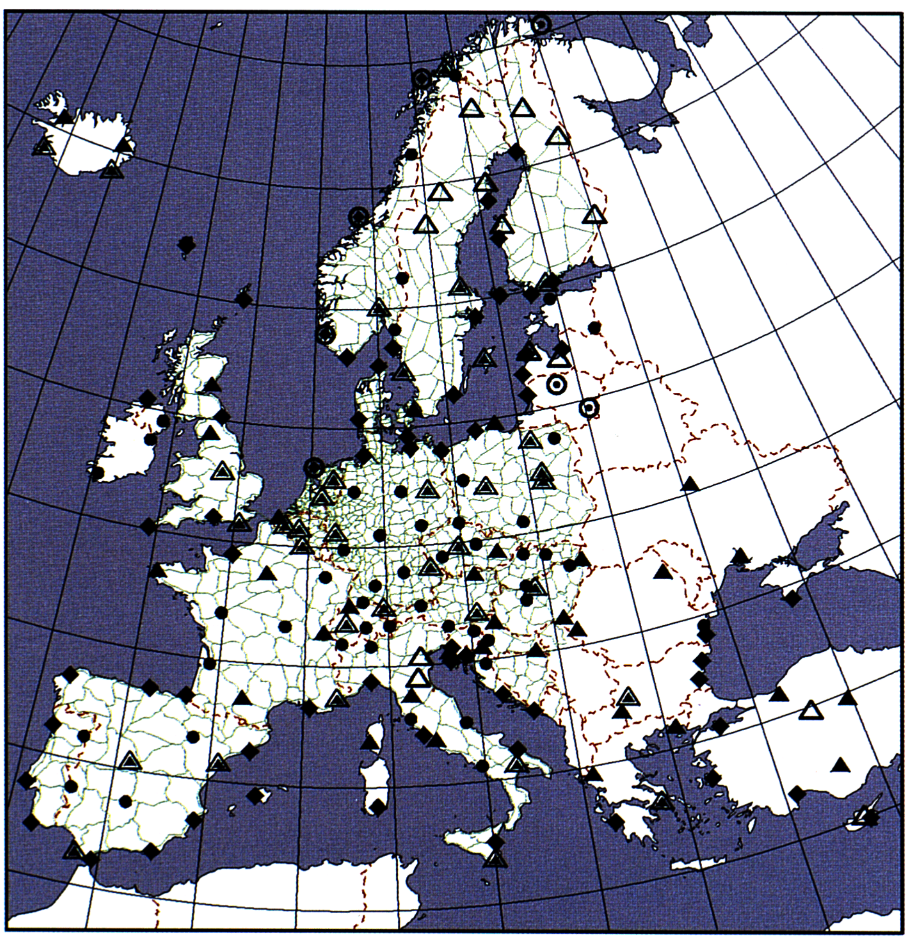
Tide gauge sites are essential to estimate a possible secular sea level rise. The tide gauge sites will provide all the information for the combination of ellipsoidal heights and physical heights along coast lines. These results will be of great importance for the proposed campaign covering whole Europe.

In total the EUVN consists of about 196 sites: 66 EUREF and 13 national permanent sites, 54 UELN and UPLN stations and 63 tide gauges (as illustrated in the following figure). The northernmost EUVN station is situated at Ny Alesund (78.9°, 12.0°) on Spitzbergen, the southernmost point is the tide gauge Larnaka (34.9°, 33.6°) on Cyprus. The westernmost point Reykjavik (64.15°, -22.0°) is situated in the North Atlantic, the easternmost point Yozgat (39.8°, 34.8°) in Turkey.

Connection levellings to UELN95 and Sea Level Observations

In order to fulfil future requests it is necessary to connect the EUVN stations by levellings with nodal points of relevant levelling networks. So it is possible to use levelling observations to update the gravity related EUVN heights in contest with new adjustment of UELN.
For all countries which are members of the UELN project it should be clear to connect the EUVN stations to the nearest UELN nodal points. All other countries should connect the EUVN stations to such levelling points which will be in future stations of their national UELN part.
With respect to the objectives of EUVN, each EUVN marker has to be connected at least to one nodal point of one of the three height references system:

1. The United European Levelling Network (UELN) 1995 for all countries which have access to the UELN (for about 80% of the EUVN points);
2. The United Precise Levelling Network (UPLN) 1982 for all countries which have access to the UPLN (for about 10% of the EUVN points);
3. National height systems for all countries or parts of countries which have not access to UELN or UPLN or which are not connected with the European continent.



January 08, 1999

European Vertical Reference Network (EUVN)

bkg

- ▲ EUREF sites
- GPS permanent stations - EUREF
- △ GPS permanent stations
- ● UELN & UPLN nodal points
- ◎ GPS permanent stations - nodal points
- ◆ Tide gauge sites
- GPS permanent stations - tide gauge
- UELN lines

The connections between the EUVN marker and the nodal points or the tide gauge bench mark should be given in geopotential number differences.

The levelling accuracy should be equal to the requirements of a first order levelling.

As the EUVN is a static height network it is necessary to know the value of the mean sea level in relation to the tide gauge benchmark at the epoch of EUVN GPS campaign 1997.5. However for future tasks it is useful to have available the monthly mean values over a period of some years. The Permanent Service for Mean Sea Level (PSMSL), as member of the Federation of the Astronomical and Geophysical Data Analysis Service (FAGS), is in principle in charge of the data collection. Independently from EUVN the PSMSL collects tide gauge data from about 1700 world- wide stations. The information which is sent to the PSMSL databank in general should also be made available for the EUVN project. Needed are the following data: tide gauge (TG) station name, tide gauge authority, contact name (if any), type of tide gauge, date of tide gauge observations, Tide Gauge Bench Mark (TGBM), height of TGBM above the datum, date of spirit levelling observations, latest data year sent to PSMSL.

EUVN tide gauge stations which are not processed by the PSMSL the responsible national surveying agencies in kindly asked to organize the data collection.

How to make Optimal Use of the Conventional European Reference System ETRS89[19] - *Erich Gubler*

To be useful in practice, a mising reference system should fulfil specific requirements:

- it should be metric and orthogonal, therefore it must be combined with a map projection;
- surveyors don't like changes, therefore it must be as invariable as possible;
- it must be reliable, i.e. all gross errors must be eliminated;
- it should be as accurate as possible, and the distortions should be negligible.

And for international projects or for the EU:

- it should be suitable for the whole of Europe, therefore one single map projection will no longer be sufficient. For small-scale maps, one standardised (equal-area) projection will do. For medium and large-scale maps, one or several projections with either sectors or zones are inevitable for keeping the distortions reasonably small.

Old National Reference Systems

The old national reference systems do not fulfil these requirements for the following reasons:

- their datum is locally defined;
- each country has its own map projection;
- the scale may be incorrect by several parts per million;
- they may be rotated by several arc seconds;
- and the worst: they show local distortions due to the limited accuracy of the old trigonometric networks.

However, they will probably still be used for quite a long time.

The New European Reference System ETRS89

In this situation the new European Reference System ETRS89, established since 1989 by the IAG Subcommission for Europe (EUREF), is the only system which fulfils all the requirements. Most European countries are well connected to ETRS89, either by:

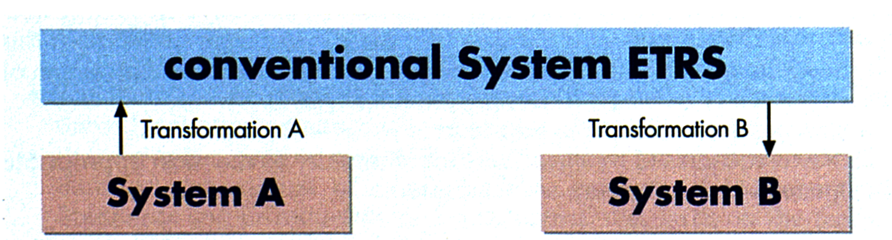
- one or more campaigns;
- permanent GPS stations included in the EUREF permanent network.

Most of the National Mapping Agencies have determined transformation formulae between their national systems and ETRS89.

Using ETRS89 as the conventional reference system for Europe, it is easy to transform:

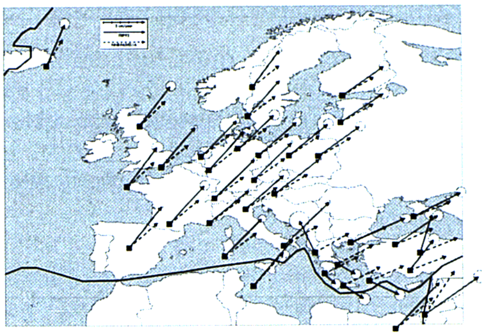
- from a national system A to ETRS89
- and then, if necessary, to another national system B.

Both transformations take into account the different map projections used by the countries.



[19] ETRS: European Terrestrial Reference System

The European Continent

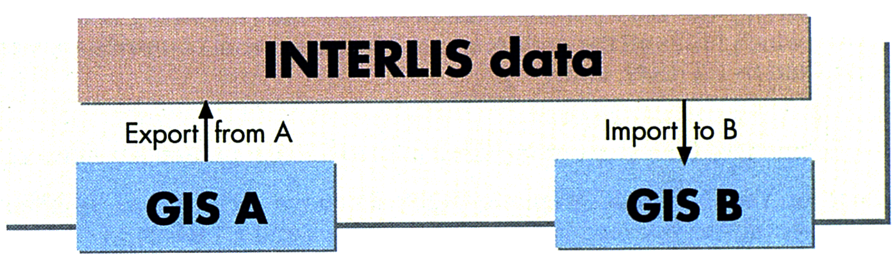


Most parts of Europe are moving north-east with respect to the global reference system ITRS. This means that using ITRS as conventional European system, the co-ordinates would change each year by 2 cm in the east and north components or 20 cm in 10 years! This would no longer fulfil the requirements of a reference system for practical purposes.

Therefore, the EUREF Subcommission has defined ETRS89 to be tied to the European continent and to move with it towards the north-east. The big advantage of this definition: the co-ordinate changes are at least one order of magnitude smaller than in ITRS. The accuracy of the frames has reached 1 cm in most parts of Europe (1 sigma). The datum is defined by forcing the totally free co-ordinate solution to have no translation and no rotation with respect to the ITRF96 at a given time. The fiducial sites are Brussels, Graz, Kootwijk, Matera, Onsala, Wettzell and Zimmerwald.

If necessary, the countries could go even one step further: they may define a national system which coincides with ETRS89 at a certain epoch, but allows an individual motion if this should appear to be necessary. The existing national system should be carefully tied to this new national reference system, and transformation formulae have to be determined, e.g. using a finite element approach, which would eliminate the major part of the distortions of the old system. Using this approach, it is possible to transform data determined in the old system with decimetre accuracy into any other system.

Transforming GIS Data



One of the major problems with transforming GIS data is that the different GIS treat co-ordinates in different ways. In order to overcome these difficulties, a standard like the Swiss INTERLIS should be used, which should be a data-modelling language and an exchange format at the same time. The new version INTERLIS 2 is able to describe reference systems in a way which makes it possible to transform GIS data.
Using a standard like INTERLIS version 2, it is even possible to export data from one GI system A into an independent exchange format. If necessary, transformations into another reference system can be made in this GI-independent format. Then the data can be imported into a GI system of the same type A or into a different system of type B.
Considering these facts, I suggest that:
ETRS89 is recognised by the scientific community as the most appropriate European reference system to be adopted.

Spatial reference by coordinates for GIS (concepts and status of relevant standards - ISO & CEN) - *Johannes Ihde*

The ISO/TC 211 Geographic Information/Geomatics works in the field of standardization of digital geographic information. This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. This work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

Overview CEN/TC 287, ISO/TC 211, OGC

This paragraph provides an overview of the standardization's activities in the field of digital geographic information. This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.

These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. This work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

CEN/TC 287 Geographic Information

CEN/TC 287 started in 1993 with 5 working groups.The work was finalised in 1999. Results: 8 ENVs and 4 reports:

- Overview (R)
- Definition (R)
- Query and update (R)
- Rules for application schema (ENV)
- Position (ENV)
- Geographic identifiers (ENV)
- Transfer (ENV)
- Metadata (ENV)
- Quality (ENV)
- Spatial schema (ENV)
- Reference model (ENV)
- Conceptional schema language (R).

Last plenary of CEN/TC 287, Vienna, Nov. 1998

Resolution 8 - Future of CEN/TC 287

Considering:

- that CEN/TC 287 work programme has been finalised successfully with the publication of 8 ENVs and 4 reports;
- that there is a need to let the implementation phase of these GI standards be conducted nationally with a maximum chance of success;
- that there is a need to review the requirements for European GI standards in the context of existing ENVs, emerging GI International Standards and introduction of GI industrial standards on the market, and taking into consideration the requirements of users at large;

- that there is a need to have a forum where issues of common concern can be discussed, (such a national implementation, dissemination and use of European standards, discovery of problems in existing ENVs and CEN reports, identification of European requirements, or harmonisation of the European view point on International Standards).

CEN/TC 287 decides to continue its activity with the following objectives:

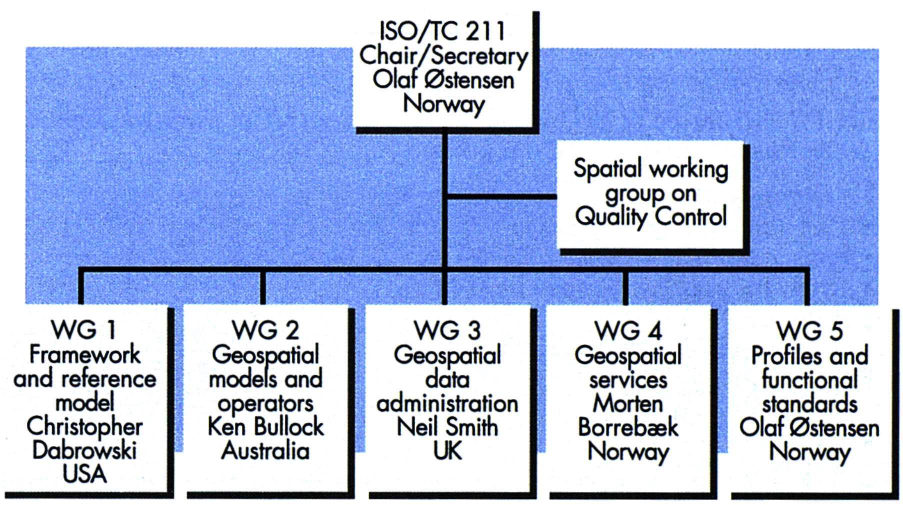
- to provide a technical body for reaching consensus on revision of ENVs and reports, and adoption of IS when becoming available;
- to review requirements for European standards leading possibly and eventually to the definition of a new work programme;
- to provide a forum for discussion of issues of common concern.

In order to achieve the requirement review, CEN/TC 287 resolves to set up an open working group using electronic mail and workshops as required, under the convenorship of John Rowley (subject to appropriate finance being available). A report shall be produced within 6 months after the establishment of the open working group. EU funding will be sought to finance this activity.

ISO/TC 211 Geographic Information/Geomatics

ISO/TC 211 started in 1994 (1st plenary Nov. 1994, Oslo). Timetable is open (12th plenary March 2001, Portugal). There are 5 WG and more than 20 work items.

ISO/TC 211 organization



ISO/TC 211 Members

Participating members - P-members (33)

Australia, Austria, Belgium, Canada, People's Republic of China, Czech Republic, Denmark, Finland, France, Germany, Hungary, Islamic Republic of Iran, Italy, Jamaica, Japan, Republic of Korea, Malaysia, Morocco, Netherlands, New Zealand, Norway, Portugal, Russian Federation, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, United Republic of Tanzania, Thailand, United Kingdom, USA, Yugoslavia.

Observing members - O-members (16)

Bahrain, Brunei Darussalem, Colombia, Cuba, Estonia, Hong Kong (China), Iceland, India, Mauritius, Oman, Pakistan, Poland, Slovakia, Slovenia, Turkey, Ukraine.

The following table provides an overview of the status of the work of the ISO/TC 211 Working Groups.

ISO/TC 211
GI Project Overview

WG	New n°	Old n°	Title	VD	CD	2.CD	3. CD	DIS	FDIS	IS
1	19101	15046-1	Reference model	96-03	98-01	98-12		99-12	00-06	00-08
1	19102	15046-2	Overview	96-09	98-07	99-04		01-09	02-05	02-07
1	19103	15046-3	Conceptual schema language	96-01	99-07	00-03				TS 00-09
1	19104	15046-4	Terminology	96-04	99-05	99-11	00-05	00-11	01-06	01-08
1	19105	15046-5	Conformance and testing	96-09	98-04	98-10		99-08	00-01	00-03
5	19106	15046-6	Profiles	96-09	99-11	00-03		00-08	01-01	01-03
2	19107	15046-7	Spatial schema	96-10	99-01	99-11	00-03	00-08	01-01	01-03
2	19108	15046-8	Temporal schema	96-03	98-11	99-11		00-05	00-10	00-12
2	19109	15046-9	Rules for application schema	96-09	98-12	99-11	00-03	00-08	01-01	01-03
3	19110	15046-10	Feature cataloguing methodology	96-09	98-04	98-11		99-12	00-05	00-07
3	19111	15046-11	Spatial referencing by coordinates	97-12	98-11	99-10		00-05	00-10	00-12
3	19112	15046-12	Spatial referencing by geographic identifiers	96-03	98-05	99-10		00-05	00-10	00-12
3	19113	15046-13	Quality principles	96-03	98-04	98-11	99-11	00-03	00-08	00-10
3	19114	15046-14	Quality evaluation procedures	96-09	99-01	99-11	00-03	00-08	01-01	01-03
2	19115	15046-15	Metadata	96-03	98-07	99-11	00-05	00-11	01-05	01-07
4	19116	15046-16	Positioning services	97-09	99-11	00-03		00-07	01-01	01-03
4	19117	15046-17	Portrayal	96-09	98-05	99-06	99-11	00-03	00-08	00-10
4	19118	15046-18	Encoding	96-09	99-03	99-11		00-03	00-08	00-10
4	19119	15046-19	Services	96-09	99-11	00-03		00-08	01-01	01-03
5	19120	15854	Functional standards		PDTR 98-07	99-04				TR 99-12
1	19121	16569	Imagery and gridded data technical report		PDTR 98-11	99-06				99-12
5	19122	16822	Qualifications and certification of personnel		PDTR 00-12	1-06				TR 01-09
2	19123	17753	Schema for coverage geometry and functions	99-04	00-03	00-09		01-03	01-09	01-12
1	19124	17754	Imagery and gridded data components	Stage 0						
		SQL			99-11			00-03	00-10	00-12

Part 11 in context with other WI of ISO/TC 211

- WI 04 - Terminology
- WI 12 - Spatial referencing by geographic identifiers
- WI 13/15 - Quality
- WI 15 - Metadata
- WI 16 - Positioning services
- WG 1 - Imagery and gridded data

And new work items with geodetic relevance:

- Geodetic codes and parameters (WG 3)
- Coordinate transformation services (WG 4)

Under the head of ISO it is not planned to standardise a special CRS for world wide GIS users, e. g. ITRS.

Spatial reference by coordinates for GIS (concepts and status of relevant standards - ISO & CEN)

ISO/TC 211 Liaisons

External liaisons

- Centre for Earth Observation, CEO;
- Digital Geographic Information Working Group, DGIWG;
- European Petroleum Survey Group, EPSG;
- International Association of Geodesy, IAG;
- International Cartographic Association, ICA;
- International Federation of Surveyors, FIG;
- International Hydrographic Bureau, IHB (IHO-International Hydrographic Organisation);
- International Society for Photogrammetry and Remote Sensing, ISPRS;
- International Steering Committee for Global Mapping, ISCGM;
- Open GIS Consortium, Incorporated, OGC;
- Permanent Committee on GIS Infrastructure for Asia and the Pacific, PCGIAP;
- UN ECE Statistical Division.

Internal liaisons

- ISO/IEC JTC 1/SC 2 Coded character sets;
- ISO/IEC JTC 1/SC 24 Computer graphics and image processing;
- ISO/IEC JTC 1/SC 32 Data Management and Interchange;
- ISO/TC 204 Transport Information and Control Systems;
- ISO/TC 20/SC 13 Space data and information transfer systems;
- ISO/TC 23/SC 19 Agricultural electronics;
- ISO/TC 184/SC 4 Industrial Data;
- ISO/TC 82 Mining;
- ISO/TC 46/WG 2 Coding of country names and related entities;
- Other important relationsship;
- CEN/TC 287 Geographic information.

OGC OpenGIS Consortium

OpenGIS is defined as transparent access to heterogeneous geodata and geoprocessing resources in a networked environment. The goal of the OpenGIS Project is to provide a comprehensive suite of open interface specifications that enable developers to write interoperating components that provide these capabilities.

What is the OpenGIS Consortium?

OGC is organized as "membership corporation" whose mission is to promote the development and use of advanced open systems standards and techniques in the area of geoprocessing and related information technologies.

Spatial referencing OGC activities

- Coordinate Transformation Working Group (CTGW);
- Cooperation with ISO/TC 211;
- New work items.

Concept of ISO/TC 211, WI 11 (ISO 19111)

The ISO/TC 211, WI 11 - Spatial referencing by coordinates (ISO 19111) standard was not made for geodetic experts, it was made for producers and users of GIS.
Therefore the structure shall be clear and easy - but correct on a common level of abstraction.

WI 11 Project group: H. Seeger (project leader, DE), J. Ihde (editor, DE),

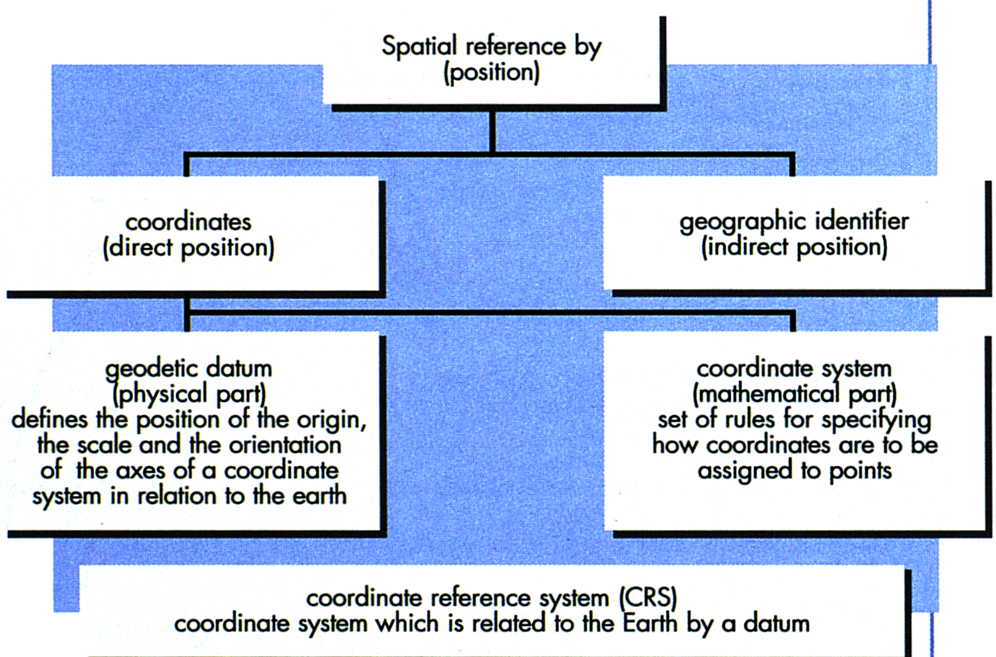
N. Ackroyd (UK), G. Blick (NZ), C. Boucher (FR), D. Dankow (US), J.-P. Dufour (FR), I. Godwin (US), C. Gower (UK), B. G. Harsson (NO), J. Hawker (AU), R. Iakovleva (RU), K. Inaba (JP), J. Jiang (CN), M. Kumar (US), R. Lott (UK), C. Macauley (AU), J. Binder Maitra (US), T. Mauney (US), A. Müller (DE), E. Profl (DE), L. Rackham (UK), R. Rugg (US), A. Ruffhead (UK), G. Tait (UK), S. True (US), R. Walker (UK).

Scope

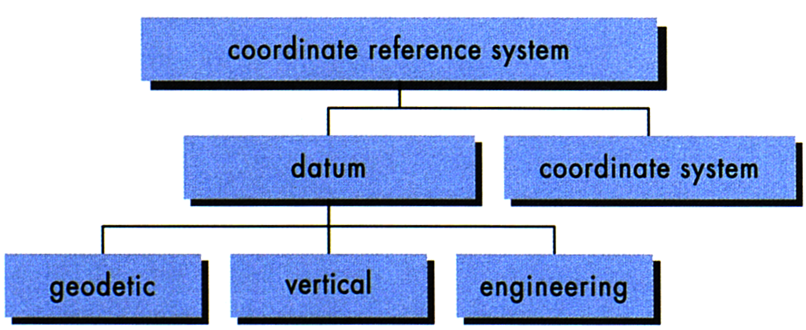
WI 11 describes the conceptual schema and defines the description for a minimum data to two cases for which 1-, 2- and 3-dimensional coordinate reference system information shall be given:

- Case A: A coordinate reference system to which a set of coordinates is related;
- Case B: An operation (transformation, conversion, concatenated operation) to change coordinate values from one coordinate reference system to another.

Case A: Coordinate Reference System

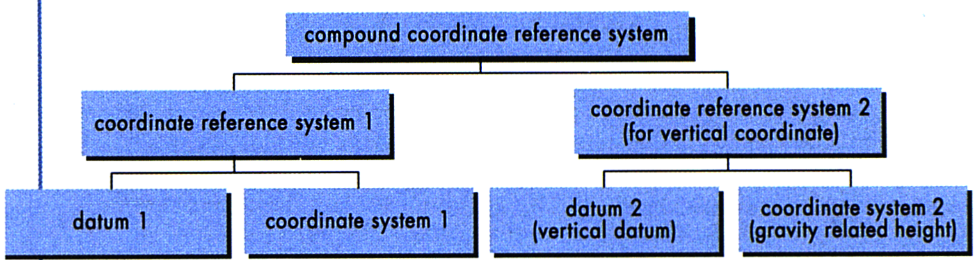


Coordinate reference system - coordinate system which is related to the Earth by a datum

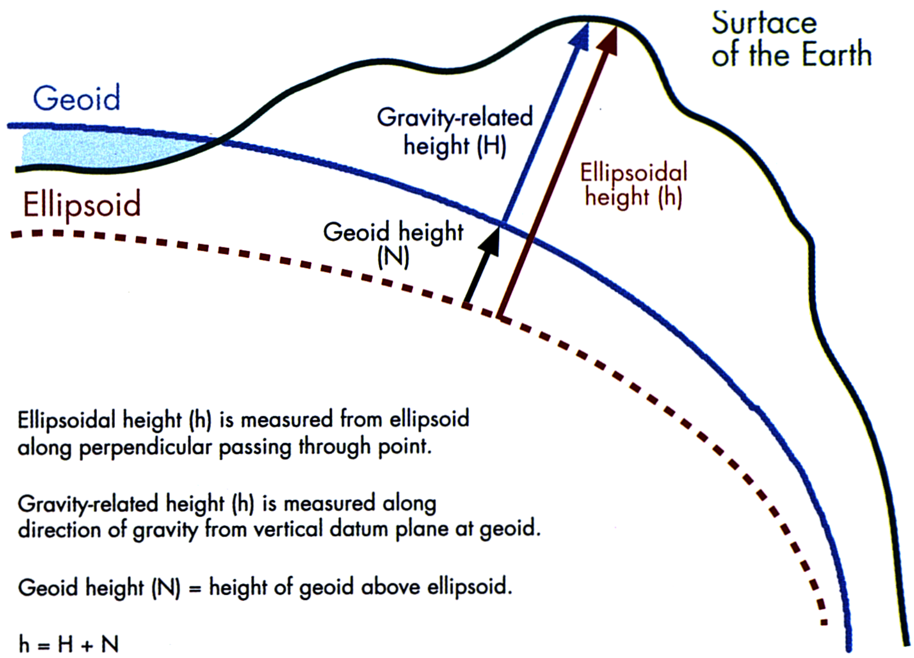


Spatial reference by coordinates for GIS (concepts and status of relevant standards - ISO & CEN)

Compound coordinate reference system - description of position through two independent coordinate reference systems



Ellipsoidal and gravity related heights



Ellipsoidal height (h) is measured from ellipsoid along perpendicular passing through point.

Gravity-related height (h) is measured along direction of gravity from vertical datum plane at geoid.

Geoid height (N) = height of geoid above ellipsoid.

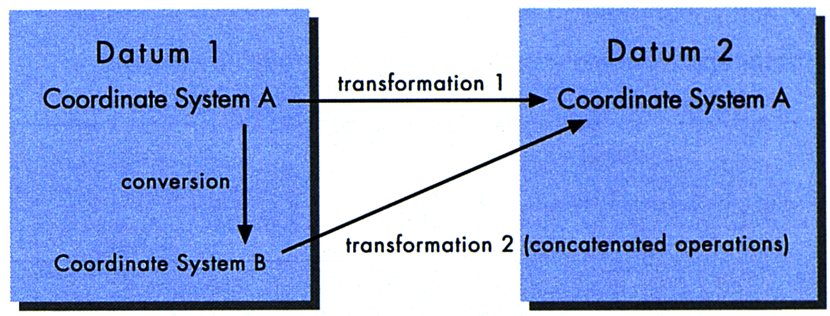
$h = H + N$

Example: Compound coordinate reference system using geodetic cartesian X, Y, Z and gravity-related height.

The compound coordinate reference system is fully described.

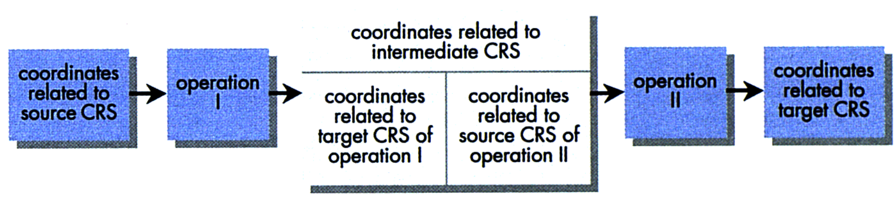
Element name	*Value*
Coordinate reference system kind code	2
Compound coordinate reference system identifier	EUVN
Compound coordinate reference system remarks	Full name: European Vertical Reference Network
Coordinate reference system 1 identifier	ETRS89/(φ, λ, h)
Datum identifier	ETRS89
Datum type	geodetic
Datum realization epoch	1997.5
Coordinate reference system validation area	Europe
Ellipsoid identifier	GRS80
Ellipsoid semi-major axis	6378137.0 m
Ellipsoid shape	true
Ellipsoid inverse flattening	298.257222101
Coordinate system identifier	geodetic coordinate system
Coordinate system type	geodetic
Coordinate system dimension	3
Coordinate system axis name	latitude
Coordinate system axis direction	north
Coordinate system unit identifier	degree
Coordinate system axis name	longitude
Coordinate system axis direction	east
Coordinate system unit identifier	degree
Coordinate system axis name	ellipsoidal height
Coordinate system axis direction	up
Coordinate system unit identifier	m
Coordinate reference system 2 identifier	UELN-95
Datum identifier	UELN-95/98
Datum type	vertical
Datum anchor point	Amsterdam
Coordinate reference system validation area	Europe
Coordinate system identifier	normal height
Coordinate system type	gravity related
Coordinate system dimension	1
Coordinate system axis name	height
Coordinate system axis direction	up
Coordinate system unit identifier	m

Case B: Operation - Conversion and Transformation



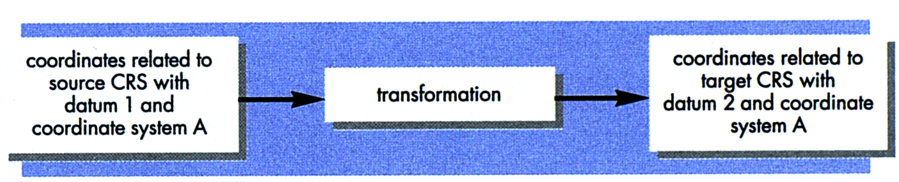
Concatenated operation

The change of coordinates from one coordinate reference system to another coordinate reference system may follow from a series of operations consisting of one or more transformations and/or one or more conversions. A concatenated operation records a change of coordinates through several transformations and/or conversions.
The figure shows a two-step concatenated operation. There is no upper limit to the number of steps a concatenated operation may have. Each step is an operation described in the normal way.



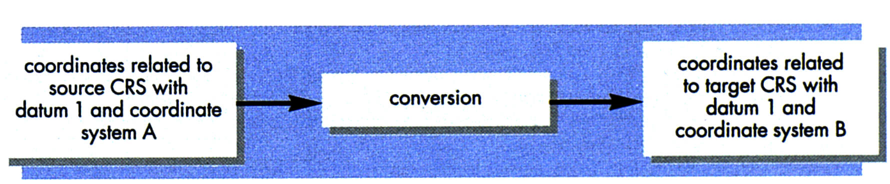
Transformation

Change of coordinates from one coordinate reference system to another coordinate reference system ased on a different datum through a one-to-one relationship.

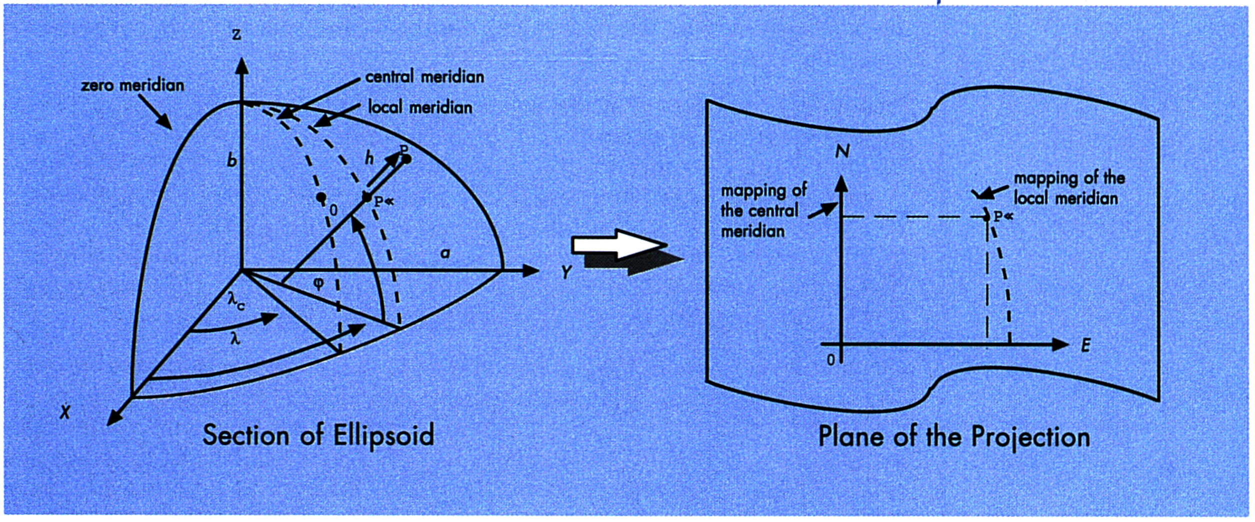


Conversion

Change of coordinates, based on a one-to-one relationship, frame one coordinate system to another based on the same datum (including map projection).



Map projection



What we shall do for European GIS Users

Introduction of the standard family of ISO/TC 211 by using CEN.

Gathering of information:

- of national European coordinate reference systems defined by
  - a datum and
  - a coordinate system
- of the relations (operations) between national and a conventional European coordinate reference system
  - between the datums (transformation)
  - and the coordinate systems (conversions)
- Declaration of a realised European reference systems as standard for European GIS users (like the GRS80 conversion for geodetic community) e. g. ETRS89, EUVN/UELN95.

The Internet Collection of Map Projections and Reference Systems for Europe - *Stefan A. Voser*

Europe is merging closer. Facts for this are the European Community or the new European currency Euro. But what about a homogeneous Geospatial Data Infrastructure? The requirements for that are a common data model, similar data capturing methods and metadata in several languages.

The most fundamental model aspects of geospatial data are coordinate reference systems like geodetic reference systems and map projections. They are the frame in which coordinates as the holder of the geometric information get their spatial semantics. In Europe, the landscape of coordinate reference systems is very heterogeneous because mostly every country built up its own reference systems. Most of them have their own history and lineage. So, most of them originally have no relations to other nations reference systems: they do not have a common geodetic datum.

On this level of modelling geospatial data, a comprehensive georeferencing model is required to homogenise coordinate reference systems. If homogenisation is reached, geographic locations get the same mathematical location, i.e. that overlaying data from different sources fit together not only in reality but also positionally within GIS.For reaching a homogeneous positional overlay, the first step is the identification of the coordinate reference system entity in which your data is stored. A second step is to find the geometric relation to the target reference system together with the functional model for the changing process.

The MapRef internet collection is an approach to support users when homogenising geospatial data from different coordinate reference systems. MapRef collects definitions and parameterisations of coordinate reference systems like geodetic reference systems and map projections, sorted by countries. Furthermore, it also includes geodetic datum transformation parameters to global systems as ETRS 89 or WGS84, the system in which GPS originally works. In MapRef, you also find other related information on coordinate reference systems, as theory, related links and additional information. This paper gives an introduction to the MapRef pages.

Spatial Reference and Coordinate Reference Systems

The main characteristic of geospatial data is their spatial semantics, meaning that to each spatial information, a geographical location is assigned.

There exist two ways to describe a spatial location within a GIS:

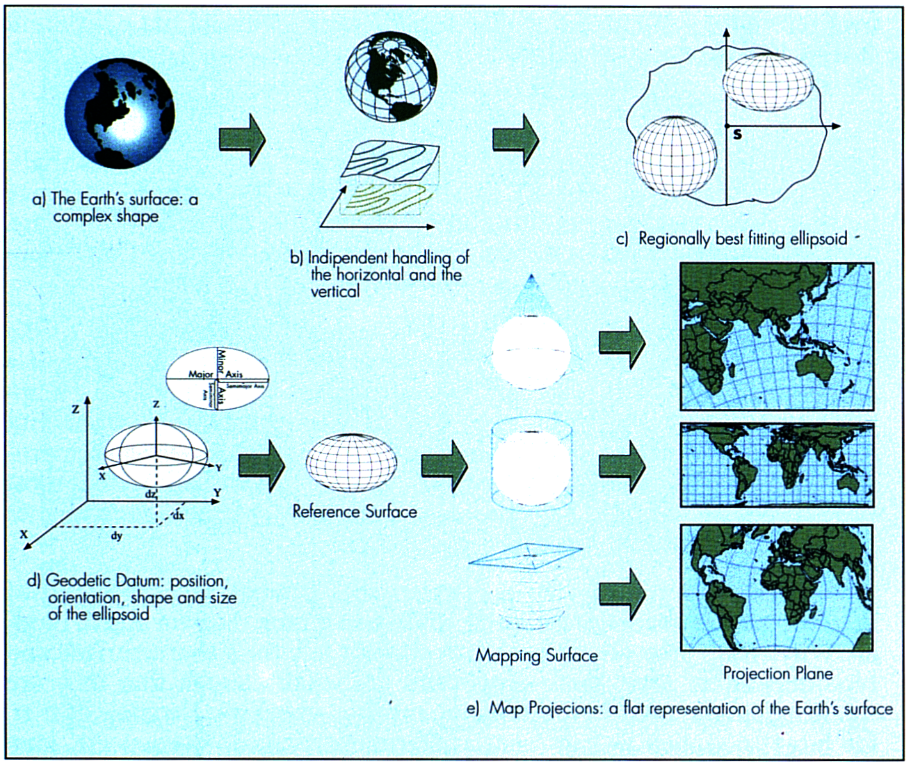
- Spatial referencing by geographic identifiers;
- Spatial referencing by coordinates.

The first method is a cognitive one, the second one is a mathematical or geodetic one. Geographic identifiers use thematic and logic models to describe and assign a geographic location. This method of spatial referencing is not followed within this discussion.

Spatial referencing by coordinates has its basics in mathematics and analytical geometry. Generically, a location is described by a set of coordinates which refers to a coordinate system. But further on, spatial locations need coordinate systems with spatial (or geographic) semantics. Such spatial coordinate systems are called coordinate reference systems. A coordinate system is defined by its origin, its axes and units, a coordinate reference system needs its spatial extension, the position and orientation of the axes in relation to the earth. This spatial extension is called the datum.

There exist various classes of coordinate reference systems. Here, we only focus on the classes for geodetic reference systems and map projections. Let's have a look at what the main issue is.

From the earth surface to the plane of a map projection



a) A spatial location is related to the earth surface. So we need a mathematical method to describe the earth shape by a reference surface to which a coordinate reference system may be assigned. For areas smaller than 10 x 10 km^2 a plane may be supposed whereas for larger regions, a curved surface has to be established. In Geodesy, the science of the determination of the figure and the size of the Earth, three types of Earth surfaces are used [Moritz 1990]:

- the topographic surface - the physical or geological one (mountains, valleys lakes, the sea ...);
- the geoid - the geophysical or gravitational one. The geoid is a surface perpendicular to the plumb lines. It is the continuation of the mean sea level surface at the continents. The geoid is the reference surface for heights, particularly the orthometric heights;
- the spheroid and sphere - a mathematical and symmetric surface. The spheroid (ellipsoid) is a sphere flattened at the poles. It mainly is used for describing a horizontal position (e.g. by geographic coordinates).

Let's conclude: the geodetic reference systems are the geoid for the heights and the spheroid (ellipsoid) for the horizontal.

b) We see an ellipsoid as a reference for the horizontal position, and for the heights, a digital elevation model as an approximation of the topographic surface is given. Each height-information is assigned to a horizontal position, but the height is not referred to the ellipsoid, but influenced by and related to the gravity field. (this leads to the problem of geodetic hybridity when modelling coordinate reference systems).

c),d) It is shown that ellipsoids may vary by their shape and size as well as by their position. This means that various geodetic datums exist. E.g. in Europe, there is a big heterogeneity. Mainly each country uses or used its own reference systems. Some may use the same ellipsoid but a different datum, but also various ellipsoids are in use. Of course, there exist various efforts to unify the geodetic reference systems.

One example is the European Datum 1950 with is/was used by NATO and primarily for militarian mapping. A newer effort is the EUREF Campaign which led to the ETRS89 (European Terrestrial Reference System 1989) together with its control point field, the ETRF89-Frame. Since this frame is realised, many countries defined new national geodetic reference systems which are referred or equal to ETRS.

e) Finally shows the way from geodetic or geographic coordinates to the national grid coordinates or generically to the planar coordinates of a map projection. A national coordinate grid, as used for topographic mapping, is based on a map projection, mostly based on a conformal one. But for thematic mapping also other geometric properties as equal-area projections and equidistant projections are in use. In e) it is shown that most projections use a conic map projection surface (cylinder, cone, plane) which is flattened to the plane.

The implementation of map projections has a much wider amount of map projection instances for authoritative mapping than for Earth models. Why? Map projections have distortions. Only for a characteristic and type dependent area, these distortions are small enough that they are smaller than the accuracy of drawing the map elements. Because of that, for larger counties as e.g. Austria, Germany, France, Sweden etc, map projection zones are used. In various European countries, also different projections are used for mapping at different scales.

Georeferencing Processes

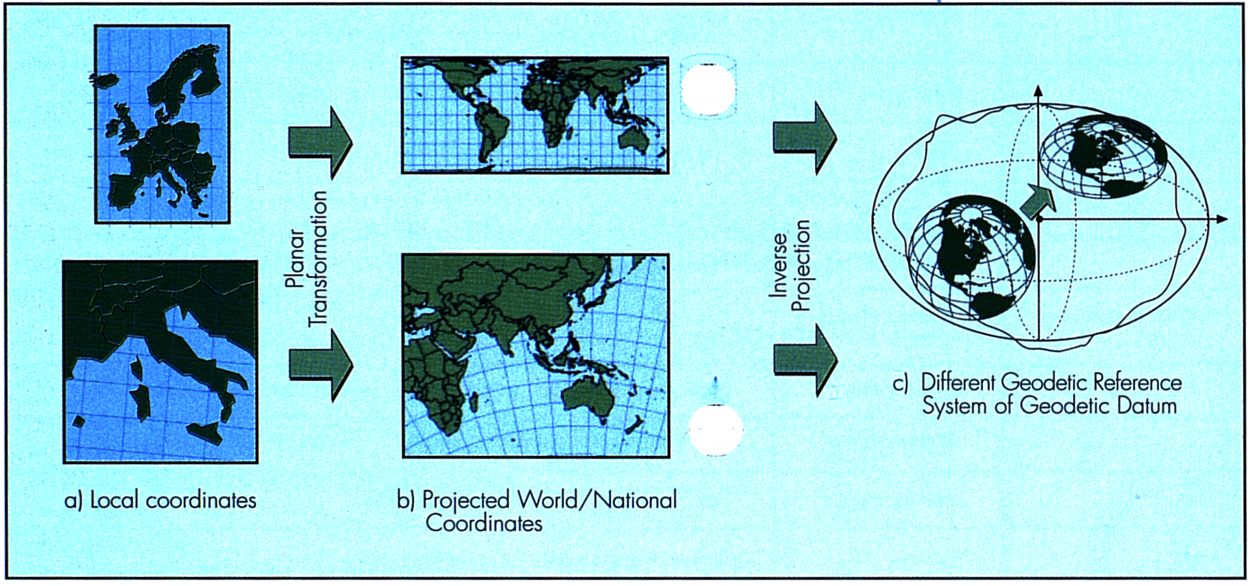
We have seen, there exist various ways for choosing a coordinate reference system for mapping. In other words, the same spatial location may have different coordinates in different maps or datasets. When using datasets from different sources but covering the same area, it may require a homogenisation of these sets by means of coordinate reference systems.

Such a coordinate reference system homogenisation is a georeferencing process. There exist two groups of georeferencing processes:

- Conversions: the relation between the coordinate reference systems is set by definition (the method as well as the parameters). E.g. the application of a map projection is a conversion of coordinates from the reference surface to the projection plane or vice versa;
- Transformations: the relations between the coordinate reference systems is determined based on measurements. Normally, the mathematical method is known, but the parameters have to be estimated. For that, fiducials or control points are used (the coordinates are known in the source as well as in the target system). Typically the following two types of transformations are used for georeferencing processes:
  - Planar transformations: e.g. used for georeferencing map sheets or scanned maps
  - Geodetic datum transformations: used for changing the geodetic reference system.

In the following figure these main georeferencing processes are shown. Planar transformations, used e.g. when digitising or scanning maps, inverse projections as conversions, and geodetic datum transformations for the change between two geodetic reference systems.

Georeferencing Processes: a Chain of Transformations and Conversions



Applications of Coordinate Reference Systems

Various coordinate reference systems were defined and implemented by authoritative bodies and organisations. These systems have a specific datum based on their definition (initialisation). E.g. national mapping agencies decided for a map projection (system) together with its underlying geodetic reference system. Their definitions are constant, and this information may be required for many georeferencing processes.

For these two groups of coordinate reference systems, it is a comfort to have the required parameters and methods collected and published or implemented. Many GIS-Software implementations support the functionality for georeferencing, as well for planar transformations as for map projections and datum transformations. A lack still is to get the correct parameters. Therefore the MapRef-pages are built up.

The MapRef Web Pages

The MapRef Web-Site (http://www.geocities.com/mapref/mapref.html) is an internet collection of information about map projections and reference systems. The main focus is done on the definitions and parameters for map projections and geodetic reference systems in Europe.

The MapRef pages are designed for the following information. Not all themes are included or completed yet.

The Internet Collection of Map Projections and Reference Systems for Europe

Theme	*Group*	*Description*
CRS-Applications/ Parameters (CRS-definitions)	Map Projections	Definitions and parameters of map projections, sorted by European countries; parameters, sample data; references.Parameters
	Reference Systems	Definitions and Parameters of geodetic reference systems, sorted by European countries; parameters, sample data; references.
	Map Series	Map Series, sorted by European countries; related reference systems; links.
Knowledge Base	Theory	The mathematical basics of mapping. Links to tutorials and other related sites.
	Terminology	Terms, glossaries and acronyms; links.
	Reference Library	Publications, books and libraries; links.
Authoritative Bodies	National Mapping Agencie	National offices for mapping and geodesy; links.
	Organisations	National or international bodies in the field of Cartography and Geodesy.
	Standardisation	What are the standardisation efforts for Coordinate Reference Systems?
	Data Exchange	Data Exchange Formats. Ready for CRS?
Tools	Software	Technical applications for georeferencing.
	Web-Tools	Internet applications for georeferencing.
Information	What is MapRef?	Metadata about the MapRef-Pages.
	What is new	Updating information.
	FAQ - Frequently asked questions	If you have questions, please check here first.
	Contact	If you really need help or have interesting information to be included.

In the following, only the main characteristics of the definitions or specifications of map projections and geodetic reference systems are discussed more in detail.

How to specify a Map Projection

A map projection is classified as a conversion between geographic and planar coordinates based on a method with its geometric properties. There exist various ways to classify map projections. See e.g. [Richardus/Adler 1972, Snyder 1987].

The methods for the classifications are:

- The extrinsics of geometry (mapping surface)
  - The nature of the mapping surface (plane, cone, cylinder)
  - The coincidence (tangency, secancy)
  - The position or alignment (normal, transverse, oblique)
- The intrinsics of geometry (properties)
  - Deformation method (conformal, equidistant, equivalent, compromise)

- The generation (geometric, semi-geometric, conventional)
- The geographic use and extent
  - World mapping
  - Hemisphere
  - Continents/oceans
  - Large and medium scale maps
  - Polar, equatorial, other area
- Others
  - Visual effects
  - Mathematical systematics
  - Etc.

These characteristics are all important when choosing a map projection for a certain purpose. A main problem when using implemented methods is their identification. The same method may have different names, or also different mathematical approaches etc.

So, when specifying an instance of a map projection, it requires the following information:

- Name
- Area of use
- Underlying Earth model (incl. datum)
- Method
- Parameters
- Control points (for checking)
- References

This information will be collected in the map projection collection, sorted by countries.

How to specify a Geodetic Reference System

At the beginning, we have seen that geodetic reference systems are used for modelling the figure of the Earth. When modelling the Earth for flattening it by a map projection, spheroids and spheres are used because of their geometrical smoothness. Such a model has geometric properties, describing the shape and size of its figure. And the datum describes the position and orientation regarding to the Earth (and its surface).

Before artificial satellites became reality, the geodetic datum was determined by astronomical measurements. Based on such measurements and regarding to the earth curvature for the specific country, the best fitting spheroid was oriented and positioned in its (national) datum. Normally, a fundamental point (e.g. the Panthéon in Paris, the old observatory in Berne, the observatory Monte Mario in Rome etc.) was used for fixing the spheroid in its datum c, d, c). By this astronomical definition of the datum, the Earth model stood for its own, and no relations to other geodetic datums were known or fixed. Important is that by this way, the position and orientation to the Earth centre (mass point) was unknown.

Since the use of artificial satellites (e.g. TRANSIT, GPS) is applicable for navigation and also for geodesy, global (world-wide) geodetic reference systems were built up (e.g. WGS72, WGS84, ITRS89), positioned in the Earth centre, oriented by the mean rotation axis and the meridian of Greenwich.

Since continental (e.g. European Datum 1950) and world-wide geodetic reference systems were built up, the need for their relations to the national datums raised. The easiest way for that is to know the geometric relations between the axis of the spheroid between the two systems. (The 3 axis of the spheroid define its "geocentric" Cartesian coordinates d). Such a modern definition of a datum is described by the ellipsoid names, and their relational positional information.

Normally, two methods were used:

- translation (3 Parameters);
- Helmert transformation, similarity (7 Parameters: 3 translations, 3 rotations, 1 scale).

These principles may have different implementations. They may vary in its signs, or they are implemented at curvilinear methods, meaning a direct transformation between the geographic coordinates related to the two ellipsoids.

So, when specifying an instance of a geodetic reference system, it requires the following information:

- Name
- Fundamental point
- Area of use
- Spheroid
- Relation to the global system:
  - Name
  - Method
  - Parameters and accuracy
- Control points (for checking)
- References

This information will be collected in the reference system collection, sorted by countries.
Not included here are the heights systems or the geoid models, because they belong to a more complex thematic.

Meta-Information about the MapRef Pages

The MapRef-Pages are not funded by any organisation or institution, they are one aspect of my work towards my PhD. Because of that, they have an experimental touch, are not complete and may change.

The initiation for the pages was given by the Project "Geodetic Reference Systems and their Applications to the Field of Nature Conservation", which I realised from 1994-1996 at the Institute of Geodesy, University of the Federal Armed Forces, Munich, funded by the German Federal Office for Nature Conservation.

Conclusion and final remarks

Coordinate Reference Systems are the mathematical fundamentals for storing spatial data with its geometry. A management is required to homogenise spatial data from heterogeneous coordinate reference systems using georeferencing processes. For many georeferencing processes, the required information is missing (e.g. the parameters of the map projections and datum transformations). The MapRef pages are built up to collect such information.

References

1. Bugayevskiy Lev M., Snyder John P.: Map Projections, A Reference Manual, Taylor&Francis, London, Bristol 1995.
2. Hooijberg Maarten; Practical Geodesy - Using Computers. Springer Verlag, Berlin Heidelberg, 1997.
3. Moritz Helmut: The Figure of the Earth - Theoretical Geodesy and the Earth's Interior. Herbert Wichmann Verlag Karlsruhe, 1990.
4. Richardus, Peter; Adler, Ron K.: Map Projections, for Geodesists, Cartographers and Geographers. North Holland Publishing Company, Amsterdam 1972.
5. Snyder, John P.; Map Projections - A working manual; U.S. Geological Survey Professional Paper 1395; Washington 1987.
6. Voser S. A.: Schritte für ein automatisiertes Koordinatensystem-management in GIS und Kartographie. (Steps Towards an Automated Coordinate System Management for GIS and Cartography) Nachrichten aus dem Karten- und Vermessungswesen, Reihe I, Heft Nr. 118, S. 111-125. Bundesamt für Kartographie und Geodäsie, Frankfurt am Main, 1998.
7. On the Web: see the MapRef-pages at http://www.geocities.com/mapref/mapref.html

Project

The GI&GIS project supports the actions to create a European Geographic Information Infrastructure (EGII). The EGII encompasses the broad policy, organisational, technical and financial arrangements necessary to support increased acces to Geographic Information in Europe. It will potentially benefit many stakeholders - government and non-government organisations, education and research institutions, the commercial sector, and the general community - at the national, regional and global level. The EGII offers the prospect of better decision-making and thus improved economic growth, social development and environmental management.

The GI/GIS project reflects the increasing awareness of the importance of spatial aspects in policy and decision making, and focuses on both policy and technical issues relating to spatial information and spatial information systems. The main activities of this project include:

- To assist the GI policy making process of the Commission, help in formalising the user requirements for the EGII, and contribute to the establishment of an interoperable European Geo-Statistical system
- To develop harmonised and coherent multidisciplinary pan-European databases and analyse spatial information across different sectoral policies and different levels of governmental organisations. This includes the creation of various spatial layers: Soil, Land Cover, Agro-Meteorology, Natura2000, to support and monitor EU policies
- To provide technical support to the Services of the Commission in defining base and thematic spatial data requirements at the European level, and operating communication facilities
- To monitor GI&GIS standards, interoperability, and market development through a Technology Watch activity.

For more information on the GI&GIS project and on GI & GIS in the European Commission visit the following websites:

GI&GIS Project homepage http://gi-gis.aris.sai.jrc.it/
GI&GIS in the European Commission http://www.ec-gis.org/

Mission

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies.

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION

As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union.

Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.