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European Spatial Data Infrastructure

1st Workshop on European Reference Grids

Ispra, 27-29 October 2003

Short Proceedings

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The workshop summary *(Alessandro Annoni)*

The 1st Workshop on European Reference Grids was organized by the Joint Research Centre (JRC) of the European Commission following a request of the European Environmental Agency[1] and the request of the INSPIRE[2] Implementing Strategies Working Group that recommended that a Europe-wide reference grid be devised and adopted in order to facilitate the management and analyses of spatial information for a variety of applications. In addition, the National Statistical Institutes have expressed their interest for a common coordinate reference system and a common equal-area grid to represent EU and Pan-Europe, expressed at the Working group meeting held at Eurostat in Luxembourg in 1999[3].

Given the complexity of the issues involved, the JRC organized the workshop inviting leading Experts of different communities representing Users of European Grids (including European Commission Directorates General), National Statistical Institutes, National Mapping Agencies, GIS Software Industry, European Organizations and Agencies but also inviting experts in Geodesy, Spatial Analysis, and Geo-Spatial Data Modeling, Standardization and Interoperability.

The workshop was articulated in various thematic sessions and various working groups were composed to better address specific issues. In particular it was possible to have an in depth overview and a comparative analysis of existing EU initiatives, projects, and regulations making use of geographical grids (e.g. ICP-Forest, LUCAS, ESPON, EEA Atlas, Atlas Florae Europaeae). The workshop gave also the possibility to evaluate current and previous technical work to build trans- national grids (e.g. TANDEM, Nordvic). In this context attention was given to spatial methods to transform information between grids, including aggregation and disaggregation of statistics, spatial entities, etc..

The last topic carefully investigated was related to the geodetic aspects including the reaffirmation of European standards selected in previous workshops jointly organized by JRC and EuroGeographics: the European Datum ETRS89[4] and related map projections[5]. This part of the workshop considered the problems related to the transformations between geodetic datum, map projections and geographical grids in geodesy and geoinformation.

The workshop participants were asked to answer specific questions like:

- Is a unique EU grid possible (long term vision)?
- How can convergence in the future be achieved?
- How to increase the integration between existing grids?
- Which spatial-statistical methods are available and recommended?
- What about Standardisation and Certification of proposed solution(s)?

The flow of information was considerable and debate was rich and productive. Despite different groups were working independently and addressing different issues when their results were presented a considerable overlapping was shown but without significant divergence. This made possible to slowly converge to a common position and to identify a technical solution (standard) to be recommended for future adoption. Because the adoption of the future should be accompanied with the adequate documentation on how to convert existing grids to the future European standard, it was agreed to test the proposed solution profiting of the project Nordvic currently running covering Scandinavian countries. The participants of this project expressed the wish to use it as Test Bed of the proposed standard.

The selected grid will be used in the future for spatial and statistical analysis including the reporting of other sources of information to the common European grid. Due to limited time, the discussion of a possible unique grid for data collection was not exhaustive and the workshop recommended to leave any decision to a second edition of the European Reference Grids workshop. In that occasion it will be

[1] "*The European Environment Agency needs a grid for immediate use and will use it until there are agreements on a common grid system, maybe being ready by 1-3 years. We would like to ask you for some advise on the choice*"- Arvid Lillethun, EEA, 27 November 2002

[2] INSPIRE - Infrastructure for Spatial Information in Europe– http://inspire.jrc.it

[3] JRC (IES)/European Commission 2003: Map projections for Europe, page 20

[4] Spatial Reference System workshop, Marne-La Vallée, 29-30 November 1999

[5] Map Projections for Europe workshop, Marne-La Vallée, 14-15 December 2000

possible to focus on data collection related issues and at the same time to analyse the results of the one year experimentation in order to final adopt the proposed standard.
The workshop results in a set of recommendations for the way forward, and an action plan for 2004.
The workshop material is available at: http://gi-gis.jrc.it/ws/grid2003/index.html

The recommendations in short

> ***"A grid for representing thematic information is a system of regular and geo-referenced cells, with a specified shape and size, and an associated property".***

The workshop recommends to the European Commission:

1. To reaffirm the recommendations of the Spatial Reference Systems workshop (November '99):
   - To adopt **ETRS89**[6] as geodetic datum and to express and store positions, as far as possible, in ellipsoidal coordinates, with the underlying GRS80 ellipsoid [ETRS89].
   - To further adopt EVRF2000 for expressing practical heights (gravity-related).
   - To identify coordinate reference systems and transformations in the format required by **International Standard 19111**.
2. To reaffirm the recommendations of the Map Projection Systems Workshop (December 2000), i.e. to adopt the following map projections to supplement the ellipsoidal system:
   - To adopt ETRS89 Lambert Azimuthal Equal Area coordinate reference system of 2001 [ETRS-LAEA], for **statistical analysis and display**.
   - To adopt ETRS89 Lambert Conic Conformal coordinate reference system of 2001 [ETRS-LCC] for conformal pan-European mapping at scales smaller or equal to 1:500,000.
   - To adopt ETRS89 Transverse Mercator coordinate reference systems [ETRS-TMzn], for conformal pan-European mapping at scales larger than 1:500,000.
3. To continue to promote the wider use of these standards within all member states and internationally, by appropriate means (recommendations, official statement, …)
4. To adopt a common European Grid Reference System for Reporting and Statistical Analysis. The system should be able to store regular grids and should be designed as reference for future Grids related to European territory. The system must satisfy the following principles:
   - easy to manipulate
   - hierarchical
   - be based on a Unified European Grid Coding System
   - based on units of equal area
   - adopt ETRS-LAEA and have a clear and simple relation to it
   - able to manage time stamps
   - follow the quality principles described in ISO 19113-11915
   - the Grid Data Model should be fully and publicly documented
   - Grid transfer must be based on non proprietary open formats
   - Metadata (following ISO specifications) must be produced and regularly updated to describe specific Grid characteristics and information related to a specific grid unit.
5. To make **possible to convert from existing grid structures** used and back again, it is highly recommended to generate data from the original detailed information when possible.
6. To test for a period of one year ETRS–LAEA (in collaboration with the Nordvic project that will be used as Test Bed of the proposed standard) with the aim:
   - to demonstrate benefits of the proposed solution,
   - to identify and develop tools, establish technical guidelines and best practice examples to support the convergence of existing grid data to a standard grid
7. To encourage future European projects to make use of a standard European grid
8. To help in **ensuring the future on-line interoperability of existing Grid systems** at European and National level (GRID Net) by providing examples of best practices and technical guidelines to be followed in establish conversion/transformation procedures
9. To continue the process of educating the users of geographic information in the complex issues associated with coordinate reference systems, map projections, grids, transformations and

[6] European Terrestrial Reference System 1989

conversions, including working with software and system suppliers to enable 'on the fly' transformations between commonly-used coordinate reference systems.

Agenda

The user needs (Comparative analysis of existing European initiatives) (day 1)

The speakers were invited to address the following common elements in their presentation (where appropriate): a) Rationale of their Project, b)Why a grid?, c) Major characteristics of the grid, d) Does the grid meet your needs, e) Link of your project with other (spatial) data.

The problem statement (morning session)

1. The ICP-Forests sampling scheme (*Javier Gallego*)
2. LUCAS: monitoring the European Union territory using a grid approach. (*Manola Bettio, Maxime Kayadjanian*)
3. Towards participatory approaches to a Multiscale European Soil Information System (*Nicola Filippi, Borut Vrscaj*)
4. EU regional policy and grids (*Hugo Poelman*)
5. ESPON (*Volker Schmidt-Seiwert*)
6. Current use of spatial reference grids in EEA (*Andrus Meiner*)
7. Atlas Florae Europaeae (AFE) – Mapping European Vascular Plants with 50 × 50 km grid (*Pertti Uotila and Raino Lampinen*)
8. TANDEM (*Lars Backer*)
9. Mapping and analyzing the distributions of plant species across the countries of Europe - an overview of research schemes and grid systems in use (*Harald Niklfeld*)
10. The grid reference system used for CGMS (*Giampiero Genovese*)
11. TREES sampling schema (*Javier Gallego*)

Identify common requirements (afternoon session)

1. Working Groups Discussion
    a. *typologies of used grids (chair: M Greaves)*
    b. *user requirements(chair: J.Gallego)*
2. Plenary: Report from working groups and Final Discussion

Grids and Spatial analysis (day 2)

Grid conversion (morning session)

1. Aggregation and disaggregation of statistics (Erik Sommer)
2. The European Datum ETRS89 and related map projections (Johannes Ihde)
3. Transformations between geodetic datum, map projections and geographical grids in geodesy and geoinformation (Johannes Ihde)
4. Design and introduction of a new map projection and grid system for Ireland (Ken Stewart)
5. Coordinating the creation of a reference system on the 25 MS in agriculture (10000 scale orthophotos (Simon Kay)
6. Grid estimation. Application to datum distortion modelling (Javier González-Matesanz)
7. In search of an infrastructure for spatial analysis (Lars Backer)
8. Dissemination of grid-based statistics in Finland and a case study about dissemination of multinational grid data of the four Nordic countries (Marja Tammilehto-Luode)
9. Modifiable areal units: Transforming data from one to another geographical system. (Javier Gallego)
10. Direct transformations between neighbour TM systems *(Jorge Teixeira Pinto)*

Grids and Spatial Analysis (afternoon session)

1. Working Groups Discussion
    a. *Grid definition and properties(chair: A.Lillethun)*
    b. *Grid conversion(chair: J.Gallego)*
    c. *Grid structure(chair: A.Annoni)*
2. Plenary: Report from working groups and Final Discussion

Formulate a Grid initiative (day 3)

Final Recommendations (morning session)

1. Working Groups Discussion
    a. *Is a unique EU grid possible*
    b. *How to increase the integration between grids and which methods are recommended*
    c. *Standardisation and Certification of proposed solution(s)*
2. Plenary: Report from working groups and Final Recommendations

Action Plan (afternoon session)

1. Plenary: Action Plan

Participants

Joint Research Centre (JRC) - Host and Organiser

- Alessandro Annoni, JRC – Institute for Environment and Sustainability
- Javier Gallego, JRC – Institute for Environment and Sustainability
- Stephen Peedell, JRC – Institute for Environment and Sustainability

European Commission

- Maxime Kayadjanian, Eurostat
- Manola Bettio, Eurostat
- Albrecht Wirthmann, Eurostat
- Hans Dufourmont, Eurostat
- Hugo Poelman, DG Regional Policy

National Statistical Institutes

- Erik Sommer, Statistics Denmark
- Marja Tammilehto-Luode, Statistics Finland
- Lars Backer, Statisics Sweden

National Mapping Agencies

- Javier Gonzalez-Matesanz, Instituto Geografico Nacional de España
- Mark Greaves, Ordnance Survey GB
- Johannes Ihde, Federal Agency for Cartography and Geodesy
- Arvid Lillethun, Norwegian Mapping Authority
- Ken Stewart, Ordnance Survey of Northern Ireland
- Klito Demetriou, Department of Lands and Surveys
- Jorge Teixeira Pinto, Instituto Geografico Portugues

European Organizations and Agencies

- Andrus Meiner, European Environment Agency
- Sophie Condé, European Topic Centre/Nature Protection and Biodiversity –MNHN

Experts in Geodesy, Spatial Analysis, and Geo-Spatial data modeling

- Raino Lampinen, Botanical Museum, Finnish Museum of Natural History
- Liliane Lizzi, UMS 2414 RIATE (ESPON)
- Harald Niklfeld, Institute of Botany, University of Vienna
- Volker Schmidt-Seiwert, Bundesamt für Bauwesen und Raumordnung (ESPON)
- Joao Torres, EUREF
- Egle Tumeliene, Vilnius Gediminas Technical University, Department of Geodesy
- Hermann Seeger
- Pertti Uotila, Botanical Museum, Finnish Museum of Natural History

GIS Software Industry

- Vladimir Spacek, INTERGRAPH
- Stanislav Sumbera, INTERGRAPH
- Michel Rives, Autodesk Europe, Middle-East & Africa Headquarters

Joint Research Centre (JRC) – others

- Simon Kay, JRC – Institute for the Protection and the Security of the Citizen
- Giampiero Genovese, JRC – Institute for the Protection and the Security of the Citizen
- Nicola Filippi, JRC – Institute for Environment and Sustainability
- Tore Tollefsen, JRC – Institute for Environment and Sustainability
- Vanda Lima, JRC – Institute for Environment and Sustainability
- Michele Conti, JRC – Institute for Environment and Sustainability
- Panos Panagos, JRC – Institute for Environment and Sustainability
- Borut Vrscai, JRC – Institute for Environment and Sustainability
- Lars Bernard, JRC – Institute for Environment and Sustainability

Introduction

When dealing with the concept of a general, multi-purpose grid the following issues must be considered:

- Grid shape
  - Rectangular (square)
  - Hexagonal
  - Based on lat-long intervals
- Grid scale
  - Up-Down scaling
- Use of GRID
  - Storing
  - Collection
  - Analysis
- Grid structure
  - Quadtree
  - Coding system
    - EU
    - Global/National / Local
- GRID DataBase
  - Time stamp
  - Data model
  - Output formats
  - Metadata profiles
    - GRID characteristic
    - GRID data
- GRID Network
  - Interoperability of GRID systems
- Quality description
  - ISO 19113-11915
- Aggregation of data to GRID
- Data Collection using GRID
- Certification/Validation
- Coordinate Reference Systems
- GRID Conversions
  - Datum changes
  - Content change

In order to address most of these issues various working groups were created in order to look to these aspects from several points of view.

The first part of the workshop focused on existing grids initiatives and in understanding user requirements. The following chapter reports the results of such discussions.

User Perspective

A working group was created to analyse the common requirements and heard the voice of the users to identify critical issues and communalities.

When Grids are used (lessons learnt)

…. To be filled by all speakers

Project	Datum-Projection	Extent	Resolution-Step	Origin	Unique[7]	Satisfactory[8]	Documentation[9]	Reference	Purpose[10]	Shape
ICP-Forest	Not defined	Pan-EU (Russia not yet included)	16 Km	50°14'15" N 9°47'06"	No	Medium	Low	EU Regulation 1696/87	Sampling Collection	Square
TREES	WGS84 Lat-Long	Global	3,000-3,500 km2	Unknown	Yes	Low	Medium		Sampling	Hexagonal
LUCAS	Extended UTM ?	EU15-25	18 km	Various National	No	High	High	?	Sampling Collection	Square
AFE	WGS84 Multiple UTM zones	Pan-European	50 km		No	Low	Low		Mapping	Mostly squares
National Square Grid	UTM-projection, zone 32. Datum: EUREF89	Denmark	100, 250 meter 1,10, 100 km	North= 6.000.000 East= 400.000	Yes	High	High	www.kms.dk	Reporting Mapping	Square
DEM (GISCO DEEU3M) as used by DG REGIO	LAEA	Pan-European	30 arcsec. (1km)	48°N 9° E	Yes	Medium[11]	High	See GISCO DBM	Reporting and mapping	Square
Land Cover (GISCO LCEUGR100) as used by DG REGIO	LAEA	EU27 + (excl. SE)	100 m	48°N 9° E	Yes	Medium[12]	Medium[13]	See GISCO DBM	Reporting and mapping	Square
European Soil Information System	Lambert Equal Area (GISCO)	Pan-European	1 Km	(see projection)	Yes	High	High	?	Integrated Spatial Analysis	Square

Grids for what?

The comparative analysis of the grids used in various European projects / initiatives and policies show that grids are used for several purposes:

1. Surveys on a sample
   a. Systematic unbiased sampling (e.g. LUCAS)
   b. Data Collection
2. Organising information on the whole territory
   a. Mapping (e.g. IMAGE2000)
   b. Spatial Analysis (e.g. CORINE Land Cover)
   c. Reporting and statistical analysis (e.g. ESPON, Atlas Florae Europaeae, Nordvic, ..)

Spatial Analysis and Reporting can be considered a unique item if the Grid requirements are the same (e.g. if the Grid should be based on an equal area projection).

Mapping is a specific issue because in some cases the grid is mapped or re-mapped using a conformal coordinate reference system for cartographic purposes. The Map Projections workshop already considered and selected the systems to be used for Mapping. For this reason the workshop recommends to the European Commission:

?? To reaffirm the recommendations of the December 2000 Workshop on Map Projection Systems, i.e. to use for conformal pan-European mapping at scales smaller or equal to 1:500,000 ETRS89 Lambert Conic Conformal coordinate reference system of 2001 [ETRS –LCC] that is specified by ETRS89 as datum and the Lambert Conic Conformal (2SP) map projection and to uses for conformal pan-European mapping at scales larger than 1:500,000 ETRS89 Transverse Mercator

[7] is the grid unique or is it a collection of several grids?
[8] did the grid satisfy user needs ? Low, Medium, High
[9] is the grid well documented? Low, Medium, High
[10] Sampling, Collection, Reporting, Mapping
[11] rather coarse resolution for some mountain areas definition purposes.
[12] temporal diversity - absence of integrated and comparable data (eg for Sweden)
[13] information on diversity of reference dates needed

coordinate reference systems [ETRS-TMzn], that are specified by ETRS89 as datum and the Transverse Mercator map projection.

Having said that the workshop initially focused on Grid for Data Collection and Grid for Reporting.

From a user point of view the following items were investigated.

Comparability
What Comparability really means ?
Many uses are driven by equal-area requirement, is it more important than equidistant?
Potential users are often spatial scientists (emphasis should be given to simplification of data collection or to preserve the scientific quality of the historical observations)

From a user point of view it means:

- ?? A clear distinction emerge between grids for collection and grids for analysis/reporting
- ?? Comparability means the possibility to combine data stored or collected using different approaches.

From a technical point of view:

- ?? Meta-data are clearly needed to describe grids and their definition unambiguously
- ?? Comparability can be achieved by using the same geodetic datum (e.g. using ETRS89 as defined by the Spatial Reference Systems workshop)
- ?? Comparability can be facilitated by having a standard projection system (e.g. using the standard projections defined by the Map Projections workshop)

Multi-Resolution and Multi-Purpose
When dealing with User Requirements the issues of Precision and Purposes must be considered.
In addition resampling or resolution reduction could be sometime necessary to avoid copyright or data sensitivity problems.
A hierarchical approach seems essential – basis for aggregation (e.g. for confidentiality / sensitivity, transformation between administrative levels), but, how low do you go? How many levels?
Obviously one size doesn't fit all – but it is possible to define systems which meet common needs.
We have to avoid Grid proliferation. We need to try and establish commonality but don't enforce a single grid.
A clear distinction is needed between new projects from those already running.

Location accuracy
Locational accuracy strongly depends on what is being observed. It is not a characteristic of the grid, but it is part of the metadata of specific layers.
If grids are used for sampling, it should be possible to accurately locate the points in the field with the help of topographic maps.

Distortion
There is some distortion (angles, distances) intrinsic to the grid (e.g. up to 3% in Turkey for LAEA). For applications for which this cannot be accepted, the grid-raster approach may be unsuitable.

Usability
It should be easy to use current GIS software to convert existing vector data to the grid and to convert between different grids.

Repeatability and Re-Use
This seems an implementation issues. The grid should be a sound basis for time-series requirements.
A single type of grids makes it more reusable and more efficient.
In this context Metadata are fundamental to document both grid characteristics and the process to rasterise the data originally collected.
For sampling grids, the number of points should be sufficient to allow for rotation of samples as subsets of a single constant grid.

Extent
The European grid to be used mainly for European purposes, but it can be useful also for national purposes.

The grid must be scalable (in fact the European Union is expanding and can further expand in the near future).
However the anchor point (origin) should be fixed and clearly defined at the beginning!

Other issues
Grids can be useful for sampling, but the details of the sampling techniques applied with the support of the grid do not need to be addressed in the definition of the grid.
A clear distinction is needed between theoretical grid and existing data.
Recommendations can be useful on how to fill a new proposed grid with data collected according to a different scheme.

The Geomatic Perspective

A second working group was created to provide a common definition for a grid and to identify main requirements and properties. For lack of time the working group focused on the grid to be used for Spatial Analysis and Reporting and not Data Collection.

Grid Definition (for Spatial Analysis and Reporting)

The working group found it necessary to find a common understanding of the concept of grids. A simple definition was formulated:

> ***A grid for representing thematic information is a system of regular and geo-referenced cells, with a specified shape and size, and an associated property.***

A series of requirements and properties were discussed, based on the lists of issues to be addressed as defined in the chapter "Introduction".

Requirements

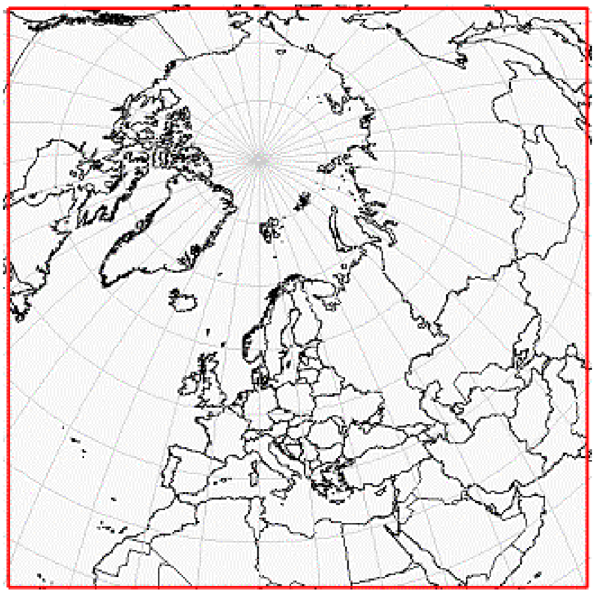
The following requirements were identified:

1. The Grid must have a common datum for geo-referencing. The datum to be used is ETRS89 as previously identified by the Spatial Reference System workshop
2. The Grid must be based on an equal area projection. Such a projection is usable for most of themes; for some kinds of mapping, for spatial assessment and for statistical purposes
3. Area of validity: Different user communities have different needs concerning a common grid. Several of the represented organisations are responsible for handling information at a Pan-European scale. The specific outer boundaries for the proposed Grid where defined to be:
   a. West: All Atlantic islands including Greenland;
   b. East: Ural mountains;
   c. South: Northernmost areas of Africa, including the southern coast of the Mediterranean Sea, including the Tripoli bay;
   d. North: to include the northern tip of Greenland, thus also covering Svalbard and polar areas.
4. Negative values in the coordinates must be avoided
5. Grid coding system
   ?? a simple system and not repeating all coordinates
   ?? possible to see where in the hierarchy of cells you are

For other purposes (e.g. Mapping) other projections may be used.

Properties
The following properties were identified for the proposed Grid:

1. The Grid should be based on the projection system Lambert Azimuthal Equal Area (ETRS-LAEA). This projection has previously been identified by the Map Projections workshop [1] as suitable for such uses. See definition in appendix 1.
2. Centre of projection: 52N, 10E (follows the recommendation of the Map Projections workshop[1])
3. False easting: 4321000,0 m, False Northing 3210000,0 m.
4. Precision: the significant number of digits to be used: Origin for the projection should have an exact location (mm precision), in practical work and operation of the grid and its coordinates number of digits should be at dm or meter accuracy.
5. Resolution of grid. Three different options were considered (but the first was selected):
6. Metric: 1,10,100,1000,10.000,100.000
7. The quad tree approach, 1,2,4,8, ….. gives a higher number of levels.
8. A mixed approach where e.g. the main focus is on the metric, but where one allows the 250 and 500 m cells
9. Grid centre point: LAEA 52N 10 E
10. Grid origin: to be defined as the south-western corner of the area of validity, see figure 1 in recommendations. This has been stipulated to be 4321000,0 m west of centre point of the projection (52N, 10 E), and 3210000,0 m south of projection centre point (52N 10 E). The location of the grid origin far to the west and south would mean that negative values in the coordinates are avoided in all foreseeable uses. The extent is large enough to cover the areas of interest. The false easting and northing values do not have to be moved. The figure below shows a quadrant of 10 000 km by 10 000 km.



11. Grid shape: rectangular and not hexagonal, more precisely square. The square shape will appear when used in the defined projection, smaller or larger distortions will appear when re-projected to other projections.
12. Grid orientation: south - north, west - east
13. Grid structure - coding system: The group did not have time available for further specifications, other working groups were also to handle this issue.

Grid Data Conversion

A second working group was created to analyse the issues related to grid conversion.
As previously defined GRID Conversions means:

- ?? Geometric transformation (e.g. change of Datum)

?? Content change

Geometric Transformation was already the subject of the Map Projections workshop that concluded: " because any change of datum is potentially introducing distortion is highly recommended to use ETRS89 a common European datum and to provide " certified" formulas and parameters on the Public domain to make the necessary transformations".
EuroGeographics and Euref have already setting-up a specific website "European Coordinate Reference System Portal (http://crs.ifag.de) managed by BKG that needs to be completed and improved in the future.

Content transformation is instead a different and more complex issue.

Scope

The various groups decided to only refer to data conversion towards grids of tiles to be treated in raster format, i.e. one figure is available for each tile of the grid. Recommendations for co-ordinate conversion of point, line, or polygon data have been widely studied in the scope of ExG G by EuroGeographics.
Conversion from point, line or polygon (vector) layers to similar layers in different spatial reference systems (Datum and projection) is widely available in GIS tools.
Conversion from raster to vector is out of the scope of the discussions.

Problems related with data conversion to a grid are different on the resolution of the original data (finer, similar or coarser). Transformation can involve disaggregation to a finer resolution and re-aggregation to a new system.

Resampling

When a raster layer of a relatively fine resolution is converted to a different grid of similar resolution, standard methods of image resampling are acceptable (nearest neighbour, bicubic convolution, etc..).

Aggregation

For transformation from small cells to large cells in a different grid system or to polygons (geographic units), simple methods, such as adding small cells with the centre inside the new cell or polygon, or simple areal weighting (allocation proportional to area) are acceptable.
National organizations should be encouraged to collect and stock geo-referenced data and with the maximum possible geographic detail.

Disaggregation

Although disaggregation can be made from statistical data on administrative units (NUTS) to a finer grid, data computation bottom-up (from detailed data to aggregated) is always preferable.
If starting data are available only for large geographical units (large cells or polygons), re-allocation of data by methods such as simple area weighting should be avoided. The search of suitable co-variables (proxies) is a keypoint.
For some data (e.g. data linked to biodiversity concerns: species and habitats/ecosystems) only available for large units, co-variables are difficult. In this case, analysis should be adapted to these units.

Who should make the conversion?

If data exist at a detailed scale and cannot be disseminated at that scale, the organization with access to these data should be in charge of aggregation to the common grid.

Is a common European grid possible?

The discussion between the participants came to the conclusion that the adoption of a common European grid for Reporting and Statistical Analysis is highly recommended and that such system should follow recommendations of previous workshops on Spatial reference Systems and Map Projections. In addition the adoption of a common system must have a minimum impact on existing systems and should be mainly considered as a way to avoid proliferation and obtain a conversion in the future (when possible and appropriate).

The complex issue of a European grid for data collection (and sampling) was considered.

Among possible obstacles related to the adoption of a common grid are the not availability of maps across Europe in a common projection systems, the need of flexibility in sampling schemas, the need of documentation and tools in support to. At the same time some communities seem sceptic that the new methods of data collection could be significantly changed in the near future (e.g. use of pda with GPS, Galileo, ..).

Mainly for these reasons and also considering the very limited time to discuss this specific issue there was no agreement about common unique strategy for data collection. This topic requires further investigation and discussion in incoming months and should be one of the topic to be addressed in the future 2nd edition of the European reference grid workhop.

So on the workshop participants agreed to focus their attention for a grid to be used only for reporting and spatial or statistical analysis. The following considerations refer only to the grid to be the used in this context.

As identified by the workshop participant, the users (existing and potential) of a European common grid are respectively:

- the National Statistical Institutes
- the Scientific Community, National Research Institutes and NGOs making research on spatial phenomena
- Institutes and organisations involved in Cross-Regional and Trans-National Spatial Planning Projects/Processes
- Regional Convention (HELCOM OSPARCOM,…)
- The International Catchments River Basin Authorities
- Environmental Impact Assessment (particularly in cross-border areas), other example could be monitoring of Natura 2000 at biogeographic level
- European TEN
- The European Commission (DG ENV, DG REGIO, DG AGRI, DG TREN, DG FISH, ESTAT, JRC …)
- The EEA and other European Agencies and Organisations

To guarantee the right management and handling of the information collected the whole data flow has to be considered. This implies various steps/phases that need to be addressed and, if possible formalised and certified in case of adoption of a unique European grid of certified quality:

1. **Data capture** - This phase concerns the way in which data are originally collected. Only if quality principles are applied since the beginning it will be possible to obtain aggregated data of certified quality. This issue relates to both the digitization process in case of data available in paper form and the conversion process in case of data directly acquired in digital form but that need to be converted before their use.

2. **Data cleaning or data validation**. Data collected are often affected by errors, imprecision and redundancies. The validation phase is a prerequisite to assess the quality of the original data. Data cleaning is a way to improve the quality, in particular if connected to the possibility to re-acquire data of lower quality.

3. **Data simplification.** This phase has been identified by the workshop as potentially critical if not well understood. In fact often the collected data are simplified to minimse the amount of information that must be handled. The simplification is driven by a specific application (user need) and don't take into account future needs that coul require the access to not-simplified data.

4. **Data management**. Accurate data collection and validation is a prerequisite for final good data but is not enough. Data management is often more critical than data collection. For example data acquired according to a specific geodetic datum are often transformed and store in a different datum without being aware that datum transformations introduce possible deformations. In addition often it is underestimated the importance to document the data and all the processes / operations that were applied. The need to compile accurate Metadata is a important aspect that need to be emphasised. Also the way to store the data often can alter their quality or limit the possibility to use and access in the future. Time stamp management is a clear eample that require a clear decision on the way to store modelise the information (e.g. requiring object modeling and unique identifier)

5. **Data sharing and interoperability**. In the context of the emerging need of distributed systems addressed within the framework of the so called Spatial Data Infrastructures, emphasis is also on the possibility to share and interoperate grids collected by different organisations. In this context the adoption of a common grid is a important step to simplify this process.

Having said that the following recommendations were agreed:

?? Original data should be maintained in the highest possible resolutions even if aggregation is required for dissemination or for particular applications.

?? The whole data flow must be considered, and the ISO standards should be applied in the future to ensure the quality of new collected data and to describe unambiguously their quality

?? To reaffirm the recommendations of the December 2000 Workshop on Map Projection Systems, i.e. to adopt ETRS89 Lambert Azimuthal Equal Area coordinate reference system of 2001 [ETRS -LAEA], for statistical analysis and display for any new project affecting Europe or cross border areas (and when a equal area grid is appropriate)

?? To ensure harmonised access to existing systems (when required) it is recommended to use appropriate documented (possibly certified) tools for data conversion and to take strong action to support the work of EUREF, EuroGeographics and the NMAs in collecting and making publicly available the definitions of various coordinate reference systems, and definitive transformation parameters between ETRS89 and national systems.

This proposed solution has several possible advantages:

- **Facilitate integration.** It will be easier to combine “disaggregated” data using a common grid (with well know characteristics and appropriate certified conversion tools) and it will be also easier to exchange data using a common “ non proprietary” data format.

- **Non Proliferation.** The adoption of a common European grid will be an obstacle toward the proliferation of incompatible grid initiatives. Independently from the obligation to use it will easily become a reference for all new projects.

- **Cross Border Areas**. A common European grid will facilitate the work not only for studies addressing the whole Europe but also for several studies on cross-border areas where there is a need to analyse and manage a territory going out of the national boundaries (e.g. the river basin management plans of the Water Framework Directive, the Trans-European Transport Network "TEN-T", the environmental impact assessment,...)

Amongst the potential disadvantages, it was considered that the obligation to adopt the system could potentially have a immediate economic/scientific impact, because could require some budget for conversion of existing grids and for some of them the possible loss of some scientific values.

Some participants underlined that existing grids are in some case regulated by existing International Conventions that will not change in a short time framework.

Standardisation and certification

The issue of standardisation and certification was also carefully investigated.
To obtain some kind of standardisation / certification the following issues must be considered:

1. The Grid Data Model should be as generic as possible.

2. The Grid Data Model should be compatible with the ISO and CEN standardizations as well as the OpenGIS implementation specifications. Following these guidelines Grid Data Model should be an objected oriented conceptual data model, addressing:
   ?? grid geometry and geometrical interpretation of the attribute data.
   Rectangular Grids, for instance, may be either *cell-based* or *corner-based*. In cell-based grids the thematic attributes are geometrically associated with the center of a grid cell and

interpreted as an averaged cell value (see lower left cell in the figure). Cell-based grids are mostly - but not only - used for categorical information (Molenaar 1998). In corner-based grids the thematic attributes are geometrically associated with a cell corner and interpreted as a value being valid for the specific point (see black points in the figure). Thus corner-based grids are mainly used to model rational scaled information.

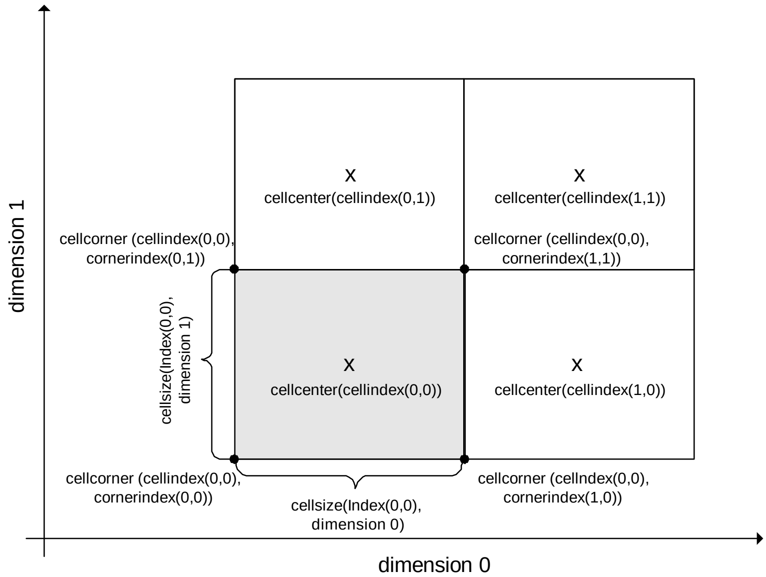
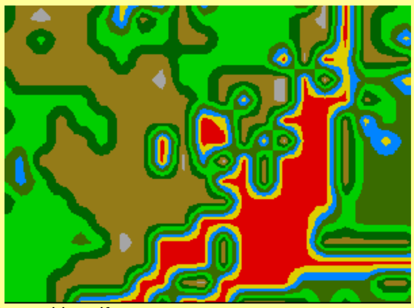


Figure: Distinguish cell-based and corner based grids.

?? Structure (including encoding, compression methods used, etc.)
?? Properties (semantics). This is a difficult part and contains reference to the various grid definitions in use.
?? Methods for aggregation and disaggregation, compressing, etc. using the benefits offered by the object oriented approach (for an example see figure).

Introduce semantic plausibility check using an object oriented approach:
Example of incorrect disaggregating as a result of a linear interpolation on categorical land cover data:

Source (water is blue, urban is red, etc.)



Derived Data with artifacts

Example of semantic plausibility check in an object oriented approach:

```
class LinearGridPointSampler : public VgPointSamplerInterface {
public:
 bool init(VgGridInterface gridIn) {
   if (grid->descriptor()->scale() != VgFeatureDescriptorInterface::Ratio) {
     error ("Using linear interpolation requires ratio scaled data");
     return false;
   }
...
```

Figure: Using an object oriented approach to avoid the application incorrect sampling methods.

- Support of 3D and temporal variations of the attribute data.
  Geological applications for instance may need 3D-Grids and temporal variations (also considering temporal resolution) is relevant in several applications. The issue of 3D identifies the need to select a common geodetical vertical datum (EVRF2000 is a suitable candidate. This issue should be debated in the next EVRS workshop).
- Multiscale and multilevel representation in a grid.
- Needed Metadata (following the ISO Standards).
- Encodings (GML, HDF, GeoTIFF, etc.).

3. Which procedures are necessary to obtain Standardisation and Interoperability?
   - How to agree upon Standardisation?
     - Workshops and Expert Group
     - Hearing in other communities
     - CEN/TC, ISO/TC, OGC
       - Are the existing Standards and Specifications a suitable and sufficient framework to describe the needed Grid Specification?
       - Introducing of new specifications when needed.
     - How to disseminate?
       - Inside the European Commission: COGI guidelines or recommendation
         - Using INSPIRE: Before the set-up of a legal framework by technical recommendations. After the set-up of a legal framework by commission decision. by comitology.
       - Provide a website with access to and information on grids available (definition, transformation, user groups, etc.); see following section.

Dissemination and Implementation - First steps required to make a common grid successful

We need to encourage data providers (National Statistical Institutes) to provide data in the common grid. This generally implies an additional burden for data providers.

To stimulate data providers two actions are needed:

- Facilitate the task, especially for teams that do not often use GIS, providing user-friendly tools for data projection, visual checking of projections, data aggregation, etc.
- Show the interest with a number of spatial analysis applications with data that can be made available in a common grid at short term.

The implementation of a website as central information point has been identified as the key tool for this purpose. This website should give free access to all needed information to support the dissemination of the common grid to the greatest possible extent. Such a website should contain at least the following elements:

- Precise definition of the grid, datum, projection parameters, indexing system.
- Recommendations on best practices for data conversion to the grid and reports on methods.
- User-friendly tool for co-ordinate transformation into the projection of the grid, including visual check of the results.
- Reports on spatial analysis performed with data on the common grid.
- Online survey on potential users to identify the most widely requested layers: population, environmental features (e.g. Natura 2000 information simplified to a grid), CLC2000, agricultural and other economical statistics, etc.).
- Providing freely available services, following international standards, and accessible in a user-friendly way, to:
  - Download grid templates in several GIS-formats (sensu stricto; without thematic information).
  - Visualize grids using an OpenGIS compliant Web Map Service supporting different scales and projections (Lat-Long, LAEA, LCC, UTMzn)
  - Transform grids from different projection systems into a common system and to visualize the results using an OpenGIS compliant Web Coordinate Transformation Service, that is linked to the Web Map Service mentioned above.

- o Search for existing data using the suggested grid and getting access to appropriate metadata, including contact points and conditions to have access to the data using an OpenGIS compliant Web Catalogue Service.

It would be good that European Institutions take the lead by inserting the links to information concerning the available pan-European or EU layers.

The implementation process should be also supported by measures that realize:

- ?? Quality checks of needed tools in form of a certification.
- ?? Dissemination of software libraries to support the installation of the needed grid tools.

Final Recommendations

Considering the recommendations of the Spatial Reference System and Map Projections workshops:

1. To reaffirm the recommendations of the November 1999 Workshop on Spatial Reference Systems:
   - ?? To adopt **ETRS89**[14] as geodetic datum and to express and store positions, as far as possible, in ellipsoidal coordinates, with the underlying GRS80[15] ellipsoid [ETRS89].
   - ?? To further adopt EVRF2000 for expressing practical heights (gravity-related).
   - ?? To identify coordinate reference systems and transformations in the format required by **International Standard 19111.**

2. To reaffirm the recommendations of the December 2000 Workshop on Map Projection Systems, i.e. to adopt the following map projections to supplement the ellipsoidal system:

- ?? To adopt ETRS89 Lambert Azimuthal Equal Area coordinate reference system of 2001 [ETRS-LAEA], for statistical analysis and display.
- ?? To adopt ETRS89 Lambert Conic Conformal coordinate reference system of 2001 [ETRS-LCC] for conformal pan-European mapping at scales smaller or equal to 1:500,000.
- ?? To adopt ETRS89 Transverse Mercator coordinate reference systems [ETRS-TMzn], for conformal pan-European mapping at scales larger than 1:500,000.

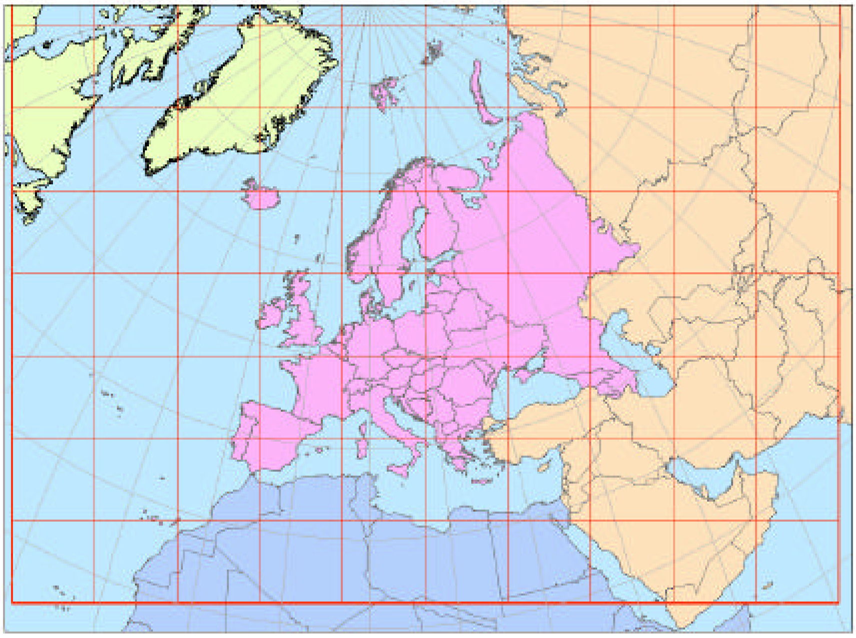


Figure 1: The LAEA extent

Considering that

- ?? A specific system for grid point seems not necessary and for storing points coordinates it should be applied the first recommendation,
- ?? A hexagonal grid is not supported by the current conception of raster mode (as implemented in software available on the market for grid analysis),
- ?? Efficient Spatial Indexing technology is now available (a quadtree structure is no more a prerequisite for efficient data handling),
- ?? Equal area grid based on geographical coordinates (e.g. authalic latitudes) have not been considered because such kind of grid will be difficult of handling with on the user level and specially at the data capture level[16]

[14] European Terrestrial Reference System 1989

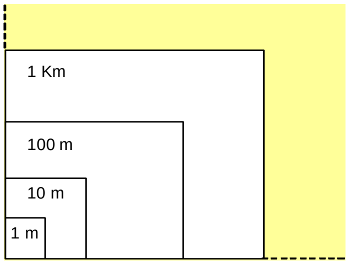
[15] Geodetic Reference System 1980

The workshop also recommend:

3. To adopt a common European Grid Reference System for Reporting and Statistical Analysis. The system should be able to store regular grids and should be designed as reference for future Grids related to European territory. The system must satisfy the following principles:

    ?? The system should be simple for users (**easy to manipulate**) and should be designed in a way that GIS system (in the market) can support it.

    ?? The system should be **hierarchical**. This will allow data storage at different levels of resolution. This structure should be linked to the Coding System and should make use of Spatial Indexing capabilities of the Modern Geo-Spatial Data Bases. ***A hierarchical metric structure is proposed for testing.***

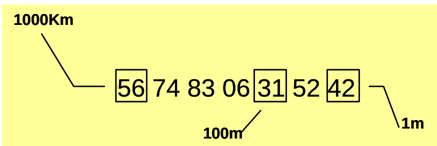


Hierarchic principle of data structure

?? The system should adopt a **Unified European Grid Coding System**. This is a strict requirement for the interoperability of distributed GRID databases and as well to support the capability to link applications within Europe

o A ***Coding System was originally proposed*** by Albrecht Wirthmann during the workshop. Successively during the consultation phase a second proposal was submitted by Mark Greaves ***for testing and adoption.***

Given the "raw" coordinates **5780354 6436122** the full code will be "56 74 83 06 31 52 42"



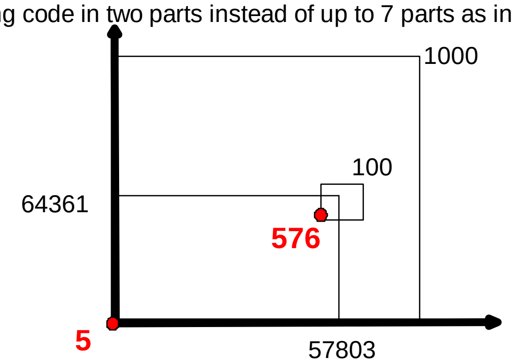
Cell Square	**System 1 -** *proposed by Albrecht Wirthmann* **Cell Code**	**System 2 -** *proposed by Mark Greaves* **Cell Code**
1000 km	56	5 6
100 km	56 74	57 64
10 km	56 74 83	578 643
1 km	56 74 83 06	5780 6436
100 m	56 74 83 06 31	57803 64361
10 m	56 74 83 06 31 52	578035 643612
1 m	56 74 83 06 31 52 42	5780354 6436122

The system 1 goes against the convention of quoting eastings followed by northings but without bringing any advantages elsewhere such as a reduction in the number of digits. The system 1 has an inherent hierarchy that reflects the hierarchy of the defined grid. With the coding of system 1 it is easy to aggregate data from a lower to the higher level simply by stripping trailing digits. System 1 is in line with conventional statistical coding systems, which append additional figures or characters for defining a new hierarchical

[16] Considering that Equal Area is important, but also Equal Distance and Equal Angles are relevant a grid in geographical coordinate is less appropriate than the selected one.

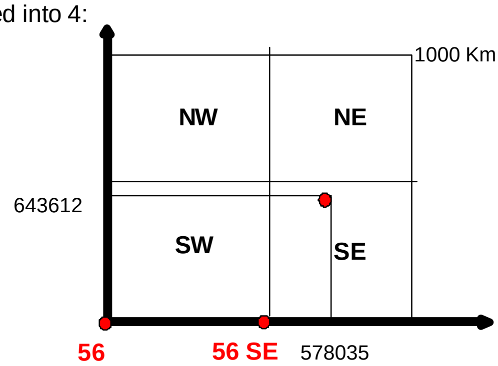
level. By traversing the figures from left to right, the user zooms from the top level to the specific cell on the lowest level. However, it may be more difficult to derive co-ordinates from the code than in system 2. On the other hand, code and co-ordinates are conceptionally different items.

The system 2 follows the more conventional eastings followed by northings approach while keeping code in two parts instead of up to 7 parts as in the other system.



In addition to those proposals Andrus Meiner suggests to make more explicit the resolution level indicator being part of cell code. Assuming the hierarchy of grid will be determined by resolution levels (7 x edge cell length) and highest resolution (level 1) will be 1m. Cell codes could have the indicator of the level added to cell number pair e.g. **756** means cell no 56 on 7th fixed level of resolution and **65764** means cell no 5764 on 6th fixed level of resolution.

With the addition of a "quadrant" (NE, SE, SW, NW) each of the above squares can be further divided into 4:



	System 1 - *proposed by Albrecht Wirthmann*	**System 2 -** *proposed by Mark Greaves*
Cell Square	**Cell Code**	**Cell Code**
1000 km	56	56
500 km	**56 SE**	**56 SE**
100 km	56 74	57 64
50 km	**56 74 SE**	**57 64 SE**
10 km	56 74 83	578 643
5 km	**56 74 83 NW**	**578 643 NW**
1 km	56 74 83 06	5780 6436
500 m	**56 74 83 06 SW**	**5780 6436 SW**
100 m	56 74 83 06 31	57803 64361
50 m	**56 74 83 06 31 SE**	**57803 64361 SE**
10 m	56 74 83 06 31 52	578035 643612
5 m	**56 74 83 06 31 52 SW**	**578035 643612 SW**
1 m	56 74 83 06 31 52 42	5780354 6436122

Lars Bernard considers that this solution it is not that easy to be interpreted by machines and also a bit inflexible. In alternative he proposes a Byte Code (00 01 10 11) for (NE, SE, SW, NW). This would give the same information and is more machine readable (as therefore all parts of the code are numbers) and easy to extent for higher resolutions.

	System 1 - *proposed by Albrecht Wirthmann (Bernard revision)*	**System 2 -** *proposed by Mark Greaves (Bernard revision)*
Cell Square	**Cell Code**	**Cell Code**
1000 km	56	56
500 km	**56 01**	**56 01**
100 km	56 74	57 64
50 km	**56 74 01**	**57 64 01**
10 km	56 74 83	578 643
5 km	**56 74 83 11**	**578 643 11**
1 km	56 74 83 06	5780 6436
500 m	**56 74 83 06 10**	**5780 6436 10**
100 m	56 74 83 06 31	57803 64361
50 m	**56 74 83 06 31 01**	**57803 64361 01**
10 m	56 74 83 06 31 52	578035 643612
5 m	**56 74 83 06 31 52 10**	**578035 643612 10**
1 m	56 74 83 06 31 52 42	5780354 6436122

Albrecht Wirthmann would not recommend the use of the binary system because it would not be possible to distinguish between regular codes and quadrant codes. This would lead to confusion and potential miscalculation. Instead, I would propose a coding with “A”, “B”, “ C” , “ D” for different quadrants in order to save characters (A=NW, B=NE, C=SW, D=SE). The code is considered as an ID and would therefore be treated as character code. Otherwise there would be a risk of losing heading zeros**.**

?? The system should have a **clear and simple relation to the coordinate reference systems recommended** by the Spatial Reference and the Map Projections workshops in Marne la Vallee (1999, 2001).

?? The purpose of the European Grid Reference System is **primarily for analysis**, and **inventorying** of phenomena with a geographic reference. For this reason the coverage must be uniform and that every element of area must have an equal probability of entering the system. This suggests that the European Territory should be partitioned into **units of equal area**.

?? For the reasons above **it is proposed to build the system using the European Coordinate Reference System ETRS-LAEA.**

?? In building the system the **quality principles described in ISO 19113-11915** should be followed.

?? **Time stamp is a prerequisite of the system.**

?? The GRID Data model should be documented and made available using XML schema.

?? The format of GRID data outputs should be based on a non proprietary open format.

?? **Metadata are a indispensable component** of any future GRID system based on the European Grid Reference System Metadata should be followed ISO specifications and produced both to describe each specific Grid (Grid- Metadata) and to describe information related to a specific unit of the Grid (Record – Metadata).

The workshop further recommend:

4. To make **possible to convert from existing grid or polygon structures** used and back again, it is highly recommended to generate data from the original detailed information when possible

5. To test for a period of one year ETRS –LAEA with the aim to demonstrate benefits of the proposed solution, identify and eventually develop tools, establish technical guidelines and best practice examples to support the convergence of existing grids or new future projects making use of European grids and to help in **ensuring the future on-line interoperability of existing Grid systems** at European and National level (GRID Net) by providing examples of best practices and technical guidelines to be followed in establish conversion/transformation procedures.

6. To support the technical development of the proposed solution after the workshop (in collaboration with the Nordvic project that will be used as Test Bed of the proposed standard).

7. To continue the process of educating the users of geographic information in the complex issues associated with coordinate reference systems, map projections, grids, transformations and conversions, including working with software and system suppliers to enable 'on the fly' transformations between commonly-used coordinate reference systems.

How can convergence in the future be achieved?

The discussion then focused on the measures to be accomplished in near future to assess the impact of the adoption of the proposed grid, to identify and remove any eventual bottlenecks and facilitate the use through the preparation of technical guidelines and the setting-up of all components and services needed.

For this reason the discussion was focused on setting-up a draft Action Plan for the European Grid initiative as originally foreseen.

Action Plan

1. Disseminate results and involve all stakeholders to achieve a broader consensus about the selected standards. The responses of the following communities should be coordinate by the respective umbrellas, organisations ,..
   a. National Statistical Institutes (responsible : Nordvic Project coordinator or Eurostat)
   b. ESPON Network (responsible : ESPON Coordinator)
   c. National Mapping Agencies (responsible: EuroGeographics)
   d. EUREF (responsible : BKG)
   e. National Geological Institutes (responsible : EuroGeoSurveys)
   f. EIONET and ETCs (responsible : EEA)
   g. National Soil Institutes (responsible : ESB Net + JRC-IES-SW unit)
   h. CAP requirements (responsible : JRC-IPSC-MARS unit)
   i. GI community in a broader sense (responsible : EUROGI)
   j. Research Organisation such as EuroSDR and AGILE (responsible : JRC-IES-LM unit)
   k. European Commission (responsible : COGI, GISCO User Committe) ...

2. Setting up a specific Test Bed including the Demonstrator making profit of the on going development of the Nordvic Project (responsible : Nordvic Project coordinator)
   a. The Nordvic team should prepare a Action plan for integration (responsible : Nordvic Team, Deadline: end 2003)
   b. The candidate partners to be involved in the test bed having European or National grid systems in place should be identified (responsible : All workshop participants, Deadline: end January 2004)

c. Link and coordination with standardisation bodies including careful evaluation of proposed ISO, OGC standard models for Grid (responsible : JRC-IES-LMU)

   i. Workshops / expert group

   ii. Hearing in other communities

   iii. ISO TC 211 – OGC, CEN/TC 287

   iv. Introducing new specs when needed

d. A first version of the prototype system should be available for discussion at mid of June. It could be presented in the occasion of the 10th EC GI-GIS workshop

e. The final version of the Prototype System should be available at the end of 2004

3. The Information System for European Coordinate Reference Systems –CRS Internet Portal - developed by BKG, EUREF and EuroGeographics should be improved and made available for the test base.

   a. It will be important to collect feedback from Users, GIS Industry and Application providers. Such feedback should make possible to identify possible areas of improvement

   b. The current system needs to be revised to better support interoperable services such as for example Web coordinate transformation services ISO compliant

4. The second edition of the European Reference Grid should be organised in about one year when the results of the Nordvic project will be consolidated. The topics of the second edition should be identified. The following topics are currently proposed (**New topics to be proposed by all during the broad consultation)**:

   a. European Reference Grid for Data Collection

   b. How can convergence in the future be achieved

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8. Waldo R. TOBLER, Numerical Approaches to Map Projections
9. Waldo R. TOBLER, Local Map Projections
10. Waldo R. TOBLER and Zi-tan CHEN, A Quadtree For Global Information Storage

Appendix 1: Description sheet for ETRS-LAEA, with details and structure following ISO standards. (As specified by the Map projection work shop 2000)

ETRS89 Lambert Azimuthal Equal Area Coordinate Reference System (ETRS-LAEA)

The European Terrestrial Reference System 1989 (ETRS89) is the geodetic datum for pan-European spatial data collection, storage and analysis. This is based on the GRS80 ellipsoid and is the basis for a coordinate reference system using ellipsoidal coordinates. For many pan-European purposes a plane coordinate system is preferred. But the mapping of ellipsoidal coordinates to plane coordinates cannot be made without distortion in the plane coordinate system. Distortion can be controlled, but not avoided.

For many purposes the plane coordinate system should have minimum distortion of scale and direction. This can be achieved through a conformal map projection. The ETRS89 Transverse Mercator Coordinate Reference System (ETRS-TMzn) is recommended for conformal pan-European mapping at scales larger than 1:500 000. For pan-European conformal mapping at scales smaller or equal 1:500 000 the ETRS89 Lambert Conformal Conic Coordinate Reference System (ETRS-LCC) is recommended.

With conformal projection methods attributes such as area will not be distortion-free. For pan-European statistical mapping at all scales or for other purposes where true area representation is required, the ETRS89 Lambert Azimuthal Equal Area Coordinate Reference System (ETRS-LAEA) is recommended.

The ETRS89 Lambert Azimuthal Equal Area Coordinate Reference System (ETRS-LAEA) is a single projected coordinate reference system for all of the pan-European area. It is based on the ETRS89 geodetic datum and the GRS80 ellipsoid. Its defining parameters are given in Table 1 following ISO 19111 Spatial referencing by coordinates.

Table 1 – ETRS-LAEA Description

Entity	Value
CRS ID	ETRS-LAEA
CRS alias	ETRS89 Lambert Azimuthal Equal Area CRS
CRS valid area	Europe
CRS scope	CRS for pan-European statistical mapping at all scales or other purposes where true area representation is required
Datum ID	ETRS89
Datum alias	European Terrestrial Reference System 1989
Datum type	geodetic
Datum realization epoch	1989
Datum valid area	Europe / EUREF
Datum scope	European datum consistent with ITRS at the epoch 1989.0 and fixed to the stable part of the Eurasian continental plate for georeferencing of GIS and geokinematic tasks
Datum remarks	see Boucher, C., Altamimi, Z. (1992): The EUREF Terrestrial Reference System and its First Realizations. Veröffentlichungen der Bayerischen Kommission für die Internationale Erdmessung, Heft 52, München 1992, pages 205-213 - or - ftp://lareg.ensg.ign.fr/pub/euref/info/guidelines
Prime meridian ID	Greenwich
Prime meridian Greenwich longitude	0°
Ellipsoid ID	GRS 80

Table 1 – ETRS-LAEA Description	
Entity	**Value**
Ellipsoid alias	New International
Ellipsoid semi-major axis	6 378 137 m
Ellipsoid shape	true
Ellipsoid inverse flattening	298.257222101
Ellipsoid remarks	see Moritz, H. (1988): Geodetic Reference System 1980. Bulletin Geodesique, The Geodesists Handbook, 1988, Internat. Union of Geodesy and Geophysics
Coordinate system ID	LAEA
Coordinate system type	projected
Coordinate system dimension	2
Coordinate system axis name	Y
Coordinate system axis direction	North
Coordinate system axis unit identifier	metre
Coordinate system axis name	X
Coordinate system axis direction	East
Coordinate system axis unit identifier	metre
Operation ID	LAEA
Operation valid area	Europe
Operation scope	for pan-European statistical mapping at all scales or other purposes where true area representation is required
Operation method name	Lambert Azimuthal Equal Area Projection
Operation method formula	US Geological Survey Professional Publication 1395, "Map Projection – A Working Manual" by John P. Snyder.
Operation method parameters number	4
Operation parameter name	latitude of origin
Operation parameter value	52° N
Operation parameter name	longitude of origin
Operation parameter value	10° E
Operation parameter remarks	
Operation parameter name	false northing
Operation parameter value	3 210 000.0 m
Operation parameter remarks	
Operation parameter name	false easting
Operation parameter value	4 321 000.0 m
Operation parameter remarks	

With these defining parameters, locations North of 25º have positive grid northing and locations eastwards of 30º West longitude have positive grid easting. Note that the axes abbreviations for ETRS-LAEA are Y and X whilst for the ETRS-LCC and ETRS-TMnz they are N and E.

Conversion formulas

To derive the projected coordinates of a point, geodetic latitude (?) is converted to authalic latitude (ß). The formulas[17] to convert geodetic latitude and longitude (?,?) to northing (Y) and easting (X) are:

northing, $Y = FN + (B / D) . \{(\cos ß_0 . \sin ß) - [\sin ß_0 . \cos ß . \cos (? - ?_0)]\}$

easting, $X = FE + \{(B . D) . [\cos ß . \sin (? - ?_0)]\}$

where

$B = R_q . (2 / \{1 + \sin ß_0 . \sin ß + [\cos ß_0 . \cos ß . \cos (? - ?_0)]\})^{1/2}$
$D = a . [\cos ?_0 / (1 - e^2 \sin^2 ?_0)^{1/2}] / (R_q . \cos ß_0)$
$R_q = a . (q_p / 2)^{1/2}$
$ß = \arcsin (q / q_p)$
$ß_0 = \arcsin (q_0 / q_p)$
$q = (1 - e^2) . ([\sin ? / (1 - e^2 \sin^2 ?)] - \{[1/(2e)] . \ln [(1 - e \sin ?) / (1 + e \sin ?)]\})$
$q_0 = (1 - e^2) . ([\sin ?_0 / (1 - e^2 \sin^2 ?_0)] - \{[1/(2e)] . \ln [(1 - e \sin ?_0) / (1 + e \sin ?_0)]\})$
$q_p = (1 - e^2) . ([1 / (1 - e^2)] - \{[1/(2e)] . \ln [(1 - e) / (1 + e)]\})$

and where

a is the ellipsoidal semi-major axis, 6378137.0 metres
f is the flattening of the ellipsoid where 1/f = 298.2572221
e is the eccentricity of the ellipsoid where $e^2 = 2f - f^2$
? is the latitude of the point to be converted, positive if North and negative if South of the equator
? is the longitude of the point to be converted, positive if East and negative if West of the prime meridian (Greenwich)
$?_0$ is the latitude of the natural origin
$?_0$ is the longitude of the natural origin (with respect to the prime meridian Greenwich)
X is the easting measured from the grid origin
Y is the northing measured from the grid origin
FE is the false easting, the eastings value assigned to the natural origin
FN is the false northing, the northings value assigned to the natural origin

The reverse formulas to derive the geodetic latitude and longitude of a point from its northing and easting values are:

$? = ß' + [(e^2/3 + 31e^4/180 + 517e^6/5040) . \sin 2ß'] + [(23e^4/360 + 251e^6/3780) . \sin 4ß'] + [(761e^6/45360) . \sin 6ß']$

$? = ?_0 + \arctan \{(X-FE) . \sin C / [D. ? . \cos ß_0 . \cos C - D^2. (Y-FN) . \sin ß_0 . \sin C]\}$

where

$ß' = \arcsin\{(\cos C . \sin ß_0) + [(D . (Y-FN) . \sin C . \cos ß_0) / ?]\}$
$C = 2 . \arcsin(? / 2 . R_q)$
$? = \{[(X-FE)/D]^2 + [D . (Y - FN)]^2\}^{1/2}$

and D, R_q, and $ß_0$ are as in the forward equations.

[17] Source: US Geological Survey Professional Publication 1395, " Map Projection – A Working Manual" by John P. Snyder.

Examples

ETRS89:	geodetic latitude:	50°00'00.000" N	geodetic longitude:	5°00'00.000" E
ETRS-LAEA:	northing (Y):	m	easting (X):	m
ETRS89:	geodetic latitude:	60°00'00.000" N	geodetic longitude:	5°00'00.000"E
ETRS-LAEA:	northing (Y):	m	easting (X):	m

Caution

All EU projections are based on ETRS89 datum and therefore use ellipsoidal formulas. In some GIS applications the Lambert Azimuthal Equal Area method is implemented only in spherical form. Geodetic latitude and longitude must not be used in these spherical implementations. To do so may cause significant error (up to 15 km !). Use the example conversions above to test whether software uses appropriate formulas.

Appendix 2: ABSTRACTS

The ICP-Forests sampling scheme

Javier Gallego

The International Co-operative Programme on European Forest (ICP-Forest) was launched in the 80's as a response to the concern on the impact of pollution on the health state of forest. Tree defoliation and decolouration of leaves is observed every year on a sample of plots. The sampling scheme is systematic, theoretically based on a regular grid of 16 km. The practical application of the sampling rules has been rather heterogeneous in different countries. We analyse the difficulties arisen to use this sample for statistical or spatial analysis.

LUCAS: monitoring the European Union territory using a grid approach

Manola Bettio, Maxime Kayadjanian

LUCAS is a pilot project launched by Eurostat in close co-operation with the DG Agriculture and the Joint Research Centre. LUCAS is an area frame statistical survey that aims at obtaining harmonised data at EU level on land use, land cover and environment. The survey consists in the ground visit in springtime of about 100 000 points sampled according to a regular grid.

The paper gives an overview of the methodology and the results of the survey that was carried out in 2001 and in 2003. In more details, the sampling plan design, its geometrical quality as well as precision of point location on the ground are reviewed.

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Towards participatory approaches to a Multiscale European Soil Information System

Nicola Filippi, Panagos Panos, Borut Vrscaj

The multi-functionality of soils, as medium for biomass production, biochemical cycling, water storage and its filtering and redistribution, as well as gene pool and habitat of a high diversity of life forms, is increasingly being understood and valued. In the EC Communication " Towards a Thematic Strategy for Soil Protection" it is recognised that there is an actual and future need for better information on the soil resources, and that the current state of soil resource information is often incomparable between member states and regions.

EU regional policy and grids

Hugo Poelman

In EU regional policy, geographic data are mainly used within the framework of statistical (NUTS) regions. Nevertheless, traditional sources of (socio-economic) data have to be complemented by indicators, developed out of georeferenced data sources. Moreover, specific territories need to be defined and analysed at various non-administrative levels. Hence, grids can be used as a framework for data collection and analysis. After raster-based analysis, results will often have to be converted to the NUTS framework. Recent grid uses include the definition process of mountain areas, various uses of Corine Land Cover data, and the development of regional typologies by the ESPON programme. Future grid systems will have to enable efficient aggregation and disaggregation towards and from the NUTS classification. Moreover, the main European-wide raster data sets should be defined in a coherent way, and should be compatible with register-based national statistical systems.

The ESPON 2006 Programme

Volker Schmidt-Seiwert

The ESPON progamme is implemtented within the framework of the Community Initiative INTERREG III. Thematic oriented transnational project groups (20 are running in the very moment) deal with the diagnosis of the principal territorial trends, difficulties and potentials within the European territory in order to improve the spatial co-ordination of sector policies. The projects are roughly devided into

- Thematic studies on important spatial development
- Policy impact studies
- Coordinating cross-thematic studies

The final results will produce cartographic pictures of the major territorial disparities and of their respective intensity; a number of territorial indicators and typologies assisting a setting of European priorities for a

balanced and polycentric enlarged European territory; some integrated tools and appropriate instruments (databases, indicators, methodologies for territorial impact analysis and systematic spatial analyses).
The range of topics from urban-rural relations, accessibillity, structural funds and CAP to cultural assets just to mentioed a few, show, that regional statistical data only will not satisfy the demand on data. Geographical data (grids) must be used in this cases to garantuees at first to get data at all and second in a harmonized form on the European territory.

Current use of spatial reference grids in EEA

Andrus Meiner
Presentation will give an overview of current use of spatial reference grids in EEA main products: EMEP grids for air pollution and deposition, UTM based grids for biodiversity mapping, 10km grids for land cover assessments, lat/long grids for variety of other uses

Atlas Florae Europaeae – Mapping European Vascular Plants with 50X50 Km grid

Pertti Uotila and Raino Lampinen
Atlas Florae Europaeae (AFE) is a pan-European project for mapping the distribution of the vascular plants of the continent. The project was launched in 1965, and has so far produced 3270 grid maps of the distribution of European vascular plants in 12 printed volumes (1972 – 1999), covering c. 20% of all the European vascular plants. The project has collaborators throughout Europe, and the secretariat editing the data is located in Helsinki.
The UTM projection and the Military Grid Reference System (MGRS) were chosen for the mapping since in the mid 1960's there were printed maps showing the MGRS grid for the whole continent. The AFE grid was adopted by several other European mapping projects — but all of these did this in a slightly different way. The grid system has recently been revised in co-operation with several faunistic mapping projects and the European Topic Centre on Nature Conservation and Biodiversity. The grid cell size in AFE is mostly 50 x 50 km, with special adjustments at the UTM zone boundaries in order to decrease the size variation between the cells. In the old AFE grid system there were lots of deviations from the general pattern (e.g., hundreds of coastal grid cells with little land joined to neighbouring cells; long peninsulas, certain isolated islands, some mountains and Istanbul were given own grid cells). There were also several minor (coastal areas) or major (Greece, Svalbard) changes in the old grid system throughout the years. Altogether, in the old system there were 4419 grid cells with land in Europe. The geodetic datum was not specified. In the revised grid system there are 4748 grid cells with land in Europe. The present grid extends over terrestrial and marine areas following a certain pattern, without any deviations for coasts, islands, peninsulas, mountains, towns etc. A new solution has been adopted for the treatment of partial slices at the UTM zone boundaries, and the revised grid uses the WGS84 datum.
The grid system has met the needs of AFE in the production of plant distribution maps, but is, even after its recent revision, still far from satisfactory for statistical analysis. At the moment the AFE data collected in or converted to the new grid system can be directly combined with the faunistic atlas datasets, but linking it with other kind of data is tedious. The grid cell size still varies considerably, and the "edge problem" still exists at the UTM zone boundaries. Adopting the proposed "Eurogrid" would strongly conflict with the existing data. The editors of AFE and the faunistic atlas projects have typically received the data from their national collaborators at the 50 x 50 km accuracy, mostly with no detailed background information. Thus the conversion of the existing data of the biological atlas projects to the "Eurogrid" would be quite difficult.

The TANDEM project

Lars Backer
The Consortium of three members (from Statistics Finland, Statistics Sweden and the Office of National Statistics, UK) have studied the feasibility of a common base for statistics across Europe. The report of the first phase of the study is published via Eurostat web-pages (http://europa.eu.int/comm/eurostat/Public/datashop). The second phase of the study will be reported by the end of November 2003. The presentation will cover the basic ideas of the Tandem consortium including a vision to develop a System of Small Area Statistics integrated into the European Spatial Data Infrastructure. The focus on the presentation will be on ideas concern-ing a regular tessellation approach (grid approach).

Mapping and analyzing the distributions of plant species across the countries of Europe - an overview of research schemes and grid systems in use

Harald Niklfeld

The manifold distribution patterns of native plant species have since long attracted the interest of botanists, biogeographers, ecologists, and people concerned with conservational issues, and have become subject to a broad variety of comparative and causal analyses. For the purpose of obtaining appropriate knowledge of these distribution patterns on a detailed scale, first approaches to cover whole countries by systematic and organized floristic mapping schemes started in 1902 in the Netherlands and in 1904 in Denmark. During the last decades a steadily increasing number of such projects were launched, and partly already finished, throughout many regions of Europe - parts of countries, whole countries, or groups of neighbouring countries. Thousands of botanists were, and are, engaged in methodical field-work (most of them on a voluntary basis), computer databases were constructed and filled with many millions of records, and a considerable number of comprehensive distribution atlases have been published, or will be published in the future. At present, wide and coherent territories, particularly of northern, western and central Europe, but also some regions of Spain and Italy are already covered by such atlases.

The grid reference system used for CGMS

Giampiero Genovese

TREES sampling schema

Javier Gallego

The TREES Project made an estimation of the change in tropical rainforest between 1990 and 1997. Forest change was carefully mapped and quantified on a sample of 100 sites. Each site corresponded to a Landsat-TM frame or quarter of frame. The tropical belt was stratified using a coarse forest map and deforestation hot spots delineated by a group of regional experts. The units for stratification were hexagonal tiles of a spherical tessellation. Hexagons were linked with Landsat observation units. The sampling scheme allowed the computation of forest change estimates with their precision and confidence intervals. However the use of hexagonal tessellations, that can provide a good tool for global sampling frames, was not necessary in this case and it introduced additional complication and reduced the efficiency of the procedure.

Aggregation[18] and disaggregation[19] of statistics

Erik Sommer

This paper presents the work with statistical grid data in Denmark and an introduction to the work with grid data in a Nordic context the work towards a common geographical base for statistics across Europe.

Kort & Matrikelstyrelsen – KMS (the National Survey and Cadastre) and Statistics Denmark have in 2001 established and in 2002 launched a national system of vector grid, the so-called National Square Grid[20] Denmark. The grid consists of five vector grids with different cell sizes (100 meter, 250 meter, 1 km, 10 km, 100 km). The National Square Grid – Denmark is constructed in a rectangular system of coordinates, but it has been decided that it should refer to the UTM-projection, zone 32. The datum used is EUREF89. Every cell is defined and given its name from the Lower Left coordinates. The Origin of the the 100 km grid is North = 6.000.000, East = 400.000.

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[18] Aggregation - For transformation from small cells to large cells in a different grid system or to polygons (geographic units), simple methods, such as adding small cells with the centre inside the new cell or polygon, or simple areal weighting (allocation proportional to area) are acceptable. National organizations should be encouraged to collect and stock geo-referenced data and with the maximum possible geographic detail.

[19] Disaggregation - Although disaggregation can be made from statistical data on administrative units (NUTS) to a finer grid, data computation bottom-up (from detailed data to aggregated) is always preferable. If starting data are available only for large geographical units (large cells or polygons), re-allocation of data by methods such as simple area weighting should be avoided. The search of suitable co-variables (proxies) is a keypoint.

[20] Kort & Matrikelstyrelsen – KMS (the National Survey and Cadastre) and Statistics Denmark have in 2001 established and in 2002 launched a national system of vector grid, the so-called National Square Grid – Denmark. Specification can be found on website www.kms.dk.

The National Square Grid – Denmark can be transforemed into other projections than UTM32\EUREF89 when using the correct transformation tools. Whenever such transformations take place, the celles cease to be identical of size.
Statistics Denmark have set up guidelines for disclosure of statistical data. There must be a minimum number of 20 households in a cluster of cells in order to release statistical data. In order to make clusters the customers can acquire a dataset with the number of households and persons in each cell. There are to general options when clustering grid cells, either “proximity” (neighbour cells) or “optimizing” (finding gridcells with equal value without necessarily being a neighbour”).

The European Datum ETRS89 and related map projections

Johannes Ihde

With the Spatial Reference Workshop 1999 and the European Map Projection Workshop 2000 the basis for the introduction of uniform European coordinate reference systems was established. Four coordinate reference systems are intended for the use of referencing of geoinformation in the European Commission. In a cooperation between EuroGeographics, EUREF and BKG an information system processing was made for the description of national coordinate reference systems and the agreed European coordinate reference systems in a CRS internet portal. The parameter for the transformation and coordinate transformation are also available by meter accuracy. Thereby a contribution for a uniform European geodata infrastructure is available. A description of ETRS89 and the agreed map projection as well as of the CRS internet portal are following.

Transformations between geodetic datum, map projections and geographical grids in geodesy and geoinformation

Johannes Ihde

The Transformation of coordinates, which refer to different geodetic datum and map projections, is a standard task for the referencing of geoinformation and one of the basic tasks of geodesy. Thereby we essentially fall back on point information. The transformation of information, which is dedicated to grids/compartiments, comes up to the physical geodesy. Principles of transformation, conversion of coordinates and information transfer, that are dedicated to grids/compartiments, are being described and discussed.

Design and introduction of a new map projection and grid system for Ireland

Ken Stewart

Coordinating the creation of a reference system on the 25 MS in agriculture

Simon Kay

The Common Agricultural Policy manages the payment of subsidies to farmers for the cultivation of land. In return for payment, farmers must identify their fields in national GIS databases.
By 31st Dec 2004, 25 countries will have implemented this approach, and nearly all (23) will use image data as a primary data sources.
These raster datasets are both:

- an important source for many grid based surveys,
- as well as an important consideration in the technical realignment of raster/gridded data with new, pan-European specifications

Grid estimation. Application to datum distortion modelling

Javier González-Matesanz

In this communication, three methods of estimating grid values from scattered data are presented: Rubber Sheeting, Minimum Curvature Surfaces and Least Squares Collocation. These methods have been employed successfully in grids of datum transition models in other countries as Canada or Australia. The first part of this presentation consists on explaining why classical methods are not valid to allow an effective change between classical datums (as ED50) and ETRS89, a datum distortion concept is needed in grid form. Secondly, how the spatial techniques mentioned above to predict datum shifts from scattered data have been used in the Spanish network. In order to proof the goodness of the three prediction models some tests with independent set of points are shown applied to two areas. Finally a conclusion about grid formats for distributing datum distortion models.The information hold in the grid can be used to improve any other grids with datum shifts information.

In search of an infrastructure for spatial analysis

Lars Backer

In this paper we would like to discuss the special requirements on a system of grids from a users perspective, represented by spatial analysts working with statistics. There is a need for a clear awareness of "real" user needs in terms of spatial data. We suggest that inductive methods are needed that will reveal the need for both descriptive and analytic information for the design and implementation of central overriding projects like spatial development. In current efforts to provide a effective SDI for Europe (as in the case of INSPIRE), we stress the need for standard infrastructures suitable for spatial analysis. Much analytical work in this and related areas are based on information collected as points. In some cases however, data are collected as aggregations to a give set of small areas (irregular tessellations), that in turn may be analysed as clusters of (gravity-) points. For analytical purposes, irregular tessellations of this type are are too large to be presented as surfaces, and are therefore generally represented as point clusters. A standard common system of grids for Europe represents therefore the main infrastructure needed for (point-based) spatial analysis. Its definition will therefore involve a series of design choices that should be based on the role they play in these users production processes (e.g.: data capture, data cleaning and pre-processing, analysis, integration with other data and dissemination etc.) Grids are widely used in all connections where point- based data are used as raw material for spatial analysis. We would like to suggest that the question of a system of grids suitable for spatial analysis could be discussed from a broader perspective (in windows larger than 1000 by 1000 km?) or a more narrow, limited perspective (involving windows smaller that 1000 by 1000km?).

Dissemination of grid-based statistics in Finland and a case study about dissemination of multinational grid data of the four Nordic countries

Marja Tammilehto-Luode

Statistics Finland has produced and disseminated data by geo-referenced 1 km x 1km grid squares (or smaller) more than ten years. Users of grid-based data have increased continuously. The presentation will include review of how the grid data is produced and examples of studies where this kind of data has been applied. The other part of the presentation will describe an effort to harmonise grid-based data of the four Nordic countries of Finland, Denmark, Norway and Sweden. It will cover an effort to compile a multinational grid-based reference data and an effort to define common terms of releasing such a data. The experiences are based on the work of the Forum of the Nordic Geo-statistics and on the results of a survey made by Statistics Finland in December 2002.

Modifiable areal units: Transforming data from one to another geographical system.

Javier Gallego

Data associated to territorial units, such as socio-economic, demographic or epidemiological data, can lead to different conclusions if the territorial units change. For example the correlation between variables often increases when data are aggregated to larger units.

Transforming data from an areal system to a different one often involves two steps: disaggregation into small units and re-aggregation. Disaggregation is always possible, but generally introduces a considerable inaccuracy. The quality of disaggregation depends above all on the quality of covariables used to guide the attribution of values to different units. If no covariables can be used, simple areal weighting is possible, but this option is not recommended in general.

Direct transformations between neighbour TM systems

Jorge Teixeira Pinto

In boundaries regions overlapping adjacent Transverse Mercator zones there are, sometimes, the need to transform coordinates of points from one TM zone to the other. If the two TM coordinates share the same geodetic Datum, this transformation is normally performed in a two step conversion: from TM (zone1) to geodetic and from geodetic to TM (zone2). These conversions can be made without uncertainty, preserving, the initial coordinates precision. But if the TM zones doesn't share the same Geodetic Datum, an intermediate step must be added to the transformation chain in order to transform Geodetic coordinates from Datum1 to Datum2. To transform from a geodetic system to another a minimum of three common points must be known. This transformation can't be made without some degree of uncertainty that depends on several factors. When the two adjacent TM zones shares the same Datum, there are the possibility to transform directly from on TM to the other, without going up to the geographic coordinates and, from there, down again to TM. If the TM zones don't share the same Datum the direct procedure can also be applied, but in this case with an uncertainty that could not be, internally, estimated. In this paper the direct method is outlined and illustrated with an application example.

Appendix 3: Represented bodies and organisations

DG Joint Research Centre (JRC)

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. The JRC consists of seven different institutes, each with its own focus of expertise, on five separate sites around Europe.
The aim of Institute for Environment and Sustainability (IES) is to provide scientific and technical support to European Union strategies for the protection of the environment contributing to a sustainable development. The combination of complementary expertise in the fields of experimental sciences, modeling, geomatics and remote sensing puts the IES in a strong position to contribute to the implementation of the European Research Area and to the achievement of a sustainable environment.
The mission of Institute for the Protection and the Security of the Citizen (IPSC) is to provide research-based, systems-oriented support to EU policies so as to protect the citizen against economic and technological risk. The Institute also continues to maintain and develop its expertise in information, communication, space and engineering technologies
The JRC, through the action "European Spatial Data Infrastructure" (ESDI), has the task to technically coordinate the INSPIRE initiative and to shepherd it the various steps working towards the realization of a European Spatial Data Infrastructure.

DG Eurostat - GISCO

Eurostat is the Statistical Office of the European Communities situated in Luxembourg. Eurostat has for mission “to provide the European Union with a high-quality statistical information service”. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions. Eurostat’s main role is to process and publish comparable statistical information at European level. We try to arrive at a common statistical ‘language’ that embraces concepts, methods, structures and technical standards. Eurostat does not collect data. This is done in Member States by their statistical authorities. They verify and analyse national data and send them to Eurostat. Eurostat’s role is to consolidate the data and ensure they are comparable, using harmonized methodology. Eurostat is actually the only provider of statistics at European level and the data we issue are harmonized as far as possible.
GISCO (Geographic Information System of the COmmission), is the sector of Eurostat responsible for managing the geographical reference database for the European Commission. Additionaly GISCO promotes and participates in Commission activities in the field of GI and GIS. Within the European statistical system, GISCO ensures standardisation and harmonisation in the exchange of geographical information between Members Staes and Eurostat.

DG Regional Policy

The Regional Policy Directorate-General is the department in the European Commission responsible for European measures to assist the economic and social development of the less-favoured regions of the European Union under Articles 158 and 160 of the Treaty. Supporting regional development is vital for stability in the European Union. The aim is to promote a high level of competitiveness and employment by helping the least prosperous regions and those facing structural difficulties to generate sustainable development by adapting to change in the labour market and to worldwide competition.
The Regional Policy DG is in charge of the administration of three major funds : a) the European Regional Development Fund (ERDF), which operates in all 15 Member States; b) the Cohesion Fund, which assists environment and transport projects in the Member States whose GNI/head is below 90% of the Community average ; c) the Instrument for Structural Policies for Pre-Accession (ISPA), which is assisting the central and eastern European candidate countries to improve the environment and develop their transport networks.

European Environment Agency (EEA)

The European Environment Agency (EEA) was launched by the European Union (EU) in 1993.
The EEA mission' 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.' The EEA is a European Union body but is

open to non-EU countries that share its objectives. All 15 EU Member States have been Agency members since the start. The European Economic Area countries — Iceland, Liechtenstein and Norway — also joined from the beginning. Membership applications were received in the late 1990s from the 13 EU candidate countries in central and eastern Europe and the Mediterranean area. By 2003, they have become full EEA members following ratification of their membership agreements, making the Agency the first EU body to open its doors to the accession countries. EEA and its EIONET partners in 31 member countries comprise wide range of organisations who act as European Topic Centres, National Focal Points and National Reference Centres.

EUREF

EUREF (European Reference Frame) is the Regional Reference Frame Sub-Commission for Europe of IAG's (International Association of Geodesy) Commission 1 Reference Frames. EUREF was established in 1987 at the IUGG/IAG General Assembly in Vancouver, Canada, as a continuation of the RETrig Sub-Commission.

The purpose of EUREF is to focus on the variety of European control networks (horizontal or vertical) as well as their connections and evolutions by means of:

- an array of GPS permanent sites - the EUREF Permanent Network
- a network of high-precision geodetic reference sites determined by various GPS campaigns
- the computation of the vertical network (UELN – Unified European Levelling Network / EVRS - European Vertical Reference System) and its integration in the European Vertical GPS Reference Network (EUVN)
- an integrated network of space and gravity technologies (ECGN - European Combined Geodetic Network)

The forum where these activities are discussed and decisions are taken is the annual symposium, organized since the EUREF foundation. The annual symposia are usually attended by more than 120 participants coming from more than 30 member countries in Europe. Current activities are governed by the Technical Working Group (TWG).

EuroGeographics

EuroGeographics is the organization that pools together the skills, information and experience from its members, currently 43 of the National Mapping and Cadastral Agencies from 40 European countries. EuroGeographics, the 2001 merger of CERCO and MEGRIN, builds on 23 years of active collaboration between the European NMCAs, and is the well recognized and trusted voice of Europe's national main custodians of geographic Reference Data.

EuroGeographics is developing products and services that address problems – at the technical as well as at legal and business levels – such as non-matching datasets and incompatible cross-country topographic information. Its vision is to achieve interoperability of European mapping (and other GI) data and so, buy contributing to a major building block of the European Spatial Data Infrastructure, help the public and private sectors develop good governance, sustainable growth and benefit future generations.

The Bundesamt für Kartographie und Geodäsie (BKG)

The Federal Agency for Cartography anf Geodesy (BKG) is a German Federal authority. Its kernel tasks are to provide geodetic reference data and basic spatial data of the Federal Republic of Germany, to advise the Federal Government in the fields of geodesy and geoinformation as well as to safeguard the relevant interests of the Federal Government at the European and global level. BKG maintains the technical contacts with the National Mapping Agencies and other scientific institutions abroad. As a member of EuroGeographics it actively takes part in several European and international projects.

The BKG has the following central tasks:

- Serving as the executive secretariat of the Inter-Ministerial Committee on Geoinformation (IMAGI) which aim is to co-ordinate the application of geoinformation in the Federal administration;
- in the fields of cartography/geoinformation the BKG department Geoinformation has to edit, update and provide digital topographic data of Germany for all kinds of users. It contributes substantially to projects serving the setup and maintenance of European spatial data bases like SABE (Seamless Aministrative Boundaries of Europe), EuroGlobalMap, EuroRegioMap, EuroSpec and EuroGeoNames;
- in the geodetic field the provision and maintenance of the geodetic reference networks of the Federal Republic of Germany including the relevant surveying techniques and theoretical work on the acquisition and editing of the measuring data, and also the cooperation in bilateral and

multilateral activities on the determination and updating of global reference systems as well as on the further development of the measuring and observation techniques employed. The national geodetic reference networks are part of European and global geodetic reference frames.

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Instituto Geografico Portugues

The Portuguese Geographic Institute (IGP), integrated in the Ministry of the Cities, Order of the Territory and Environment, is the responsible organism for the execution of the politics of geographic information. Its creation occurred in 2002, supported for a decision of administrative modernization and consolidation of the public finances express in the Resolution of Cabinet nº 110/2001, of 10 of August. The IGP succeeded in all the extinct rights, obligations and attributions to the National Center of Informacao Geografica (CNIG) and Portuguese Institute of the Cartography and Cadastro (IPCC). IGP is the Portuguese National Authority on Geodesy, Cartography and Cadastre. The mission and the attributions of the IGP are consecrated in its Statutes, approved under the law 59/2002, of 15 of March."

Botanical Museum, Finnish Museum of Natural History

The Finnish Museum of Natural History is an independent institute of the University of Helsinki. Its Botanical Museum is the main scientific botanical institution in Finland holding ca. 3 million herbarium specimens of plants and fungi. The Botanical Museum also maintains a national distribution database of the Finnish flora, at the moment with ca. 3.7 million records. The secretary of the Committee for Mapping the Flora of Europe is located in the museum and produces the volumes of Atlas Florae Europaeae (AFE) on the basis of the distribution data provided by national collaborators throughout Europe.

Norwegian Mapping Authority

The Norwegian Mapping Authority (NMA) is a public management company under the Norwegian Ministry of Environment. The core activities include the principal task of creating and operating "Norway Digital", the national geographic information infrastructure. NMA coordinates cooperation with a wide range of partners (data owners) at local, regional and national levels. NMA handles geodesy, positioning services, national maps for land and sea, property information and has a separate division of sales - products and services.

European Topic Centre/Nature Protection & Biodiversity (ETC/NCB)

The European Topic Centre on Nature Protection & Biodiversity (ETC/NPB) is designated by the European Environment Agency (EEA) to assist in its work of collecting, analyzing, evaluating and synthesizing information relevant to national and international policies for the environment and sustainable development. The ETC/NPB supports also the implementation of the European Union network of sites designated by Member States under the Bird Directive and under the Habitats Directive.

In the topic of Biodiversity Indicators and Monitoring, efforts are focused on two related tasks: definition of agreed Core Set of Indicators and cooperation and collaboration with other international initiatives. In relation with these activities, ETC/NPB has issued several major products such as the European Nature Information System (EUNIS) including both reference tools and databases to assess Europe major biodiversity issues. The ETC/NPB is involved, on behalf of the EEA, in various working groups, steering committees, fora of international or European programmes. This proves to be of major importance for the exchange of information and for maintaining and developing contacts with the network of experts, as a complement to EIONET.

Bundesamt für Bauwesen und Raumordnung (BBR)

The BBR (Federal Office for Building and Regional Planning) is Leadpartner of project 3.1 of the ESPON 2006 programme titled "Intergrated tools for the European spatial development"The project tasks include technical and analytical support and coordination (data-base, GIS and mapmaking, concepts and typologies for spatial analyses, spatial concepts), territorial and thematic coordination of the ongoing projects, preparation for the exploitation of results of all projects, the compilation and structuring of recommendations to further policy development in support of territorial cohesion, assistance in the promotion and networking of the ESPON programme and offering scientific support for the achievement of the objective of the ESPON 2006 Programme.

The work of the BBR itself focuses on aspects of spatial planning, of building technology and of housing at the federal level. In this function it is also the contact partner for equivalent authorities in the international context. The scientific part of the BBR concentrates on departments I (Spatial Planning and Urban Development) and II (Building, Housing, Architecture). This part has been accepted as a federal research institution. Department I deals with research tasks and gives scientific advice to the Federal Government in the field of spatial planning and urban development. Important tasks are to draw up relevant spatial planning and urban development reports, to operate a spatial information system, to elaborate prognoses (e.g. population prognosis, spatial planning prognosis), to attend and evaluate research projects scientifically, to draw up reports and expert's reports, to implement and evaluate model projects of spatial planning and urban development, to issue publications as well as to carry out conferences. Department II mainly deals with housing aspects from the scientific point of view.

Autodesk

Autodesk is the world's leading design software and digital content company, offering customers progressive business solutions through powerful technology products and services. Autodesk helps customers in the building, manufacturing, infrastructure, digital media, and wireless data services fields increase the value of their digital design data and improve efficiencies across their entire project lifecycle management processes. For more information about the company, see www.autodesk.com.

Aero-Topografica, Lda

Aero-Topografica, Lda. is the oldest private company in Portugal, operating since 1951, providing services in the field of geo-engineering and geo-information.

Ordnance Survey GB

Ordnance Survey is Great Britain's national mapping agency. It is responsible for surveying the constantly-changing British landscape and maintaining the master map of the entire country, from which it produces and markets a wide range of digital map data and paper maps for business, leisure, educational and administrative use. It operates as a self-financing Trading Fund wholly owned by the UK government with an annual turnover of around £100 million. The agency is currently implementing an ambitious e-strategy to enhance still further its services to customers.

Statistics Denmark

Statistics Denmark is Denmark’s central statistical office and is responsible for the co-ordination of all official statistics concerning Denmark and Danish society. These statistics cover a broad spectrum of topics within the areas of population, business, industry, the environment and the economy.
Statistics has a long history in Denmark where the first population census was conducted in 1769. In 1850 Statistics Denmark was established as an institution, and the foundations of its present day activities are to be found in the Act on Statistics Denmark, which was adopted by Parliament in 1966. This Act gives an independent Board of Governors the responsibility to determine the institution’s work programme. One important provision in the act is that it allows Statistics Denmark access to data from all public administrative registers in Denmark. These have now become the institution’s principle data source.

Intergraph Corporation

Intergraph Corporation is a worldwide provider of technical software, systems integration, and professional services. Tools from Intergraph are used to acquire, analyze, share, reuse, and manage engineering and mapping data. This core data is linked to other workflow and business information – a linkage which leads to more informed decision-making and more efficient business operations for the life of a project.
The company’s four core businesses address these markets:

- The design, construction, and operation of process and power plants, offshore rigs, and ships.
- Computer-aided dispatching and records management for public safety agencies and others.
- Information technology (IT) services and management consulting for government and commercial clients.
- Mapping, geographic information systems, map and chart production, earth imaging, and utilities and communications.

Founded in 1969 and headquartered in Huntsville, Alabama, Intergraph currently employs approximately 3,800 people. Intergraph products are sold in more than 60 countries.

Instituto Geografico Nacional de Espana (IGNE)

The Instituto Geografico Nacional de España is the Spanish Mapping Authority for Spain. It is integrated in the Ministry of Fomento and comprises: Geomatic, National Topographic Map, Geodesy and Geophysics as Subdirectorates the National Astronomical Observatory and the National Centre for Geographic Information (CNIG). The IGNE have been working in cooperation with multitude of European /Pan European organisms as Eurogeographic, EUREF, IAG, IberoAmerican organizations etc in order to provide geographical data or geodetic infrastructures and technical cooperation in Geosciences areas and many other tasks in mapping, remote sensing, geophysical and standardization areas.

Statistics Sweden

Vilnius Gediminas Technical University, Department of Geodesy

In 1990 the Vilnius Civil Engineering Institute became Vilnius Technical University, which on August 22, 1996 was awarded the name of Gediminas, Great Duke of Lithuania. At present the University has 8 faculties, Aviation Institute named after A.Gustaitis, International Studies Centre, Centre for Continuous Education, 4 research institutes and some laboratories. The Institute of Geodesy (Faculty Of Environmental Engineering) is active in the following research areas:

- Adoption of Lithuanian state system of geodetic coordinates
- Development of Lithuanian state EPS system, gravimetric network and vertical geodetic network
- Testing of Lithuanian territory geoid
- Application of GPS system
- Investigation of geodynamic processes
- Analysis of aerophotogrammetric methods
- Creation of geodetic base information system

Cyprus Department of Lands and Surveys

The Department of Lands and Surveys is a government department offering services in the areas of land registration, survey, cartography, valuation, state land management, tenure and administration. DLS is operating under the Cyprus Ministry of the Interior. DLS undertakes all the work associated with land registration, geodesy, topography, mapping, photogrammetry, hydrography, cadastral surveys, land tenure, land consolidation, management of state land, property valuation and the implementation of an integrated national GIS.

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