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FOREWORD

This book has been produced under the project PANEL-GI (A Pan European Link for Geographical Information; http://www.gisig.it/panel-gi), co-ordinated by the GISIG Association.

PANEL-GI is a concerted action funded within INCO-COPERNICUS, the Programme launched by the European Commission for promoting the scientific and technological cooperation with Central and Eastern European Countries (CEEC) (http://www.cordis.lu/inco/src/projcop.htm)

PANEL-GI is then a European Network aimed at involving partners from the CEEC in the process of creating a Pan European GI Forum. The network gives an important contribution to realise in perspective, a full and integrated European GI context and to stimulate or enable GI business in CEEC.

The wider goal of the project is to contribute to the establishment of shared foundations for the Information Society in CEEC, in the particular area of GIS. The Network's main focus lies on the following GI issues: European Geographical Information Infrastructure (EGII), GIS Interoperability and Open GIS, metadata, data availability, GIS applications and European dimension.

This "PANEL-GI Compendium. A Guide to GI and GIS" is one of the main outputs of the project. It has been designed as a reference book useful to have a vision of the key issues of the GI/GIS framework. The Compendium aims at offering to the reader a synthesis of the main GI topics and should support to orient her/him in the GI/GIS field, stimulating as well new business approaches and initiatives for the development of new projects and products.

The PANEL-GI partnership has decided to pursue the policy of a wide dissemination of the project results and so anybody interested in can find the PANEL-GI Compendium also on the Web, together with other useful material and information organized in the so-called PANEL-GI Extended Package (http://www.gisig.it/panel-gi/package/pack.htm).

We do hope that this Compendium could give a significant improvement of a common awareness and a share of the most important GI issues under discussion at a European level and that it would contribute to an efficacious transfer of knowledge among European Countries and to an effective development of a Pan European GI infrastructure.

We also hope that the PANEL-GI Network and its effort for GI and GIS could give an additional contribution in pushing the development of the GI Market in Europe.

1. INTRODUCTION TO THE GUIDELINES

Geographic Information (GI) is a complex, rapidly growing and important part of the Information Society. New Geographic Information technologies are developing rapidly. The great advantage of GI is that it has the capability of summing up and visualising graphically what vast amounts of data are trying to tell one about the relationship between various phenomena on the Earth surface (such as the relationship between climate and certain health risks). There are many applications in international, national and local government, business and research, and in various commercial sectors. Geographic Information is important because of its value for planning, land management, marketing studies, environment, renewable energy resources, emergency services, health care, political analysis and many other uses (GI2000).

Geographic Information Systems (GIS) are tools for the management of geographic information, for spatial analysis and the visualisation of this information. GIS are complex yet general purpose tools, serving many types of users, but a frequently stated problem is that this complex functionality is not accessible to end-users in administration, planning, decision making and other work domains because the technology has been developed for technical experts. Due to ergonomic deficits, today GIS user interfaces are not easy to use and require much time to learn. Because task performance with GIS imposes high workload on users, the results may not be as optimal as required.

The quality of GIS user interfaces is a key-factor for efficiency and effectiveness of GIS use, for user satisfaction, and therefore for GIS diffusion. This quality must be improved for end-users, especially since the technology is becoming more inexpensive and is therefore reaching more, normally non-expert, users within the general public.

A key issue in GIS application development is the design of user-system interaction. However, the needs and requirements of real GIS users - a prerequisite for good user interface design - are not taken into account to a satisfactory degree for the development of GIS applications.

1.1 Objectives

These ”Guidelines for the Best Practice in User Interface Development for GIS” have been produced by the BEST-GIS project based on the experience of GIS end-users and experts.

The objectives are to increase user and customer awareness regarding the development and customisation of GIS applications. GIS end-users will be able to define more precisely their requirements and tasks. GIS customers will be able to understand the relevant cost and benefit factors to be taken into account for GIS procurement decisions.

GIS developers, experts involved in GIS customisation, end-users and other stakeholders in the GIS life cycle will be introduced to the user-centred design (UCD) approach and will find methods applicable to GIS user interface evaluation.

1.2 Audience

The target audience of the guidelines are GIS end-users, i.e. persons who sit at a workstation and have (or intend to have) hands-on experience with a GIS, both technology users and domain specialists. Some information will also guide GIS customers to make reasonable GIS purchase decisions.

In addition the guidelines will be useful for GIS developers and experts who customise GIS to specific user requirements.

1.3 Overview

Section 2 describes the development process of GIS applications and the status of usability engineering in this domain. The most important GIS user interface issues are described. The discussion about GIS user interfaces standards is summarised.

Section 3 is an introduction to the user-centred design approach. The emphasis is on the role of end-users and customers in user-centred design of GIS applications. An overview of appropriate methods for GIS user interface evaluation is given.

Section 4 explains how to perform user requirements and task analysis. GIS stakeholders and user groups will be described together with typical task and workflow scenarios.

Section 5 contains a check list for the selection and definition of user requirements for a specific GIS application. The list is useful as a starting point in order to derive user requirements for a GIS application. Readers are invited to adapt and extend this list for their own purposes and to future GIS technology.

The checklist in section 6 gives an overview of the most relevant GIS specific technical features.

Section 7 provides recommendations for the best use of significant GIS user interface functions described in section 6. This section is addressed in particular to those users looking for useful hints on the usability and drawbacks of GIS functions.

A checklist for testing the conformance of GIS user interfaces to the European Directive 90/270 on minimum requirements for health and safety of display screens equipment is provided in section 8

The guidelines end with recommendations on how to perform a cost / benefit analysis of GIS usage in section 9. This section emphasises consideration of the whole GIS life cycle for the analysis and lists the most relevant and important cost and benefit factors to be taken into account for the analysis.

1.4 How to read the guidelines

Section 2 introduces the reader to the problem with GIS user interfaces. This section will be useful for readers who are not at all familiar with the GIS domain.

Readers having no basic knowledge about usability engineering should read the introduction to the user-centred design approach in section 3. The overview in this section will be useful for end-users and customers as well as for developers and customisers.

Sections 4 to 8 are especially useful for end-users who are responsible for requirements specification.

Section 9 is intended for customers who want to find out more about the relation of costs caused by GIS usage and its benefits.

1.5 Benefits

Today, in public or private organisations, many architects, civil engineers, geologists, and many others, who could make use of GIS tools in their work domains, *either* do not exploit the technology *or* rely on the expertise of a GIS expert. On the other hand, the expert may be highly familiar with GIS technology but often has limited experience in different domain problems.

The short term benefits of these best practice guidelines will be:

for end-users to improve the statement of their needs and requirements,

for customers to improve cost / benefit calculations of GIS usage,

for developers and customisers to better understand user needs and requirements and thus taking these into account,

- resulting in a better exploitation of GIS which are currently available on the market.

in the long term making use of these best practice guidelines should lead to:

- user-centred development of GIS user interfaces with higher quality,

- GIS user interfaces which can be applied by the end-users more efficiently (speed up work) and effectively (do the right thing) and which are accepted by the end-users,
- improvement and speed up of the GIS development process,
- reduction of customisation effort.

2. ASSESSMENT OF THE EU AND SEE SITUATION AS REGARDS THE MUNICIPAL ADMINISTRATION WORKING PROCESS AND SERVICES: METHODS (QUESTIONNAIRE) AND BEST PRACTICE EXAMPLES

3. THE BACK OFFICE

3.1 The EDMS

3.2 Interface to external Information resources

3.3 The Mayor's Office Information Network

4. THE FRONT OFFICE

4.1 The Municipality and City Portal

4.2 Citizens' tool set

4.3 Interface tool set

5. IMPLEMENTATION SOLUTIONS

5.1 E-municipality Offices

5.2 Municipality portal

5.3 Kiosk for services to citizens

6. GEO-INFORMATION AND MUNICIPALITY INFORMATION SYSTEMS

7. CHECKLIST FOR SELECTING AND IMPLEMENTING E-SERVICE APPLICATIONS

This section introduces a checklist for driving the end user in requirement collection for a specific GIS application. The granularity of the checklist, that is, the degree of detail of its points, has been chosen having in mind two contrasting objectives: completeness and applicability. The former objective has been pursued by splitting the requirement collection into general (steady) aspects and other (evolving) aspects related to single application fields. The latter takes advantage of the checklist organisation into homogeneous modules that should focus user attention on clear and distinct subjects.
The section is subdivided into three sections. The first section justifies the need for such a checklist and explains how the underlying requirement collection criteria have been identified and validated. The second section gives brief indications on how the checklist should be used effectively by the end user and what the expected result is after its application. Finally, the third section proposes the checklist in terms of seven general modules (Project organisation, Project outcome, Map acquisition, Derivation process, User interface, Map visualisation, Database organisation) and two application-oriented modules (Environment Control, Urban Planning).

7.1. Task rationale and procedure for criteria identification

It is widely recognised that end users find it difficult to clearly define what their requirements are when facing the development of a new GIS project. As domain experts they usually know quite well what the project is aimed at, but the distance existing between their culture and lexicon with that of the adopted GIS technology still constitutes a huge obstacle. The solution most commonly pursued is informally transferring these requirements to a GIS technology expert, relying on his/her ability to understand (and possibly complete) the representation of the project objectives.
Requirements specification with the guidance of this checklist if communicated to the developers is the beginning of a full user-centred application development.

7.1.1 The user requirements checklist

The near future will probably see the definition of proper requirements representation models conceived for a direct use by the end user, and proper GIS-Office technologies that will put the end user in a position to operate alone on the geographic database to select maps and derive new territory representations. However, much can already be done starting from the current practice by taking advantage of the experience gained in many different GIS projects.
We consider a significant step forward the possibility, for the user, to collect alone his/her own requirements. This knowledge can be used as a basis for the preparation of good bid requests and contracts with the candidate application developers, and as a guide for the systematic control of the project intermediate and final results. A very simple and familiar mean to help the user in this task is providing him/her with a checklist that recalls all the main requirement collection aspects. In fact, one of the most important issues of requirement collection is completeness in both functional and nonfunctional terms. Then, the checklist helps the user to not forget significant aspects and to structure the collected requirements so as to favour comparison, verification and (possibly) the reuse of previous documentation.
In order to understand which are the requirements that allow the user to represent his/her needs and objectives, it is useful to consider the view the user has of the GIS application. In general the user is neither interested in, nor informed of what happens inside the GIS platform; rather he/she tends to keep thinking in terms of the concepts and objects that are familiar in his/her world: maps, symbols, scales, drawings. The image the user has of a GIS application is exactly that resulting from the application interface which, in some sense, plays the role of a "window" on the underlying GIS system. In other words, all what happens on the interface is a matter of requirement specification, the rest being necessarily left to developer experience.
The second consideration to take into account in defining the user requirements checklist refers to the fact that, typically, a GIS application is aimed at deriving information (usually a new map) from the data available in the geographical database. When facing a new project the user traditionally describes to the application developer the characteristics of the map to be derived and the sequence of operations to be performed on the available data in order to achieve such a result. In short, user mental model is strongly focused on the idea of the derivation process, hence the application cannot but adapt to, and possibly reinforce, it. The checklist itself, in particular the part concerning the functional requirements, must be defined clearly in this respect.

7.1.2 The procedure for criteria identification

The end user has a deep knowledge of the application domain and of the problem to be solved, but normally s/he is not used to expressing in some structured and disciplined way his/her requirements. This difficulty is due to at least two reasons: (i) every GIS project takes years to be carried out, thus the user is seldom involved in requirement specification; (ii) analysis techniques constitute a rather specialised competence, which is difficult to acquire and normally known only to the application developer.
In turn, the application developer is interested in collecting and interpreting the user needs with the aim of identifying the most convenient solution to them. Convenience means, in GIS projects, limit the very high costs of data collection and deliver a minimal set of functions in the shortest possible time. This habit is not negative in itself as it tries to meet the user needs in reasonable economical conditions: unfortunately, it can lead to misunderstandings and, ultimately, to the well-known and very diffused user dissatisfaction.
For these reasons we consider it unlikely that the user alone or the application developer alone are able to propose a valuable and complete checklist. The user's important contribution should be concentrated on the indication of requirements for single GIS projects and on the final checklist validation and improvement activity. Similarly, the application developer's contribution is mainly focused on providing practice knowledge from which a project (and hence an interface) design best practice can be drawn. A further contribution comes, in this case, from those organisations that play the role of intermediary user, as they represent the interests of user groups with respect to technology providers and application developers.
The BEST-GIS Consortium includes representatives of all these categories, which joined their efforts and skills to draw a general and flexible checklist. The procedure followed in the identification of the requirement specification criteria was based on four main steps:

1. A tentative checklist was prepared as a synthesis of experiences and practices identified within the Consortium, and taking advantage of the study of some particularly interesting application projects.
2. The checklist was submitted to users within and outside the BEST-GIS consortium for validation, i.e. applying it to the collection of requirements of ongoing and new projects.
3. The checklist below is an improved version based on the validation results.
4. The checklist has now been disseminated to collect further comments from a wider audience which can lead to its periodic improvement, extension and possible specialisation by type of application field.

7.2. How to use the checklist

Collecting and specifying the requirements for a GIS application is a difficult and critical work, especially for the end user. The difficulty mainly arises from the need to explicitly determine all the aspects and constraints that can have an impact on the application design and development. The criticism arises from the fact that incompleteness and possible ambiguities have a negative effect on the following phases of the application development cycle and introduce misunderstandings that require much effort in order to be removed. For these reasons, and for the role that requirements play in the definition of a new project, particular care must be spent in their collection and compilation.
In this section we give brief indications on how the checklist should be used effectively by the end user and what the expected result is after its application.

7.2.1 Requirements specification (RS)

Generally speaking, requirements are intended as a description of the user problems which GIS application must solve and the constraints the solution must satisfy. In order to understand their role it is useful to remember that the requirements specification (RS) phase precedes the design and development phases in the application development cycle. Thus, it enables the developer to fully understand the overall nature and the specifics of the application, and also acts as an opening for the establishment of adequate user contacts throughout the remaining phases of the cycle.
In particular, for very complex and innovative systems (as GIS applications are) a full RS is needed as a basis for feasibility estimation in order to reduce contractual risks. It means that the RS document is fundamental in establishing a correct and unambiguous contract with the developer organisation where all the significant aspects are clarified and evaluated in their development cost and time. Besides, it is vital that the specified requirements be verified at the end of the development cycle and during testing. This document is valuable throughout the whole project as it is a clear and complete statement of the required functionality for the intended application, jointly prepared and agreed upon by both the user and the involved developer.
The application requirements represent the conversion of broad-based user needs into a working specification document upon which development effort can be focused. The RS output should present all

the functional and non-functional system requirements (or, at least, those identified at this early stage) and indicate design and implementation directives of the intended application:

- Functional requirements display the functionality of the application. It means making explicit the actions and operations which the application must provide to the user, and the data types to which these functions are applied.
- Non-functional requirements tend to be constraints that the completed system must fulfil. In addition to performance issues (e.g.: response time, data volume, execution frequency) they include indications on user role, application audience, data accessibility.
- Design directives are user constraints upon the structure of the system solution and could detail hardware selection, data storage and transfer methods such as communication protocols. Implementation directives constrain the developer by defining choice of implementation language or database management system.

While the checklist proposed in this section deals with the first two points, design and implementation directives are considered in sections 6 and 7 of these Guidelines.
An important aspect to consider when compiling an RS document is the form that this document should take. Most of the RS models proposed in the literature are informal, in that they simply suggest a reasonable organisation of the RS document into chapters and sections without defining a formal syntax to fill it. One reason is that, at the specification time, many aspects are still open or not completely decided: the RS document must be complete but it remains independent of implementation issues. Another reason is that a formal RS language could hardly be employed by the end user and this would limit its role and autonomy. Finally, the RS phase cannot consume too much effort as it consists in a preliminary phase of a development cycle that could terminate at the feasibility stage.

7.2.2 Checklist application

Preparing the RS document means collecting and synthesising the viewpoints of the different identified application users. In fact, because of its high cost, only a long life cycle and the benefits it can bring to a number of users justify a GIS application. Each of these users tends to have his/her own focus on the functions the application will make available: taking into account all of them is a necessary condition to create a useful application. We see two alternative ways of using the proposed checklist to derive the synthesis requirements:

- Every user collects and specifies his/her own requirements by following the checklist alone (obviously, not all the users will consider all the points of the checklist). Then, the resulting documents must be discussed and unified into the final RS document. This requires meetings on the different sections, with the participation of interested users and, possibly, the application developer. The main advantage of this approach is the total freedom of the single user in expressing his/her viewpoint and, hence, the completeness of the final document. The main drawback is the redundancy of the specification work as many users may give the same indications on many points.
- Users organise meetings for the different sections of the checklist with the purpose of discussing requirements point by point. The outcome of this work is directly the final RS document. A first important by-product of this approach is a very early constitution of a working group where all members are aware of the common interest and objectives. Besides, convergence on a single point is likely to be reached faster than with the previous approach. The drawback is that some users tend to become meeting leaders and impose their viewpoints.

Going through the checklist sections, it is worth taking into account the following suggestions for a good use of the checklist itself:

0. ***General requirements.*** This section recalls some general requirements that are applicable to different projects and especially to software based projects. The requirements listed in this section are general, and the accomplishment of each of them may depend on different items among those which are listed in subsections 1 - 8.

1. ***Project organisation requirements.*** When compiling this section, the user must keep in mind that a success key in every project is stating clearly, from the beginning the purpose and scope of the intended initiative. In fact, many problems (high cost, long delivery time, insufficient or overspent resources, changes with work in progress, conflicts with the developer) often arise from starting a project whose content boundaries are not well understood. Another aspect that is worth capturing is the user roles and the management responsibilities along the project. This is necessary to avoid user participation only in the early and final phases of the development cycle, and also to avoid vague developer identification of his/her counterparts.

2. ***Project outcome requirements*****.** As the project is usually aimed at producing maps, characterising the project outcome is a very important issue. It is well known that starting from outcome description makes it easier to describe all the other aspects of an application (input data, computation process): this is the reason why we put this section first. Another justification of the importance we assign to this section is that project feasibility is better carried out by comparing the benefits expected from the project outcome (and the desired due time) with the cost of its production (and the planned delivery time). This also holds for those cases when the project result is not a map but, for instance, an analysis or simulation package.

3. ***Map acquisition requirements*****.** Once the project outcome has been described completely the user has all the elements for understanding what the input data are for the application he/she will use. In general, only some of them are already available in the user organisation databases, hence a specific acquisition activity is often required. We suggest paying much attention to this aspect since the acquisition of geographical data is a very time and resource consuming task. Planning an application which relies on the acquisition of many new data introduces risk elements that must be carefully evaluated. A better approach consists in distinguishing the data to be fully acquired from those that can be imported from other organisations or obtained by adaptation and completion. This checklist section includes points that help the user in taking into account this possibility, and also suggests considering volume and cost issues.

4. ***Derivation process requirements*****.** Most GIS applications are aimed at studying and comparing territory properties, that is, deriving new maps from those already available. After having described the expected outcome and the input maps (that represent the analysed territory properties) the derivation process is illustrated. This is, more than others, an end user task (intended as the application domain expert) since he/she is the only one in condition to say how the input data contribute to the construction of the project result. In fact, the derivation process should be the exact image of the idea the user has of the problem to be solved with the intended application. We suggest answering this checklist section by preparing very clear and detailed information, that is, a precise representation of the functions to perform on the input data. This requires, compared to the other sections, a higher degree of formalization in describing the functions to be executed at every derivation step. For this reason we propose that a catalogue be made available to the user which contains the description of common or already developed functions(see section 6 and 7).

5. ***User interface requirements*****.** Many requirements on the possibilities the application interface should offer to the user are collected according to points of the other checklist sections. In fact it is worth remembering that the application interface corresponds, for the user, to the way the application is thought of. Here we invite the user to focus again on the

interface to make explicit aspects that might have been neglected, so as to avoid their specification while the development work is in progress. Aspects that require particular attention are help and navigation capabilities, as well as protection against user errors or unauthorised accesses. We suggest that this section be compiled in collaboration with the developer, as it deals with technical issues.

6. ***Map visualisation requirements.*** A distinctive aspect of GIS applications is the role that map rendering has for the users. The user is in charge of the complete definition of map visualisations (size, colours, fonts, symbols, legends and the like) with respect to every rendering means. We suggest considering the three main means available today, namely workstation display, paper (through different plotting technologies) and the Internet. Although the user is the only one in a condition to decide upon the aspect of visualised maps, important help can come from having proper look-up tables available or, as an alternative, by collaborating with the application developer.

7. ***Database organisation requirements.*** Geographical data have usually associated attribute (quantitative, descriptive) data. This means that the GIS application is provided with both a graphics database and an attribute database. While the application developer derives the content of the former from requirements concerning project outcome, inputs and derivation process, the latter needs further specifications. With this section we aim at driving the user to consider which attribute data are useful, which are available and to which territory entities they are associated. We suggest the user describe the application attribute data by means of a simple and semi-formal conceptual model, possibly with the aid of the developer.

8. ***Specific application requirements.*** The two last sections are aimed at proposing further points that are specific in a certain application context. After the user has compiled the previous sections in all their aspects, he/she can consider the application section of specific interest. Here he/she can find hints on needs and functions that are peculiar in such field: they are derived from previous experiences and hence can be enriched every time the checklist is used. The richer these sections become, the more effective their use in capturing exhaustive requirements.

7.3 Checklist of functional and nonfunctional requirements

The following checklist is proposed as a guide to drive the end user in collecting and expressing the requirements of a new GIS application project. In fact, going through the checklist the user has the opportunity of ascertaining whether the comprehension he/she has of the application is sufficiently clear and whether the collected requirements are complete and properly organised. In other terms, compiling this checklist means building up the documentation which is recalled by each of the identified points.

At the time of its delivery the checklist corresponds to the knowledge, on the project development process, that has been found within the BEST-GIS Consortium. Validation of the checklist showed that the degree of completeness of this checklist is indeed rather high, the most important aspects on which a GIS project relies are taken into account. Nevertheless, further points can be conveniently added as soon as they are considered capable of capturing other aspects here neglected or collapsed.

An interesting direction to follow in making this checklist more and more effective is that of its specialisation by type of application field. As shown in the last two sections, devoted respectively to Environment Control and Urban Planning, it is useful to integrate the general aspects with application-oriented points. These are mainly focused on recalling user needs that have often been met in concluded and ongoing projects of the single application type. These sections can hence increase in number and richness of points and thus constitute the principal evolution path for the checklist itself.

7.3.1 General requirements

This section concerns the specification of some general requirements aimed at satisfying fundamental user needs. These requirements have to be accomplished not only in GIS projects, but in almost any type of software based project. For each considered item a short description is provided. These general requirements have to be considered as a general reference framework when addressing more specific requirements listed in subsection 5.3.2 to 5.3.10.

0.1	Are the level of the detail and the accuracy of the work defined ?	
0.2	Are the necessary speed of access and manipulation defined ?	
0.3	Is the complexity of task under control?	
0.4	Is the size of involved data under control ?	
0.5	Are security requirements defined ?	
0.6	Are reliability requirements defined ?	
0.7	Is the use of legacy systems identified ?	

7.3.2 Project organisation requirements

This section concerns the specification of requirements relative to the project intended as a whole and its organisation and control. In particular, it is aimed at pushing the user to explicitly describe project aspects that are often neglected or left to the initiative of the application developer. Because of the general view it suggests, this section essentially refers to non-functional requirements.

1.1	Are the GIS project overall objectives and results clearly understood and explicitly expressed?	
1.2	Are the parties interested in the GIS project identified and the expected use of the project results described?	
1.3	Are general rules fixed to regulate the accessibility of the GIS project audience to the project results?	
1.4	Are the GIS project financial, temporal and other constraints clearly understood and explicitly expressed?	
1.5	Are the GIS project stakeholders identified with their respective decisional role and priority?	
1.6	Has the user organisation nominated a manager for the GIS project, who is responsible for the relations with stakeholders and the application developer?	
1.7	Is the GIS project workplan formally established with indication of the main phases, precedence, milestones and checkpoints?	
1.8	Are evaluations of the GIS project progress planned and the responsible person for conformity verification and replanning identified?	
1.9	Are installation procedures and acceptance tests explicitly established and included in the GIS project contract?	

7.3.3 Project outcome requirements
This section is intended to be replicated for every single result (typically, a derived map) expected from the GIS project execution. Main aspects are the explicit definition of the output map itself, the associated descriptive and quantitative information and the representation of possible constraints on its use and diffusion.

2.1	Is the output map properly described in terms of its meaning and expected use, and unambiguously characterised by its component layers?	
2.2	How critical is this product in terms of calculation frequency and (human and computer) resource occupation, with respect to the other project outcomes?	
2.3	Are the desired map features (scale, tiles, accuracy, quality, topographical constraints, etc.) expressed?	
2.4	Are the envisaged accesses to the output map (open, export, etc.) and to the single layer coded so as to make the developer realise the corresponding interface commands?	
2.5	For each layer, is the relative content clearly described and its graphic representation (points, lines, etc.) correctly determined?	
2.6	For each layer, are the associated descriptive and quantitative data identified and declared?	
2.7	For each layer, is a default presentation (colours, symbols, data, etc.) decided so as to make the developer realise the corresponding interface commands? *(*)*	
2.8	Is the set of the input maps used to derive the output map in discourse clearly identified and explicitly declared?	

(*) The user could be facilitated by having proper look-up tables available for the selection of the most suitable colours, styles, symbols and other effects. The tables should be progressively extended with the introduction of new options decided by the user.

7.3.4 Map acquisition requirements
This section expresses the requirements on how to obtain the basic maps that constitute the input to the GIS project. The following points must be replicated for every single map expected from the execution of the GIS project. Generally speaking, they can be already available in some databases, or be imported from other organisations, or even be acquired from a finalised territory survey. A complete identification of the input maps is fundamental in planning the application development work.

3.1	Is the input map properly described in terms of its meaning and unambiguously characterised by its component layers?	
3.2	Are the envisaged accesses to the input map (open, import, etc.) and to the single layer coded so as to make the developer realise the corresponding interface commands?	
3.3	For each layer, is the relative content clearly described and its graphic representation (points, lines, etc.) known?	
3.4	For each layer, are the associated descriptive and quantitative data identified and declared?	
3.5	For each layer, is a default presentation (colours, symbols, data, etc.) decided so as to make the developer realise the corresponding interface commands? *(*)*	
3.6	Is the input map source (local or remote database, adaptation of an existing map, import from another organisation, result of on-field survey, etc.) recognised?	
3.7	In case of adaptation, is the required preparatory transformation or completion activity described?	

3.8	In case of import, is a format or other conversion required and, if any, is it clearly described?	
3.9	In case of a survey, are the survey aims focused, the data to collect identified, and the digitisation criteria specified?	
3.10	Is the size of the map to be acquired clearly understood and the acquisition or adaptation cost evaluated?	

(*) The user could be facilitated by having proper look-up tables available for the selection of the most suitable colours, styles, symbols and other effects. The tables should be progressively extended with the introduction of new options decided by the user.

7.3.5 Derivation process requirements

This section is aimed at stimulating the end user to express his/her own idea on how each GIS project outcome can be obtained from the input maps. This information should be replicated for every output map, although some phases can be common to more derivation processes. The sequence of operations and transformations is split into elementary steps and each of these must be described in terms of the input data, output data and operation performed. In particular, the operation description is very critical as it impacts on software development.

4.1	Is the derivation process unambiguously described in terms of steps, each of which can be represented separately from the others?	
4.2	How critical is this derivation process and each of its steps in terms of execution frequency and (human and computer) resource occupation, with respect to the other project processes?	
4.3	Is the process univocally denoted, and its representation and management functions (do, undo, redo, etc.) explicitly requested, so as to make the developer realise the corresponding interface commands?	
4.4	For each step, are its input and output data identified, denoted and characterised in graphical and descriptive terms?	
4.5	For each step, is the transformation or derivation operation described in detail, possibly taking advantage of an operation catalogue? *(*)*	
4.6	Is the set of step input data, output data and operations properly classified so as to make the developer realise the interface commands to access and activate them?	
4.7	Is a test and validation plan established to perform an early conformity control of the operations as they are realised by the application developer?	

(*) Having available a catalogue where the most common operations are already characterised makes this task much simpler. The user can identify the operation of interest within the catalogue, or describe it as a specialisation or a variant of an existing operation, or add a new operation whenever it must be defined from scratch.

7.3.6 User interface requirements

This section concerns the specification of requirements relative to the final user interface. The user interface defines the way to access geographical data. Customisation of interface windows, menus, buttons, and the like plays an important role for the usability of the system, defining the basic interactions with data. Moreover, the user interface provides navigation capabilities so that he/she may find the needed information. Hereafter the term view indicates a complete interface item or window possibly with its map, menu, buttons, icons, tool bars and others. A complete interface consists of multiple views connected by a set of (logical) links which provide one or more navigation paths.

5.1	Is the overall design of the user interface, views, navigation paths and links, clearly defined by the application developer in a form suitable for user evaluation?	
5.2	Is an analysis of the proposed interface carried out to ensure that it provides an efficient navigation to limit the number of steps necessary to get to the searched data/map?	
5.3	Is the design of each interface view properly defined to provide a clear and efficient access to a consistent piece of information?	
5.4	Does the interface design provide suitable help and is it simple enough to make the beginners able to operate with its major features without using manuals?	
5.5	Is the interface efficient enough to avoid tedious and time-consuming interactions for the experienced, smart user?	
5.6	Does the interface protect data against input errors, and provide help to check input validity?	
5.7	Does the interface protect data against unauthorised accesses?	
5.8	Are the characteristics of the overall environment (single application, centralised or distributed control) taken into account by the interface design?	

7.3.7 Map visualisation requirements

This section collects the requirements on the desired aspect of map rendering. The following points apply to every single rendered map, no matter if it is an input datum, an output datum, an intermediate datum or any combination of them. At least three different representation media should be considered: display, paper and the Internet. Indications on the aspect that every map and its single layers will take on the alternative media, and the definition of possible freedom degrees for the user in deciding the rendering form, are taken into account.

6.1	Is map visualisation clearly and fully described in general terms (scale, style, legend, etc.)? *(*)*	
6.2	For each layer, is the desired rendering (colours, symbols, data, etc.) decided so as to make the developer realise the corresponding interface commands? *(*)*	
6.3	Are the relations between layer visualisations within the map (overlapping, transparency, and other effects) made explicit? *(*)*	
6.4	For each display map, are the required interactive graphical functions (zooming, highlighting, changes in colour and other aspects, etc.) decided so as to make the developer realise the corresponding interface commands? *(*)*	
6.5	For each paper map, is the resulting sheet quality (size, type of paper, type of plotter, etc.) classified so as to make the developer realise the corresponding interface commands? *(*)*	
6.6	For each Internet map, is the simplified aspect of the resulting map, and the possible links to other data, decided so as to make the developer realise the corresponding interface commands? *(*)*	

(*) The user could be facilitated by having proper look-up tables available for the selection

of the most suitable colours, styles, symbols and other effects. The tables should be progressively extended with the introduction of new options decided by the user.

7.3.8 Database organisation requirements

This section is intended to provide help in evaluating the requirements for databases associated to a GIS project. The database main goal is here to hold information that cannot be adequately represented in a graphical manner, and to provide an alphanumeric integration of graphical information. In any case, most data contained in the database are normally geo-referenced. Hereafter we use the term attribute data to indicate data contained in the database.

7.1	Are the meaning and function of attribute data clearly specified?	
7.2	Are the sources of attribute data clearly identified and the procedures for data update defined?	
7.3	Is the correspondence between geo-elements and classes of attribute data clearly established?	
7.4	Are the relationships between attribute data expressed at the conceptual level?	
7.5	Are data import/export problems clearly identified and addressed?	
7.6	Are the volumes of attribute data understood and the acquisition cost evaluated?	

7.3.9 Environment Control requirements

This section represents an example of specialised points with respect to the single application context. While general-purpose requirements are collected with the previous sections, here the focus is on content and method issues that are typical of the considered context. A progressive extension of this section is expected by those organisations that have acquired experience in the Environment Control field.

8.1	Are the features of the required Digital Terrain Model (DTM) clearly understood so as to drive the developer in choosing the right model?	
8.2	Does the application require visibility analysis (i.e. determination of the territory extent visible from a given point) by using a DTM?	
8.3	Does the application require hydrological flow analysis (i.e. determination of water flow paths) by using a DTM and a fluid pressure model or ground water model?	
8.4	Does the application require real time hydraulic simulation (i.e. simulation for flood management, simulation for surface pollution propagation)?	
8.5	In general, which kind of integration is expected between the GIS system and external packages for environmental modelling?	
8.6	Does the application require the loading of external data sets coming from environmental monitoring (e.g. on line acquisition, real time information from sensors)?	
8.7	Does the application require the combination of raster images with vector maps?	
8.8	Does the application require the support to raster analysis functions (e.g. analysis of satellite images)?	

7.3.10 Urban Planning requirements

This section represents an example of specialised points with respect to the single application context. While general-purpose requirements are collected with the previous sections, here the focus is on content and method issues that are typical of the considered context. A progressive extension of this section is expected by those organisations that have acquired experience in the Urban Planning field.

9.1	Does the application require the integration of the different levels of Urban Planning committed to different decision levels?	
9.2	How should data and information sharing among the different users be managed?	
9.3	Do any functions of this application need to be accessible to users not skilled in GIS technology (e.g. decision-makers)?	
9.4	Does the application require reading CAD formats directly, without importing them (as urban planners may have large heritage of CAD maps)?	
9.5	Does the application require calculating parallel buffers to street centre lines, so as to determine affectation to private land?	
9.6	Does the application require simulation functions (e.g. for evaluating future scenarios according to hypothesised development models or planned decisions)?	
9.7	Does the application require performing network analysis with real time data (e.g. traffic analysis, traffic lights management)?	
9.8	Does the application require performing dynamic segmentation?	
9.9	Does the application require performing ”roving window” neighbourhood analysis?	

7.1 Introduction to the checklist

7.2 General requirements for the e-service implementation

7.3 Organisational requirements

7.4 Promotional requirements

7.5 Back Office requirements

7.6 Front Office requirements

7.7 Geographical Information requirements

8. CONCLUSIONS

This book describes how Geographical Information is used and produced with today's Information Technology. It attempts to give an overview of the situation in Europe. We have seen the contributions provided by the technology to change the way Geographical Information is collected, managed and distributed. We witness a transformation of the Geographical Information industry from cartography to GI business. The transformation is gradual and follows the potential provided by the technology with a delay of several years, because the industry consists not only of the technology – which could be changed quickly – but also of organisations and institutions, which are much slower to change.

When the first cars were designed, they appeared as "horse drawn carriages without horses", but had the same form, the same basic parts as horse drawn carriages. It took more than fifty years to develop a "car" structure that was emancipated from the horse carriage. Similarly, when information technology was initially applied to cartography, the product was still a map and distributed as a printed paper map. Slowly, we find new, more suitable solutions where information is produced and communicated on demand in small units – just what is needed.

We hope to have shown the availability of the technology to improve the methods used for collecting, managing and distributing Geographical Information. The technology is here. We have also provided a glimpse at the thousands of useful applications, where Geographical Information can help people, citizens, companies, organisations and governments to make better decisions and thus help us to make better use of the limited resources of the world and to improve citizen wealth and the environment at the same time. The demand is here.

Many of these applications need relatively simple, often used geographical data, topographic map data, demographic data as collected by the national statistical offices, which is all stored on some computers. The computers are linked together and technically the bits can be transferred from the source to the place where they are needed. There are challenges in providing the organisational structure to make this happen.

The world is not only technology and not everything that is technically feasible should be done. The unlimited collection of information about people and their communication would change the way we interact socially and is potentially dangerous for human society. It is necessary to carefully assess the dangers and the benefits and to establish rules that preserve important values of society (e.g. personal freedom, privacy etc.). These values are not the same for every society and therefore the rules must be adapted to the particulars of different countries.

The organisations that are involved today with Geographical Information, National Mapping agencies in particular have an important role to play in the future Information Society. Geographical Information is widely used and it has been proposed to consider it as an "infrastructure" which a country must provide as it provides roads, police or education. The role of agencies for Geographical Information Infrastructures is different from the role of today's National Mapping Agencies – not less important, but very different. Every organisation involved with Geographical Information today is facing the challenge to find the new role it plays in the future Geographical Information Infrastructure.

The future for Geographical Information is bright: there is a strong demand that is increasing rapidly. New technology makes the production and distribution of Geographical Information much more feasible. Geographical Information Systems move from systems designed by specialists for specialists and having few users within closed organisations to systems designed for use by the population at large. The market will truly explode if we can provide the services requested.

To make this happen, the technology must be made simpler to use through standardisation: unnecessary complications that result from proprietary solutions have no place in the Information Society of the twenty-first century. Organisations must adapt to the Information Technology – which is not a problem specific to Geographical Information as the general discussion of copyright etc. testifies. The spatially aware professionals, that is surveyors, geographers, environmentalists, and all the other professionals working with spatial data can jointly contribute to allow progression at the turn of the millennium.

ANNEX 1: TEMPLATE FOR ACTION PLAN

ANNEX 2: WEB LINKS

This annex will contain links (URL's) and keywords to EU-related sites and big initiatives such as European commission, joint research Centre GIS page, Centre for Earth Observation, Agenda 2000, agenda 21, GNSS etc. this list of links can also be found at the PANEL-GI website http://www.gisig.it/panel-gi/.

European Commission	
Europa, European Union web server	http://www.europa.eu.int/
European Commission Community Research and Development Information Service (Cordis)	http://www.cordis.lu/
European Commission Information Dissemination on GI and GIS	http://ams.egeo.sai.jrc.it/
Joint Research Centre (JRC)	http://www.jrc.org/
JRC Space Applications Institute (SAI)	http://www.sai.jrc.it/
Information Society Technologies Programme	http://www.cordis.lu/ist/
Information Society Promotion Office (ISPO)	http://www.ispo.cec.be/
GI and GIS Project (JRC)	http://gi-gis.aris.sai.jrc.it/
European Commission Directorate General Enterprise and the Information Society	http://europa.eu.int/comm/dgs/information_society/index_en.htm
GISCO (Eurostat)	http://europa.eu.int/comm/eurostat/
Centre for Earth Observation (CEO)	http://www.ceo.org/
Agenda 2000	http://europa.eu.int/comm/agenda2000/
National/International links	
European Environment Agency (EEA)	http://www.eea.dk
Multipurpose European Ground Related Information Network (MEGRIN)	http://www.megrin.org/
Association Française pour l'Information Géographique (AFIGEO)	http://www.cnig.fr
The Association for Geographical Information Laboratories in Europe (AGILE)	http://www.uniroma1.it
Association for Geographical Information (AGI) (UK)	http://www.agi.org.uk/
Portuguese National Infrastructure for Geographical Information (SNIG) (Portugal)	http://snig.cnig.pt
The Citizen component of the SNIG (GEOCID) (Portugal)	http://geocid-snig.cnig.pt/
National Land Survey of Finland (NLS)	http://www.nls.fi
The National Mapping Agencies of Europe (CERCO)	http://www.cerco.org/
National Centre for Geographical Information and Analysis (NCGIA) (USA)	http://www.ncgia.ucsb.edu/
The Association of the Geological Surveys of the European Union	http://www.eurogeosurveys.org/
Geocommunity	http://www.geocomm.com/links/education/

ESRI	http://www.esri.com/
INTERGRAPH	http://www.intergraph.com/
LASERSCAN	http://www.laserscan.com/
SICAD Geomatics	http://www.sicad.com/
PCI Geomatics	http://www.pcigeomatics.com/
Data and Metadata	
European Spatial Metadata Infrastructure (ESMI)	http://esmi.geodan.nl/
National Geospatial Data Clearinghouse (NSDI) (USA)	http://nsdi.usgs.gov/
MEGRIN's Geographical Data Description Directory (GDDD)	http://www.megrin.org/gddd/
National Spatial data Infrastructure (NSDI) (USA)	http://www.fgdc.gov/
Global Spatial Data Infrastructure (GSDI)	http://www.gsdi.org/
Interoperability	
GIS Interoperability Stimulating the Industry in Europe (GIPSIE)	http://gipsie.uni-muenster.de/
Open GIS Consortium (OGC)	http://www.opengis.org/
PANEL GI Project partners	
Geographical Information Systems International Group GISIG (Italy)	http://www.gisig.it
CNIG (Portugal)	http://snig.cnig.pt
European Umbrella Organisation for Geographical Information (EUROGI)	http://www.eurogi.org/
Technical University of Vienna (Austria)	http://www.geoinfo.tuwien.ac.at/
National Institute for Research and Development in Informatics, ICI (Romania)	http://td1.ici.ro/
National Land Information Systems Users Association (GISPOL, Poland)	http://www.gispol.org.pl
Masaryck University (Czech Republic)	http://www.geogr.muni.cz/
FOMI (Hungary)	http://www.fomi.hu/
HUNAGI (Hungary)	http://www.fomi.hu/hunagi/index.htm
Technical University Sofia (Bulgaria)	http://www.vmei.acad.bg/
University of Zilina (Slovakia)	http://www.utc.sk/
Examples of GIS Applications Projects	
DISGIS	http://www.disgis.com
Tele Atlas	http://www.teleatlas.com/
Web Mapping testbed	http://www.opengis.org/
Geobusiness	http://www.geomarketing.net http://www.gismo.nl http://www.wigeogis.at

Crop Growth Monitoring System (CGMS)	http://gi-gis.aris.sai.jrc.it/agro-meteo/
City Council of Genova	http://www.comune.genova.it/
City Council of Vienna	http://service.magwien.gv.at/wien-grafik/wo.html
EURSIS	http://gi-gis.aris.sai.jrc.it/soils/esb.html
CORINE	http://etc.satellus.se
TREES (Tropical deforestation monitoring)	http://www.gvm.sai.jrc.it
Cadastre	http://www.bev.gv.at
Radioactivity Environmental Monitoring	http://java.ei.jrc.it/
MURBANDY (Monitoring urban dynamics)	http://murbandy.sai.jrc.it

ANNEX 3: GLOSSARY (IT/MIS)

The table below is a subset[1] of entries kindly made available from:

- the AGI dictionary (http://www.agi.org.uk/pag-es/dict-ion/dict-agi.htm),
- the ESRI Glossary[2] (http://www.esri.com/library/glossary/glossary.html) and
- the glossary from OGC's "OpenGIS guide" (http://www.opengis.org/techno/guide.htm).

One of the interesting aspects of GIS is that many people are still struggling with its definition. Plenty of definitions exist, each with a (slightly) different focus. Some are limited to the technological aspect; others include the scientific or even organisational side. As an illustration, here are five different definitions. For the main glossary, we have selected the AGI definition, mentioned here first.

GIS is:

1. A computer system for capturing, storing, checking, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System (or Spatial Information System) is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map. (AGI)
2. A set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes. (Burrough, 1998)
3. An organized collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate, analyse, and display all forms of geographically referenced information. (ESRI)
4. A database system in which most of the data are spatially indexed, and upon which a set of procedures are operated in order to answer queries about spatial entities in the database. (Smith, 1987)
5. A special-purpose digital database in which a common spatial coordinate system is the primary means of reference. GISs contain subsystems for: 1) data input; 2) data storage, retrieval, and representation; 3) data management, transformation, and analysis; and 4) data reporting and product generation. It is useful to view GIS as a process rather than a thing. A GIS supports data collection, analysis, and decision-making and is far more than a software or hardware product. Other terms for GIS and special-purpose GISs include: Land-Base Information System, Land Record System, Land Information System, Land Management System, Multipurpose Cadastre, and AM/FM (automated mapping and facilities management) system. (OGC)

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1 The criteria for an entry to be included in the Panel-GI glossary are:

- The entry appears in the text of the package, or
- the entry is part of basic, essential GIS jargon, and
- the entry is not part of common sense general language.

Where duplicates occur, preference has been given to use entries from the AGI dictionary, as this is European and non-proprietary.

2 Selected terms and definitions reprinted courtesy of Environmental Systems Research Institute, Inc. www.ESRI.com.

Acceptance Test	A series of tasks performed by either hardware or software to assess performance. Test data is used as input and the response is analysed regarding suitability for operational use. Usually conducted under the control of the procurer of the product, rather than the vendor, to determine whether a product lives up to the claims of the vendor and whether it is fit for purpose.
Accessibility	An aggregate measure of how reachable locations are from a given location.
Accuracy	The closeness of observations, computations or estimates to the true value as accepted as being true. Accuracy relates to the exactness of the result, and is distinguished from precision that relates to the exactness of the operation by which the result was obtained.
Address Matching	A mechanism for relating two files using address as the relate item. Geographical coordinates and attributes can be transferred from one address to the other. For example, a data file containing student addresses can be matched to a street coverage that contains addresses creating a point coverage of where the students live.
Aggregation	The grouping together of a selected set of like entities to form a single entity. For example, grouping sets of adjacent areal units to form larger units, such as grouping UK electoral wards to form districts. Any associated attribute data is also aggregated into a single group.
AI	Artificial Intelligence. A term that applies to that branch of computer science, which aims to imitate the thought, processes of the human brain. There are a number of different methods of achieving this, these include creating a computer with a similar although greatly simpler structure), as the human brain through the use of neural networks, or alternatively, to simply imitate the thought processes through the use of software. The latter approach is perhaps the most common and has resulted in the development of expert or knowledge based systems
Algorithm	A finite ordered set of well-defined rules for the solution of a problem.
AM/FM	Automated Mapping and Facilities Management. Geographical Information System designed for the optimal processing of information about utilities and infrastructures such a pipes, cables networks and power lines. These systems combine digital mapping functionality with systems for managing spatial and non-spatial databases.
ANSI	American National Standards Institute. A US institute which co-ordinates standards relating to many different aspects of computing. It has strong links with ISO, the International Standards Organisation; consequently many ANSI standards are ISO approved.
API	See Application Program Interface
Application	A process that uses data or performs some function on a computer system.
Application Program Interface	An API is a set of system calls or routines for application programs to access services from operating systems or other programs. An API allows your program to work with other programs, possibly on other computers. API is fundamental to client-server computing.
Arc	An ordered string of vertices (x,y coordinate pairs) that begin at one location and end at another. Connecting the arc's vertices creates a line. The vertices at each endpoint of an arc are called nodes.
Architecture	Internal structure of a computer system, including the organisation of the major components, memory storage, I/O operations and the user interface. Often displayed as a schematic diagram.
Archive	A store of information on permanent storage media, usually off-line
Area	A bounded continuous two-dimensional object usually defined in terms of an external polygon or in terms of a continuous set of grid cells.
ASCII	American Standard Code for Information Interchange. A set of codes for representing alphanumeric information. For example, the letter 'A' is stored as the value 65, and 'B' as 66 and so on until the letter 'Z' which is 90.

Attribute	1. A trait, quality or property describing a geographical feature. 2. A fact describing an entity in a relational data model, equivalent to the column in a relational table.
Back-up	A copy of a file, a set of files, or whole disk for safekeeping in case the original is lost or damaged.
Bandwidth	A measure of the volume of data that can flow through a communications link.
Base Map	A map containing geographical features used for locational reference. Roads, for example, are commonly found on base maps.
Benchmark	A standard test devised to enable comparisons to be made between computer systems.
Benchmark Testing	A variety of tests undertaken on computer software or hardware to ensure products meet all user requirements and conform to the claims made by vendors regarding product performance. Typically these tests involve data and operations most likely to be encountered in the workplace.
Binary	A number system of base 2. Numbers are represented simply as a series of 0's or 1's in contrast to base 10 number systems that represent numbers using the characters 0-9.
Bit	Short for binary digit. A bit can take one of two possible binary values, 0 or 1. It is the smallest unit of storage and information within a computer. The values 1 and 0 can represent on/off, yes/no or true/false.
Bitmap	The representation of an image on a computer screen whereby each pixel corresponds to one or more bits.
Buffer	A zone of a specified distance around coverage features. Both constant- and variable-width buffers can be generated for a set of coverage features based on each feature's attribute values. The resulting buffer zones form polygons-areas that are either inside or outside the specified buffer distance from each feature. Buffers are useful for proximity analysis (e.g., find all stream segments within 300 feet of a proposed logging area).
Byte	A unit of computer storage of binary data usually comprising 8 bits, equivalent to a character. Hence Megabyte one million bytes, and Gigabyte, one thousand million bytes.
CAD	See Computer Aided Design.
Cadastre	A public register or survey that defines or re-establishes boundaries of public and/or private land for purposes of ownership and taxation.
Calibration	In spatial analysis, calibration is the process of choosing attribute values and computational parameters so that a model properly represents the real-world situation being analysed. For example, in pathfinding and allocation, calibration generally refers to assigning or calculating appropriate values to be entered in impedance and demand items.
CAM	See Computer Aided Mapping
Cartesian Coordinate System	A two-dimensional, planar coordinate system in which x measures horizontal distance and y measures vertical distance. Each point on the plane is defined by an x,y coordinate. Relative measures of distance, area, and direction are constant throughout the Cartesian coordinate plane.
Cartography	The organisation and communication of geographically related information in either graphic or digital form. It can include all stages from data acquisition to presentation and use.
CD-ROM	A read only optical disk similar to a commercial audio compact disk. The storage capacity of CD-ROM's is approximately 650 Megabytes.
CEN	Comitée Européen de Normalisation. The regional standards group for Europe. It is not a recognised standards development organisation, and so cannot contribute directly to ISO. It functions broadly as a European equivalent of ISO and its key goal is to harmonise standards produced by the standards bodies of its member countries. Membership is open to EC and EFTA countries.
Central Processing Unit	That part of a computer where essential arithmetic and logical operations are performed, often considered as the heart of a computer.

CERCO	Comitée Européen des Responsables de la Cartographie Officielle. The European Committee of Representatives of Official Cartography, under the auspices of the Council of Europe.
Class	Group of entities that share given attribute values.
Classification	A method of generalisation. In the process of classification, an attempt is made to group data into classes according to some common characteristics thereby reducing the number of data elements. Classification tends to be based upon the attributes or characteristics of data rather than their geometry. In digital image processing, images are usually classified according to the spectral properties of the pixels composing the image. In spatial analysis, a map can be classified according to any attribute value, for example, soil types, population density, unemployment etc. The result of performing classification is a thematic derived map.
Client	A computer system or process that requests a service of another computer system or process (a server). For example, a GIS workstation requesting data from a database server is a client of the database server.
Client-Server	A software partitioning paradigm in which a distributed system is split between one or more server tasks which accept requests, according to some protocol, from (distributed) client tasks, asking for information or some action. There may be either one centralised server or several distributed ones. This model allows clients and servers to be placed independently on nodes in a network. GIS are usually based upon client-server architecture. The database may exist upon a central server, however the graphics subsystem exists upon a local workstation, and the two communicate via a local area network.
COM	Component Object Model. Microsoft's underlying object architecture for allowing objects written by different companies in different programming languages to interact.
Computer Aided Design	1. The design activities, including drafting and illustrating, in which information processing systems are used to carry out functions such as designing or improving a part or a product. 2. Software packages designed for high quality graphical output regarding the design of products.
Computer Aided Mapping	Software packages designed for graphical output in the form of maps. These packages usually contain no analytical or manipulative qualities as the data has no topological links.
Conceptual Model	A database modelling technique that defines the types of entities or objects which are of immediate interest and the relationships between them without being specific to any particular database semantics. Thus a conceptual model can theoretically be implemented in any type of database management system.
Configuration	The particular arrangement of computer hardware and software for use within specific applications.
Continuous Data	A surface for which each location has a specified or derivable value. Typically represented by a tin or lattice (e.g., surface elevation).
Contour	A line connecting points of equal surface value.
Control Point	A system of points with established horizontal and vertical positions which are used as fixed references in positioning and relating map features, aerial photographs or remotely sensed images.
Coordinate System	A reference system used to measure horizontal and vertical distances on a planimetric map. A coordinate system is usually defined by a map projection, a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions to locate x,y positions of point, line, and area features.
CORBA	Common Object Request Broker Architecture. The basic distributed object scheme developed by the Object Management Group (OMG), a consortium similar to OGC but focused on object technology instead of distributed geoprocessing. Object Request Brokers (ORBs) help clients find servers.

CPU	See Central Processing Unit.
Currency	The level to which data is kept up to date.
Data Conversion	The translation of data from one format to another.
Data Dictionary	A repository of information in a database in which information is stored on all the objects within the database and their relationships.
Data Model	An abstraction of the real world which incorporates only those properties thought to be relevant to the application at hand. The data model would normally define specific groups of entities, and their attributes and the relationships between these entities. A data model is independent of a computer system and its associated data structures. A map is one example of an analogue data model.
Data Quality	Indications of the degree to which data satisfies stated or implied needs. This includes information about lineage, completeness, currency, logical consistency and accuracy of the data.
Data Set	A named collection of logically related data items arranged in a prescribed manner.
Data Type	The characteristic of columns and variables that defines what types of data values they can store. Examples include character, floating point and integer.
Database	A logical collection of interrelated information, managed and stored as a unit, usually on some form of mass-storage system such as magnetic tape or disk. A GIS database includes data about the spatial location and shape of geographical features recorded as points, lines, areas, pixels, grid cells, or tins, as well as their attributes.
Database Design	Formally, database design can be regarded as the third stage in the development of a database. It is where the conceptual model, developed during the data modelling or second stage, is applied to a specific database management system.
Database Management System	A collection of software for organising the information in a database. Typically a DBMS contains routines for data input, verification, storage, retrieval and combination.
Datum	A set of parameters and control points used to accurately define the three-dimensional shape of the Earth (e.g., as a spheroid). The datum is the basis for a planar coordinate system. For example, the North American Datum for 1983 (NAD83) is the datum for map projections and coordinates within the United States and throughout North America.
DBMS	See Database Management System.
De Facto Standard	A standard that has been informally adopted, often because a particular vendor was first to market with a product that became widely adopted. MS-DOS and Microsoft Windows are examples.
De Jure Standard	An official standard created in a formal “juried” process, such as the International Organization for Standards Technical Committee 211 (ISO TC/211).
DIGEST	The Digital Geographical Information Exchange Standard is produced under authority of NATO's Digital Geographical Information Working Group. DIGEST is a standard for digital Geographical Information which will enable interoperability and compatibility among national and multinational systems and users.
Digital Elevation Model	A digital representation of a continuous variable over a two- dimensional surface by a regular array of z values referenced to a common datum. Digital elevation models are typically used to represent terrain relief. Also referred to as 'digital terrain model' (DTM).
Digital Map	The representation of data in graphical form, whereby the data are divided into discrete quantified units.
Digital Terrain Model	See digital elevation model.
Discrete Data	Geographical features containing boundaries: point, line or area boundaries.
Distributed Database	A database for which different components are located on different nodes in a computer network. This network can be a simple LAN with a small number of users, to a database that is connected via a WAN such as the Internet with possibly thousands of users.

Distributed System	A complex computer system where the workload is spread between two or more computers linked together by a communications network.
DOS	Disk Operating System. Originally created by Microsoft for the IBM PC as one of the first operating systems. Operations are carried out through command line, rather than menu-driven instructions. Has become a de-facto standard within the industry.
DTM	Digital terrain model. See digital elevation model.
DXF	Data Exchange Format. A format for storing vector data in ASCII or binary files. Used by CAD software for data interchange.
EDI	See Electronic Data Interchange
EDIFACT	Electronic Data Interchange For Administration, Commerce and Transport. A set of syntax rules for the preparation of messages to be interchanged.
Electronic Data Interchange	The interchange of processable data between computers electronically.
Encoding	The assignment of a unique code to each unit of information, such as encoding of English using the ASCII character set.
Entity	A collection of objects (persons, places, things) described by the same attributes. Entities are identified during the conceptual design phase of database and application design.
Entity Relationship Diagram	A graphical representation of the entities and the relationships between them. Entity relationship diagrams are a useful medium to achieve a common understanding of data among users and application developers.
Entity-Relationship Model	A logical way of describing entities and their relationships within relational databases. An entity-relationship model is often used in the conceptual design phase of creating a relational database and is usually expressed as a diagram showing the entities and the linkages that exist between them.
Eurostat	The European Community statistical agency.
Expert System	A computer system that provides for solving problems in a particular application area by drawing inferences from a knowledge base acquired by human expertise, it is a form of artificial intelligence. Knowledge based systems, or more commonly, expert systems have been used for purposes of automated map generalisation. This is an area that they have particular application within the field of Geographical Information Systems.
Feature	A set of points, lines or polygons in a spatial database that represent a real-world entity. The terms feature and object are often used synonymously.
Federal Geographical Data Committee	A US organisation composed of representatives of several federal agencies and GIS vendors, the FGDC has the lead role in defining spatial metadata standards.
FGDC	See Federal Geographical Data Committee
Field	A set of one or more alphanumeric characters comprising a unit of information.
Format	The pattern into which data are systematically arranged for use on a computer. A file format is the specific design of how information is organized in the file.
Generalisation	Simplification of map information, so that information remains clear and uncluttered when map scale is reduced. Usually involves a reduction in detail, a resampling to larger spacing, or a reduction in the number of points in a line. Traditionally this has been done manually by a cartographer, but increasingly semi-automated and even automated methods have been used, particularly in conjunction with a GIS.
Geodata	Information that identifies the geographical location and characteristics of natural or man-made features and boundaries of the Earth. Geodata represent abstractions of real-world entities, such as roads, buildings, vehicles, lakes, forests and countries.
Geographical Analysis	See Spatial Analysis
Geographical Data	Data that record the shape and location of a feature as well as associated characteristics, which define and describe the feature.

Geographical Information	Information about objects or phenomena that are associated with a location relative to the surface of the Earth. A special case of spatial information.
Geographical Information System	A computer system for capturing, storing, checking, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System (or Spatial Information System) is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map.
Geometry	The shape of the represented entity or entities, in terms of its stored co-ordinates and the lines connecting those co-ordinates.
GI	See Geographical Information
GIS	See Geographical Information System
Global Positioning System	A satellite based navigational system allowing the determination of any point on the earth's surface with a high degree of accuracy given a suitable GPS receiver.
GPS	See Global Positioning System
Graphical User Interface	The use of pictures rather than just words to represent the input and output of a computer program.
Grid	A geographical data model representing information as an array of equally sized square cells arranged in rows and columns. Each grid cell is referenced by its geographical x,y location. See also raster.
Ground Control Point	Any point which is recognisable on both remotely sensed images, maps and aerial photographs and which can be accurately located on each of these. This can then be used as a means of reference between maps or, more commonly, between maps and digital images. Often used in the geometric correction of remotely sensed images and surveying.
GUI	See Graphical User Interface.
Hardware	All or part of the physical components of an information processing system. For example, hardware might include the monitor, printer/plotter, network, digitising tables, scanners as well as the computers themselves.
I/O	Input/Output. Refers to the ability to input data for processing or display purposes, through peripheral devices, and subsequently produce either hard or soft copy output from these processes. Peripheral devices which can be used to input data are digitising stations, photogrammetric workstations, alphanumeric workstations and scanners. Output devices include plotters and printers.
IEC	International Electrotechnical Committee. This organisation has the same status as ISO, but focuses on electrical and electrotechnical issues, especially electricity measurement, testing, use and safety.
IEEE	Institute of Electrical and Electronics Engineering Inc. A major international professional body and an accredited standards setting organisation.
Interface	For communication, a hardware and/or a software link that connects two computer systems, or a computer and its peripherals, or between a computer and its user.
Interoperability	The ability of different software systems to exchange information and requests, using methods, through an object request broker in accordance with OMG standards. It allows different applications from different vendors to work together seamlessly.
Interpolation	The estimation of z values of a surface at an unsampled point based on the known z values of surrounding points.
ISDN	Integrated Services Digital Network. Provides combined transmission of analogue and digital services. It is a set of communications standards allowing a single wire or optical fibre to carry voice, digital network services and video.

ISO	International Standards Organisation. A world-wide federation of national standards bodies that develops international standards. A Technical Committee (ISO/TC211) is developing international Geographical Information standards. Among many other computing standards, ISO also maintains an SQL standard and is developing an extended version, SQL3, which will support queries on geographical data sets.
Java	Java is an object oriented application development language written by Sun Microsystems. It is an interpreted object oriented programming language similar to C, but has been designed to run with minimum resources. It is entirely platform independent and is intended to be used to create Java applet (small application) objects which can be stored on public servers and downloaded to PCs or other network devices when needed.
Knowledge Based System	A computer system that provides for solving problems in a particular application area by drawing inferences from a knowledge base acquired by human expertise, it is a form of artificial intelligence. Knowledge based systems, or more commonly, expert systems have been used for purposes of automated map generalisation. This is an area that they have particular application within the field of Geographical Information Systems.
LAN	See Local Area Network
Land Information System	A system for capturing, storing, checking, integrating, manipulating, analysing and displaying data about land and its use, ownership and development.
Lineage	The ancestry of a dataset describing its origin and the processes by which it was derived from that origin. Lineage is synonymous with provenance, but is more than just the original source or author.
LIS	See Land Information System
Local Area Network	Computer data communications technology that connects computers at the same site. Computers and terminals on a LAN can freely share data and peripheral devices, such as printers and plotters. LANs are composed of cabling and special data communications hardware and software.
Macro	A text file containing a sequence of commands that can be executed as one command. Macros can be built to perform frequently used, as well as complex, operations.
Map Projection	A mathematical model that transforms the locations of features on the Earth's surface to locations on a two-dimensional surface. Because the Earth is three-dimensional, some method must be used to depict a map in two dimensions. Some projections preserve shape; others preserve accuracy of area, distance, or direction. See also coordinate system. Map projections project the Earth's surface onto a flat plane. However, any such representation distorts some parameter of the Earth's surface be it distance, area, shape, or direction.
Metadata	Data about data and usage aspects of it.
Middleware	Software that enables applications to access data and computing resources distributed across networked computers, regardless of incompatible operating systems and networks.
Model	A simplified representation of reality used to simulate a process, understand a situation, predict an outcome, or analyse a problem. A model can be viewed as a selective approximation which, by elimination of incidental detail, allows some fundamental aspects of the real world to appear or be tested.
Multimedia	A combination of a variety of user interfaces and communication elements such as still and moving pictures, sound, graphics and text.
National Institute of Standards and Technology	National Institute of Standards and Technology is the agency that produces the Federal Information Processing Standards (FIPS) for all US government agencies except the Department of Defence.

National Land Information Service	The National Land Information Service is an ongoing project with the aim of providing easier access to all land and property data in Britain. It is a direct result of the Citizen's Charter of 1992. Based upon BS7666, the NLIS is a hub-based network with access to data held by HMLR, The Valuation Office, OS and local government. The NLIS is a precursor to the development of a National Geospatial Database.
National Spatial Data Infrastructure	Established as a result of an Executive Order from the United States government, this is an attempt to promote the sharing of Geographical Information and increase its use in policy formation. The aim of this initiative is to enhance the United States economy and maintain a competitive edge.
Network	1. An interconnected set of arcs representing possible paths for the movement of resources from one location to another. 2. A digital map representing linear features containing arcs or a route-system. 3. When referring to computer hardware systems, a local area network (LAN) or a wide area network (WAN).
NIST	See National Institute of Standards and Technology
NLIS	See National Land Information Service
Node	The beginning and ending locations of an arc. A node is topologically linked to all arcs that meet at the node.
Normalisation	A data modelling method first devised as a database design tool for relational databases, but has since been found a useful tool for conceptual modelling. Normalisation is a bottom-up approach to data modelling.
NSDI	See National Spatial Data Infrastructure
NTF	National Transfer Format. British Standard BS7567, used for the transfer of geographical data, administered by AGI.
Object	A set of points, lines or polygons in a spatial database that represent a real-world entity. The terms feature and object are often used synonymously.
Object Management Group	The Object Management Group, founded in 1989, is a computing industry collaboration to promote object-oriented interoperability among heterogeneous computing environments. They continue to develop specifications which address the many aspects of this problem, the most popular of which is the Common Object Request Broker Architecture (CORBA). Members include all the main hardware and software vendors, as well as leading users of object technology. Further details can be found at http://www.omg.org.
OGC	See Open GIS Consortium
OLE	Object Linking and Embedding. Microsoft's specification for object technology, which it is using throughout its operating systems, development tools and applications. Based upon the underlying Component Object Model (COM), OLE is the foundation for component software to interact and co-operate. OLE also makes it easy to create compound documents consisting of multiple sources of information from different applications, for example, embedding a MS Excel spreadsheet into a MS Word document.
OMG	See Object Management Group
Open GIS Consortium	The Open GIS Consortium is a voluntary, non-governmental, non-profit organisation dedicated to the development of an open systems approach to geoprocessing.
Open System	An information processing system that complies with the requirements of open systems interconnection (OSI) standards in communication with other such systems.
Operating System	The low-level software which schedules tasks, allocates storage, handles the interface to peripheral hardware and presents a default interface to the user when no application program is running.
Oracle	A relational database management system.

OSI	Open systems interconnection. This defines the accepted international standard by which open systems should communicate with each other. It takes the form of a seven-layer model of network architecture, with each layer performing a different function.
Picture Element	See Pixel
Pixel	Square shaped cell comprising the smallest unit that makes up a computer image. Pixel size determines resolution of an image and the quality of graphical output. Pixels can be assigned a number of attribute values.
Plotter	Peripheral device used in the making of hard copy maps or graphical output.
Polygon	A feature used to represent areas. A polygon is defined by the lines that make up its boundary and a point inside its boundary for identification. Polygons have attributes that describe the geographical feature they represent.
Precision	The exactness with which a value is expressed, whether the value be right or wrong.
Projection	See map projection.
Protocol	Protocols are a fixed set of rules used to specify the format of an exchange of data.
Quadtree	The expression of a two dimensional object, such as a digital image, as a tree structure of quadrants which are formed by recursively subdividing each non-homogeneous quadrant until all quadrants are homogeneous with respect to a selected property, or until a predetermined cut-off 'depth' is reached.
Query	A statement expressing a set of conditions that forms the basis for the retrieval of information from a database. Queries are often written in a standardised language such as SQL.
Query Language	Method of communicating data manipulation and definition commands to a database. Command driven interface rather than menu-based. Commands are typed by the user and then analysed by the query compiler which subsequently passes them to the processor. The de facto standard in use is the Standard Query Language (SQL). Query languages allow data to be inserted, modified and retrieved. Query languages are more highly structured than earlier command-based systems, approaching English in syntax.
Raster	A method for the storage, processing and display of spatial data. Each given area is divided into rows and columns, which form a regular grid structure. Each cell must be rectangular in shape, although not necessarily square. Each cell within this matrix contains an attribute value as well as location co-ordinates. The spatial location of each cell is implicitly contained within the ordering of the matrix, unlike a vector structure which stores topology explicitly. Areas containing the same attribute value are recognised as such, however, raster structures cannot identify the boundaries of such areas as polygons. Also raster structures may lead to increased storage in certain situations, since they store each cell in the matrix regardless of whether it is a feature or simply 'empty' space.
RDBMS	See Relational Database Management System
Record	1. In an attribute table, a single 'row' of thematic descriptors. In SQL terms, a record is analogous to a tuple 2. A logical unit of data in a file.
Reference Model	Provides the complete scientific and engineering contextual framework for a technology area. The underlying elements, rules and behaviours.
Relational Database Management System	A database management system with the ability to access data organized in tabular files that can be related to each other by a common field. An RDBMS has the capability to recombine the data items from different files, providing powerful tools for data usage.
Remote Sensing	The technique of obtaining data about the environment and the surface of the earth from a distance, for example, from aircraft or satellite.
Resolution	A measure of the ability to detect quantities. High resolution implies a high degree of discrimination but has no implication as to accuracy. Resolution is a term that is used often within remote sensing.

Scale	The ratio of the distance measured on a map to that measured on the ground between the same two points.
SDM	See Systems Development Methodology
Server	A computer which provides some service for other computers connected to it via a network. The most common example is a file server which has a local disk and services requests from remote clients to read and write files on that disk.
Spatial Analysis	Analytical techniques associated with the study of locations of geographical phenomena together with their spatial dimensions and their associated attributes. Spatial analysis is useful for evaluating suitability, for estimating and predicting, and for interpreting and understanding the location and distribution of geographical features and phenomena.
Spatial Information	Information that includes a reference to a two or three-dimensional position in space as one of its attributes.
Spatial Modelling	Analytical procedures applied with a GIS. There are three categories of spatial modelling functions that can be applied to geographical features within a GIS: 1, geometric models, such as calculating the Euclidean distance between features, generating buffers, calculating areas and perimeters; 2, coincidence models, such as overlays; and 3, adjacency models (pathfinding, redistricting, and allocation).
Spatio-temporal data	Data that is concerned with both space and time.
Spatio-temporal Database	Databases designed for the storage and management of spatio-temporal data. Most GIS only have limited capabilities for storing and manipulating temporal data, although specifically designed to cope with spatial data.
Spiral Model	A model of the software development process in which the constituent activities, typically requirements analysis, preliminary and detailed design. Coding, integration, and testing, are performed iteratively until the software is complete. See also: Waterfall Model.
SQL	Structured Query Language. A syntax for defining and manipulating data from a relational database. Developed by IBM in the 1970s, it has become an industry standard for query languages in most relational database management systems
Systems development Methodology	An integrated set of techniques and methods for effective and efficient planning, analysis, design, construction, implementation and support of computer systems.
TCP/IP	Transmission Control Protocol/Internet Protocol. A communication protocol layered above the Internet Protocol. These are low-level communication protocols, which allow computers to send and receive data. It is the communication standard that underlies the Internet.
Temporal Database	A database containing information indexed by time. Time can either be represented as discrete steps, or less commonly, as a continuous variable.
TIGER	Topologically Integrated Geocoding and Referencing. A data format developed by the US Bureau of Census for the 1990 US census.
TIN	Triangulated Irregular Network. A form of the tesseral model based on triangles. The vertices of the triangles form irregularly spaced nodes. Unlike the grid, the TIN allows dense information in complex areas, and sparse information in simpler or more homogeneous areas. The TIN dataset includes topological relationships between points and their neighbouring triangles. Each sample point has an X,Y co-ordinate and a surface, or Z-Value. These points are connected by edges to form a set of non-overlapping triangles used to represent the surface. Tins are also called irregular triangular mesh or irregular triangular surface model.
Topographic Map	1. A map containing contours indicating lines of equal surface elevation (relief), often referred to as topo maps. 2. Often used to refer to a map sheet published by the U.S. Geological Survey in the 7.5-minute quadrangle series or the 15-minute quadrangle series.

Topology	The spatial relationships between connecting or adjacent coverage features (e.g., arcs, nodes, polygons, and points). For example, the topology of an arc includes its from- and to-nodes, and its left and right polygons. Topological relationships are built from simple elements into complex elements: points (simplest elements), arcs (sets of connected points), areas (sets of connected arcs), and routes (sets of sections, which are arcs or portions of arcs). Redundant data (coordinates) are eliminated because an arc may represent a linear feature, part of the boundary of an area feature, or both. Topology is useful in GIS because many spatial modelling operations don't require coordinates, only topological information. For example, to find an optimal path between two points requires a list of the arcs that connect to each other and the cost to traverse each arc in each direction. Coordinates are only needed for drawing the path after it is calculated.
Triangulated Irregular Network	See TIN.
Triangulation	A process of subdividing a 2D space into bounding regions that are triangles.
Tuple	A row in a relational table; synonymous with record, observation.
Turn-key System	A term that describes a system (hardware and software) which can be used for a specific application without requiring further programming or software installation. The user can just 'turn the key' (switch it on) and use it.
User Interface	A method by which a user controls operation of a computer system. Typical types of user interface include command line, conversational mode and graphical user interfaces (GUI).
User Requirement Analysis	A study of the needs of a user of a system conducted prior to system development.
UTM	Universal Transverse Mercator. A grid system based upon the Transverse Mercator projection. The UTM grid extends North-South from 80 o N to 80 o S latitude and, starting at the 180 o Meridian, is divided eastwards into 60, 6 o zones with a half degree overlap with zone one beginning at 180o longitude. The UTM grid is used for topographic maps and georeferencing satellite images.
Vector	One method of data type, used to store spatial data. Vector data is comprised of lines or arcs, defined by beginning and end points, which meet at nodes. The locations of these nodes and the topological structure are usually stored explicitly. Features are defined by their boundaries only and curved lines are represented as a series of connecting arcs. Vector storage involves the storage of explicit topology, which raises overheads, however it only stores those points that define a feature and all space outside these features is 'non-existent'.
Vertex	One of a set of ordered x,y coordinates that constitutes a line.
Visualisation	A term that is applied to the field of computer graphics that attempts to address both analytical and communication issues of visual representation. Visualisation in GIS often refers to the visual representation of geographical data for purposes of spatial analysis.
WAN	See Wide Area Network
Waterfall Model	A model of the software development process in which the constituent activities, typically a concept phase, requirements phase, design phase, implementation phase. test phase, installation and checkout phase, and operation and maintenance, are performed in that order, possibly with overlap but with little or no iteration. Contrast with rapid prototyping; spiral model.
Wide Area Network	Computer data communications technology that connects computers at remote sites. WANs are composed of special data communications hardware and software and usually operate across public or dedicated telephone networks.

Workstation	A general purpose computer designed to be used by one person at a time and which offers higher performance than normally found in a personal computer, especially with respect to graphics, processing power and the ability to carry out several tasks at the same time. This performance difference however is decreasing, and in time the distinction between a desktop and a workstation will be meaningless in terms of performance.
Z-Value	The value of a surface at a particular X,Y location, for example, elevation. The Z-value usually refers to 3D features, but in GIS it can also refer to what is known as 2.5D features.