THE INDONESIAN STANDARDS FOR THE EXCHANGE OF DIGITAL DATA BETWEEN VARIOUS GIS SYSTEMS

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ABSTRACT:

The development of standards for the exchange of digital spatial data between various GIS in Indonesia, is a task of high priority. This includes the design of the information model and its supporting data structure and the transfer format for the data exchange. This model is based on the object-oriented concept in order to allow the transfer of terrain features at various levels of complexity and abstraction and with freely defined descriptors. computer packages were developed for the interfacing between this standard and the existing GIS systems.

NEEDS FOR STANDARD DATA EXCHANGE FORMAT IN INDONESIA

The inventory of natural resources in Indonesia is vital for its economical growth. Agencies involved in this task are under the pressure to make the optimum use of the technological advances achieved in the area of GIS applications. Among many organizational and technical components, the availability of terrain information in digital form, with a specified format and data organization, is a prerequisite in these systems. With a special reference to the on-going Land Resource Evaluation and Planning Project, LREP, the present phase of development was directed towards the acquisition of digital data on resource potentials and environmental conditions in major Islands in Indonesia. These data should be made available to the Regional Planning Offices (BAPPEDA's) for the analysis and evaluation of resource data.
The National Coordination Agency for Surveys and Mapping, Bakosurtanal, is taking a leading role in coordinating these activities and the creation of a National Topographic Database that can be used continuously by all potential users, is a task of high priority, [4]. It is also agreed to assign to Bakosurtanal the leadership in defining and maintaining Government's earth science standards. Under this agreement, Bakosurtanal is coordinating the development of a standard for the exchange of digital data between GIS systems in Indonesia. The solution to the data exchange problem will promote the use of GIS technology since it reduces the initial effort and cost required to set up a database and facilitates the integration of different data types from different sources.
The first draft (a prototype) of the proposed standard was produced in 1991 under the name: BAKO_DATA_EXCHANGE_FORMAT, in the frame of the ITC-BAKOSURTANAL Cooperation Programme, TAT Project, [6], [7].
This prototype will be tested, enhanced and adapted to the Indonesian environment, before submission for designation as a National Standard for Data Exchange.

GENERAL CONSIDERATIONS IN THE DATA EXCHANGE STANDARDS

Since the middle of the 60th, various information systems had been developed for spatial data analysis and GIS applications in various disciplines. In these early days of development, the work was not coordinated and the same or equivalent data is repeatedly collected by different groups. This problem of redundancy and/or shortage of particular data types in a specific format and quality, leads to much wasted time and resources.

With the increasing activities in this field, there is greater need for exchanging digital spatial data between organizations and GIS systems. Data sharing reduces costs by avoiding duplication of data capture and maintenance and ensure data integrity.
Transferring spatial data, however, is often complex due to the incompatibility of various GIS systems. Each has its own concept for the modelling of reality, different data structures and data processing levels and computer systems of different make.
It had been realized in many countries that the full benefit of data sharing depends on the availability and wide use of an efficient and effective method for the exchange of spatial data. Developing direct convertors for the transfer of data between systems, each has its own data format, is not an efficient approach particularly when the number of different systems to be supported is large. Instead, the use of an intermediate standard format as the transfer form and the development of convertors for interfacing between the various formats and the standard one (i.e. converting data to and from the standard form), offer various advantages:

- Less effort in software development and free from constraints imposed by changes and upgrading of specific system(s) in the information communication network.
- Standard format provides 'agreement' on concepts for the modelling of reality, definition and classification of spatial entities, and structuring and formatting of the transfer. This will assist all levels of communication between spatial data users and avoid reliance on vendor-specific formats.

Decision on standards for data transfer involves many aspect:

- What purpose will the transfer support: data display or spatial analysis operations?
- Concepts for the modelling of the real world: the transfer data model (description and organization of spatial features and relationships) and its supporting data structure (how descriptors, relationships and links are implemented).
- Standards for the definition of terrain features, attributes and authority for the data definition.
- Flexibility of the transfer data model to accommodate a wide range of sender/receiver data models.
- How to report about data quality (lineage, positional accuracy, attribute accuracy, logical consistency and completeness of the data).
- Format of the transfer (organization of the transferred data in data-records).

- What effort is needed to extract transferred information once being available in such a standard format, and without losing its meaning.
- What tools the transfer should carry in order to support the retrieval and restructuring of the transferred data to the receiving system
- What are the physical characteristics of the transfer media and format for information encoding (e.g. ISO 8211 Format).

Various research groups had been formed in many countries since the 80th in order to handel these issues and design standards for the exchange of digital data.
Several standards had been developed such as the Canadian CCSM National Standards for the Exchange of Digital Topographic Data, the USGS Digital Line Graphic Enhanced DLG-E, the UK National Transfer Format NTF, the USA Spatial Data Transfer Specification SDTS, the Digital Geographic Information Exchange Standard DIGEST for Nato nations, [3], [8]. With few exceptions, the majority of these standards are in an experimental status (i.e. prototypes), subject to evaluation and enhancement.
The International Cartographic Association ICA had founded the ICA working group on Digital Cartographic Database Exchange Standards with the objective to develop a mechanism for the exchange of experiences concerning such developments in many countries, [2], [3].

DEVELOPMENT PLAN

Reference to the decision taken at Bakosurtanal in the frame of the next phase of the LREP project, 1992-1996, the task of developing standards for the exchange of digital spatial data between the GIS Systems in the Information Network in Indonesia, is to be shared between Bakosurtanal and the BPPT (GIS and Remote Sensing Division, Ministry of Technology), where:
- Bakosurtanal has the task to develop Standards for Data Exchange.
  This will include the design of the Information Model and its supporting Data Structure and the Transfer Format for the Data Exchange.
- BPPT has the task to develop the 'interfaces' between this Standard and the various GIS Systems. This will include the development of procedures and computer packages for the conversion of data files in these systems to the Standard Format, and vice versa.

The Bakosurtanal Working-Group on Specification, has the task to develop:
- Standards for Data Transfer
- Standards for Data Definition and Classification
- Standards for Reporting on Data Quality
- Data Dictionary

Due to the complexity of such a task and the time and manpower needed for its completion, and the lack of information about the systems to be considered, we proceeded with this task as follows:
- Study and analysis of the available documents about the specifications made by many mapping institutions around the world, as listed in [8].
- Based on this study and reference to our previous work on the design of concepts for the Bakosurtanal Topographic Databases, [5], the first draft (a prototype) on standard was produced in 1991 under the name: BAKO_DATA_EXCHANGE_FORMAT. This work involves the definition of data types, the transfer's data model for the modelling of terrain features, the data structure which support this model and the format for data organization (i.e. data records).
- Empirical testing on this prototype and the following versions has be completed before submission for designation as a National Standard for Data Exchange.
  In this test, encoded data files, extracted from the Bakosurtanal Database, will be exchange and decoded by the participating agencies. The concepts of the transfer will be evaluated and suggestions for enhancement and adaptation to the Indonesian environment will be considered in the next version.
- At this phase of development, only the transfer of vector data is considered. Raster data will also be considered in later stage.

TRANSFER STRUCTURE IN THE BAKO_DATA_EXCHANGE_FORMAT

The main feature of the Bakosurtanal Standard is the use of of the 'Object-Oriented' concept in modelling terrain features as a base for the transfer of terrain information. This concept is consistent with the logic of the user's view on the real world as a sets of objects of different semantic classes and of different levels of complexity. This is contrary to the conventional approach which is 'map-sheet' oriented and based on the use of the basic map elements (point/line/area), classified in themes, for the modelling of terrain information.

In most of the published Standards, with few exceptions, the object to map element relation is 1:1 relation, i.e. the object is either a point, a line or an area. In our approach, this relation is n:m relation, i.e. one object in the transfer, will refer to other objects of less complexity and/or more than one map element for its spatial description. Similarly, one map element could be shared by more objects, in the same or different sematic classes in the data hierarchy.

Further, the semantic attributes are defined and assigned to the object, rather than to the basic map elements. These elements however, will have a set of 'standard' attributes: reference to classes which it belongs, and information about source, method and quality of its extraction.

Terrain information and other supporting information being transferred at any one time is called 'TRANSFER' which might occupy one or more physical volumes.
Logically, the Transfer in this Standard Format will consist of several (related) data types:
- Data Area-Tiles: each consists of geographically related collection of Data Theme-Groups
- Data Theme-Groups: each consists of topologically and geographically related collection of Data Themes (Entity Classes)
- Data Themes (Entity Classes): each consists of a collection of thematically related Entity-Types (Subclasses).
- Data Entity-Type: a collection of terrain features (objects). These objects are described by its spatial (location and geometry) and semantic (attributes) descriptors and the relationships between them.
- Objects: objects included in the Transfer can be at various levels of complexity, where complex objects are composed of objects of lower logical level in the data hierarchy. In the lowest level, objects are sets of primitive map elements (points, lines, areas).
  The composition of a complex object is described by a set of indices to the data records of the

corresponding components: other 'less' complex objects and/or primitive elements which compose this complex object.
- Map elements: a set of topologically related map elements: Nodes /Lines/ Polygons), which provide the spatial descriptions of Theme Objects.
The primitive elements which are related to all Theme-objects in one Data Theme-Group are grouped in one 'pool', referred to as Theme 0. This will preserve the topology between the spatial objects on both levels: in the theme as well as across themes.

The semantic descriptors of terrain objects are given as a set of values for a given Attribute List which is defined in the Transfer's Data Dictionary. Two sets of attributes can be assigned to theme's objects: Standard Set (defined by the specifications), and Non-Standard Set (defined in agreement with the receiving agency).

The structure of this Transfer in the physical volumes, as shown in figure (1), has the following schema:

SET (1): Transfer Global Information Records:
Administrative aspects, definition and area coverage, Data Dictionary.

SET (2): Area-Tile Records:
Definition, area coverage and description of contents, spatial coordinate reference, overall evaluation for the data quality.

SET (3): Theme-Group Records:
Definition of the Theme-Group and list of the Themes included.

SET (4): Theme Records:
1. Definition of the Theme and the type of its objects.
2. Definition of Theme's Entity-Types (sub-classes) and definition of their objects attributes.
3. Theme-Object Lists (object identifiers, quality parameters, attribute lists and reference to their spatial components (other objects and/or map elements).

SET (5): Primitive Map Elements Records (Nodes/Points, Lines, Areas) Coordinates and topology of these elements.

Further details are given in the Appendix.

COMPUTER PACKAGES FOR DATA CONVERSION

The development of standards for the exchange of digital data includes the design of 'interfaces' between the proposed standard and the various GIS systems. These include procedures and computer packages for the conversion of the data files in these systems to the Standard Format, and vice versa.
The effort and time needed for this task should not be under estimated and it might exceed the benefits for their specialist applications. Its complexity vary according to the nature of the internal data structure of the database in comparison with those of the proposed Standard. Subset or 'profiles' of the proposed standard may therefore be required to simplify implementation for particular applications.

Within the framework of the first prototype development, two computer packages (ARCINFO_TO_BAKO and BAKO_TO_ARCINFO) were developed for the conversion of terrain information (organization, locations and attributes of terrain features), in the ARC/INFO files (where the Bakosurtanal Database is resident) into the proposed Standard Format and vice versa. At this stage of development, these programs are based on a simplified 'profile' of the proposed Standard, and are subject to modification and expansion. The objectives of these packages are:
- provide a tool for the exchange data files, extracted from the Bakosurtanal Database, to other agencies which are taking part in the testing of the first prototype.
- give an example to follow in order to help BPPT in developing further 'interfaces' between this Standard and other available GIS systems in Indonesia.

The program package ARCINFO_TO_BAKO consists of various modules which are executed in a similar sequence to that in Figure (1). The tasks of these modules is to process the information stored in the Bakosurtanal Topographic Database in the ARC/INFO MAPLIBRARY files, [5], and organize them in the required data structure and format:
- Information about the organization of the terrain features in Area-Tiles, Theme-Groups, Themes and Theme's Entity-Types and Theme-Objects will be obtained from the MAPLIBRARY DATABASE MANAGEMENT Files and used to write the data sets: SET (1), SET (2), SET (3), SUB-SET (4.1), SUB-SET (4.2).
- Semantic descriptors (Attributes) of themes objects will be obtained from the INFO and other related Databases Files and used to write the data set: SUB-SET (4.3).
- Spatial descriptors (location and topology) of the theme's objects will be defined by the basic map elements (Nodes, Points, Lines, Areas). These elements are described by their location (coordinates) and the topological relationships amongst them and obtained from ARC/INFO Files (ARC, PAL, CNT, LAB, AAT, PAT), in order to write the data set: SET (5).

The program package BAKO_TO_ARCINFO will process the information encoded in the Transfer and organize them in ARC/INFO coverages and INFO files:
- Information in data sets: SET (1), SET (2), SET (3), SUB-SET (4.1), SUB-SET (4.2) are organized in the MAPLIBRARY DATABASE MANAGEMENT Files.
- Information in data set: SUB-SET (4.3) about object attributes are stored in INFO Tables, ARC/INFO Coverage-wise, and the references to map elements in SET (5) are used to pick up the corresponding elements which form the Theme's objects and stored in ARC/INFO Files (ARC, PAL, CNT, LAB, AAT, PAT).

Note: complex objects (formed from 'less' complex ones) are not considered in this version and only a simplified profile of this Standard is considered for the transfer of topologically structured vector data.

These modules were written in FORTRAN Language and use the various subroutines in the ARC/INFO Programmer Library in order to access various data files in ARC/INFO, [1].

FUTURE DEVELOPMENT

In the next phase of the LREP Project, 1992-1996, the task of testing and upgrading the proposed

Standards will continue. Further interfaces with other GIS systems will be developed in order to promote the proposed Standard and encourage more agencies to participate in these developments. The support of the BAKO_DATA_EXCHANGE_FORMAT Standard by various geo-information producers and users, will insure full benefit of data sharing and achieve compatibility between GIS systems.

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[8] Selected Documents on Standards:
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- DIGEST, Digital Geographic Information Exchange Standard Defense Mapping Agency, USA, June 1991
- SDTS, Spatial Data Transfer Standard, Federal Interagency Coordinating Committee for Digital Cartography, USGS, USA, 1991
- VPF, Vector Product Format, Defence Mapping Agency, USA, 1990 (also the Digital Chart of The World Database)
- Canadian CCSM National Standards for the Exchange of Digital Topographic Data, 1985
- DLG-E Digital Line Graph, USGS Internal Data Format, 1989

APPENDIX

BRIEF DESCRIPTION OF THE TRANSFER RECORDS

SET (1): GLOBAL INFORMATION ABOUT THE TRANSFER
The administrative aspects, definition, spatial reference and the data dictionary of the Transfer, are given as follows:

SUB-SET (1.1): TRANSFER HEADER RECORD
It provides a reference to the administrative aspects of this transfer.

SUB-SET (1.2): TRANSFER IDENTIFICATION RECORD
It gives general information about the Transfer contents, spatial domain and geographic area reference, range of data-scale and dates of cultural validity.

SUB-SET (1.3): TRANSFER SECURITY RECORD
This module provides information about the security of data, copy right, authority for data update, etc.

SUB-SET (1.4): TRANSFER DIRECTORY RECORDS
This Directory Record(s) appears only once in the first physical volume and after the Transfer Header Record. It helps in locating the various Area-Tiles Header Records in the physical volume(s) files.

SUB-SET (1.5): DATA DICTIONARY RECORDS

SUB-SET (1.5.1): SPECIFICATION DOCUMENTS REFERENCE RECORD
It provides reference and publication date of the various specification documents.

SUB-SET (1.5.2): ENTITY DEFINITION RECORDS
It gives definition of entities of interest for the Transfer: definition, source and authority for the entity's definition and its attributes.
Entities included in this Transfer will have two sets of attribute lists: Standard Set (defined by specifications), and Non-Standard Set (defined in agreement with the receiving agency).

SUB-SET (1.5.3): ATTRIBUTE DEFINITION RECORDS
It gives definition of Standard/Non-Standard Attributes: definition, source and authority for the attribute's definition and the valid range of its value.

SET (2): AREA-TILE DATA RECORDS
One Area-Tile consists of one or more geographically related Theme-Groups, and is described by:

SUB-SET (2.1): AREA-TILE DATA HEADER RECORD: DEFINITION
It includes information about area name, area coverage, no. of Theme-Groups and list of Themes and brief description of its contents.

SUB-SET (2.2): AREA-TILE DATA DIRECTORY RECORDS
This Directory Record(s) is used to locate (in the physical volume(s) files) the various Theme-Groups in this area.

SUB-SET (2.3): RECORDS FOR THE SPATIAL REFERENCE
The spatial reference in a spatial data transfer is defined through the use of the following modules:

SUB-SET (2.3.1): SPATIAL DOMAIN RECORD
Definition of coordinate system, units, and the extent of the spatial address. This is given as reference to specification's document which handle this matter.

SUB-SET (2.3.2): INTERNAL SPATIAL REFERENCE RECORD
Internal Spatial Reference: from the internal coordinate system to the external system. This includes coordinate type, format, and scaling and shifting of coordinates.

SUB-SET (2.3.3): EXTERNAL SPATIAL REFERENCE RECORD
External Spatial Reference (to define the external coordinate system).

SUB-SET (2.4): AREA-TILE DATA QUALITY RECORD
It provides an overall evaluation for the Data in this area, such as the source of information (database reference), completeness and cultural validity, reliability of positional and classification of its contents (descriptive text).

SET (3): DATA THEME-GROUP RECORDS
One Theme-Group includes one or more topologically/logically related themes. Themes in one Group share the same primitive map elements (Node/Line/Polygon). They are numbered from Theme 1 to Theme n, While Theme 0 refers to the map elements in this group. One Theme-Group is Described by:

SUB-SET (3.1): THEME-GROUP HEADER RECORD
It gives definition of this Group, list and definition of Themes included and nature of relationships between them.

SET (4): THEME RECORDS
Each Theme (class) in the Theme-Group is defined by several Records:
- Overall theme's characteristics
- Definition of theme's entity-types (subclasses)
- List of objects and object's descriptors in each entity-type

SUB-SET (4.1): THEME DEFINITION RECORDS

SUB-SET (4.1.1): THEME HEADER RECORD
It gives Theme-ID, Theme definition and No., definition and list of Entity-Types in this Theme and index to their records in the Transfer.

SUB-SET (4.1.2): THEME QUALITY RECORDS
Two sets of records are provided:
- First set: overall quality evaluation for the whole of the theme's content, such as source and methods of data acquisition, date of cultural validity, completeness, reliability of positional and classification accuracy (miscloser matrix of a selected sample)

- Second set: set of records to provide quality evaluation for sub-sets of theme's objects. The quality parameters included are:
  . indicator for source and method of data acquisition
  . indicator for cultural validity and rate of change
  . Resolution indicator and its map scale equivalence
  . Positional Accuracy (numerical statistical estimate for coordinate miscloser)
  . Indicator for attribute Accuracy (misclassification matrix of a selected sample)

SUB-SET (4.2): THEME ENTITY-TYPE DEFINITION RECORDS

SUB-SET (4.2.1): THEME ENTITY TYPE HEADER RECORD
A record per one Theme-Entity Type in order to give definition of this sub-class: its ID, description, code and no. of attributes for theme's objects in this sub-class.

SUB-SET (4.2.2): ATTRIBUTE DEFINITION RECORDS
One set of records per one Theme's Entity-Type in order to give definition of the Object's Attributes in this sub-class. The Attribute Descriptors include ID, definition and source of authority for attribute definition, format, and range of valid values.

SUB-SET (4.3): OBJECT LIST RECORDS
One set of records per one Theme Entity Type in order to give list of objects in this Entity Type: its Name, ID, Class-Code, Bounding Rectangle, Reference Point, Orientation, Evaluation code and reference to Theme's Quality Records, List of Attribute ID and Values, References to object's components (other objects in this Theme and/or Map Elements in Theme 0 which form this object).

SET (5): MAP ELEMENTS (TOPOLOGICALLY RELATED ELEMENTS)
One set of data per Theme-Group (Theme 0) in order to give spatial and topological descriptors to the Primitive Elements (point/line/area) which form the Objects in the Themes of this Theme-Group. This set consists of:

SUB-SET (5.1): NODE/POINT-RECORDS
A group of records to provide the Node/Point ID, location, No. and list of Line-ID of the Lines attached to this Node, List of classes (themes) which share this element, source and quality parameter for data acquisition.

SUB-SET (5.2): LINE-RECORDS
A group of records to provide the Line's ID,, list of Line's vertices, start and end Nodes, left and right Areas, list of classes (themes) which share this element, source and quality parameter for data acquisition.

SUB-SET (5.3): AREA-RECORDS
A group of records to provide the Area's ID, list of bounding Lines, Area's label point, list of classes (themes) which share this element, source and quality parameter for data acquisition.

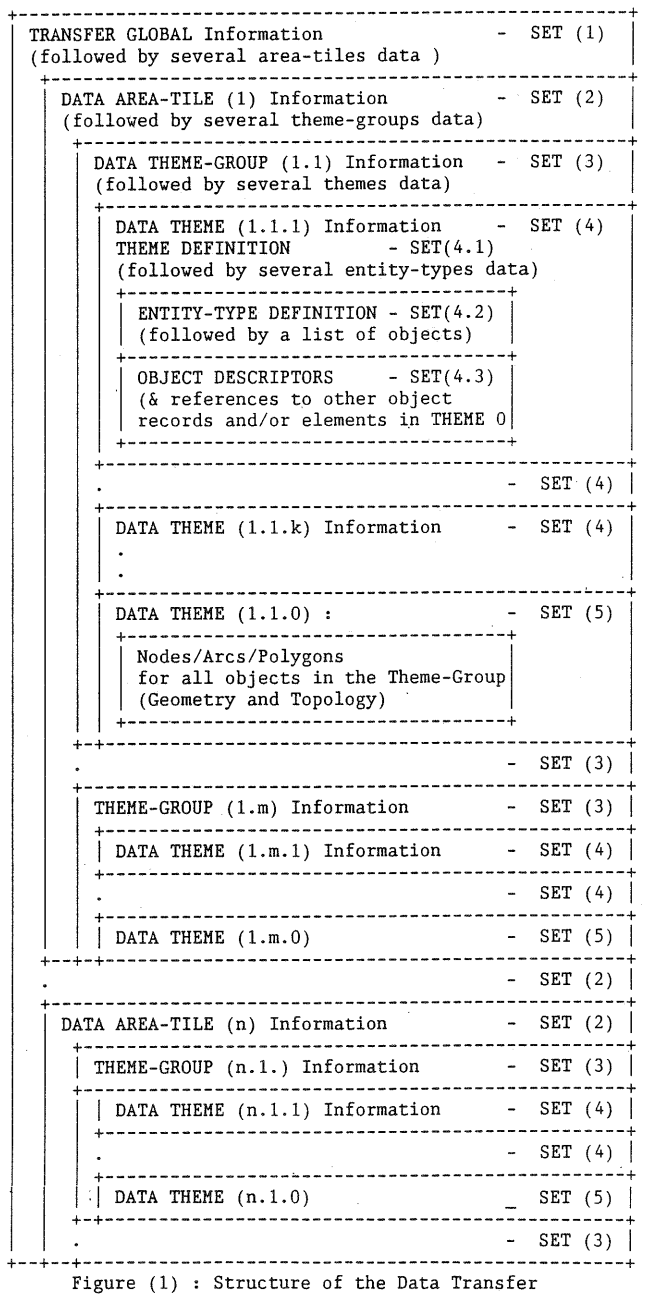

Figure (1) : Structure of the Data Transfer