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10-C Approach for Quality Assesment and Accuracy of Geospatial Information in Indonesia

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Abstract

This paper discuss about the accuracy and quality of geospatial information in Indonesia comprehensively. The 10C-approach is proven effectively during last 10 years, when this method is introduced for first time. The 10C-approach consisted of 7C-technical aspects and 3C-non-technical aspect. The 7C are Coverage, Completeness, Consistency, Correctness, Currentness, Creativity-level and Communicative; while the 3C are Cost-effective, Conform-to-the-law and Contextual. The Accuracy as Correctness will be diviede in Object, Sensor, Ackquisition, Process, and Visualization-Accuracy.

Keywords: accuracy, quality assesment, geospatial information, 10C-approach.

1. Introduction

Spatial data and geography information in the beginning of the 21st century have become popularly used either for the needs of technical planning or environmental control. At the same time, the awareness of users for the quality of data and geographic information also has increased. Users have become more critic and skeptic after they realize that the procurement, maintenance and modernization of spatial data and geographic information need a lot of funding. Frank (1991) has predicted that the price of the data component reaches 80 %, while the software and hardware procurement respectively only reach about 15 % and 5 % from the total investment for one operational geographic information system.

Although Indonesia has introduced government regulations no.10 (PP10) about map accuracy levels for spatial region management, still when these regulations are evaluated, they look too general and have not touched the technical issues, so it is no surprise that some questions of practical level still remain open.

Some typical questions are:

- What is the appropriate accuracy and horizontal/vertical resolution of DEM to create models of flooding?
- What is the map scale which is needed together with its DEM?
- Until what scale can the data be used to make maps, with σ accuracy?
- What is the accuracy of data, which is needed to make S scale maps?
- Until what map scale the raster data (Landsat, SPOT, Ikonos, Insar) can be used either in way of raster map or after vectorization?

2. Taxonomy of accuracy and the quality of data.

Goodchild (1991) has defined accuracy as the relation between the measurement and the reality, which should be drawn. The Indonesian Goverments Act PP10/2000 about the Map Accuracy Level for Spatial Planning Management mentions on: Section 1 paragraph 2: Map scale is the comparison number of the distance between 2 points on the map with their distance on the earth. Section 1 paragraph 3: Map accuracy is the accuracy, detail and the completeness of data and or geo-reference and thematic information. The map of Indonesian state as a whole is oriented at the minimum map scale of 1: 1.000.000, while the province 1: 250.000, the rural districts (kabupaten) 1:100.000 and the urban area (kota) 1: 50.000.

Some GIS experts don't evaluate accuracy separately from the quality of data. Chrisman (1991), Bernhardsen (1992) and some other authors use the term "the error component" and mention position, attribute and accuracy as "dimension" of data, so these are recognized as position accuracy, attribute accuracy, logic topology consistency (for instance: polygon must be closed) and completeness. While Burrough (1986) started the discussion of the quality problem of data by detailing some amount of possible error sources in GIS. But in general, it can be distinguished between the type quality of data and the accuracy which is experienced by the data in the journey from the real world object to information which is accepted by users. The quality type of data can be described briefly by the "10c principle", while the journey of accuracy degradation can be divided into 5 phases.

2.1 The 10C Approach

The quality of spatial data/map is not only covering the accuracy, detail and completeness of the map, but also covering the consistency of contents, coverage and the congruity of time and price. In English, these characters can be simply formulated in abbreviation of "10C".

- Coverage (the width coverage of respective data)
- Completeness (completeness of contents, detail data attributes, etc)
- Consistency (homogenous and "logic" topologically, etc)
- Correctness (data accuracy from measurement until visualization)
- Currentness (the actuality of data)
- Creativity-Level (step of processing, raw data, geodatabase, cartographic)
- Communicative (different type of formats and used symbology)
- Cost-effective (effort to obtain the data according to requirments.)
- Conform-to-the-law (regulation to access, use or distributing of the data)
- Context (political or cultural aspect which might restrict the data).

Within these 10 aspects, the geometry accuracy (correctness) is indeed only one of the points. But this aspect is influenced by many things, so it can be spelled out in a "accuracy taxonomy" which is applied to the journey of data from object in a real world up to the information which is ready to be obtained by users. Figure 1 is one of the brief approximations to that taxonomy.

Object accuracy →	Sensor accuracy →	Acquisition accuracy →	Process accuracy →	Visualization accuracy →

2.2 Object Accuracy.

The data accuracy of a geographic object always starts from the object itself. What is measured from the object can be metric and non metric, however to process the non-metric it is needed to transform them into metric data, for instance time data, gravitation, temperature, atmospheric pressure, etc. The measurement instruments for every parameter are certainly different.

There are objects, which have sharp strong definitions. One point on the corner of the roof of the building will be measured more precisely than a point in the middle of an intersection of the road or the corner of the dike on the rice field. Also, the height of land surface will be measured more thoroughly than the heights of trees. The edges of the big rivers are measured easier because the inner side and the edges are not covered by other objects. Although the measurement instruments themselves are equally accurate, but as long as the definition of objects, which are measured is not strong, then the geometry accuracy will not be high. Then when the object is formed from another object, which is simpler in a topology, then its total accuracy is also determined by this topology configuration. Because of that in the measurement of net control, the net configuration has totally significant influence on the object accuracy. Kraus (1986) has given an example of description of empirical experience with such object accuracy :

Table 1: Object Accuracy

Object	σxy-def	σz-def
Canal cover	4 – 6 cm	1 – 3 cm
House	7 – 12 cm	8 – 15 cm
Edge of the non-irrigated rice field	20 – 100 cm	10 –20 cm
Trees	20 – 100 cm	20 – 100 cm

2.3 Sensor Accuracy.

Data of some objects can have different accuracy when measured with different sensors. Global Positioning System instrument (see Table 2), airborne camera and stereo plotter (photogrammetry), image (such as IKONOS-see Table 3) and radar. Each has a wide spectrum o accuracy, which is connected to the precision of the producer and certainly to the price. The accuracy value is usually obtained in a calibration laboratory, which is well controlled, not under the nature conditions. Many of these sensors can be divided in 2 types, those are vector data producers (point sensor) and raster data producers (area sensor).

Table 2: GPS Error Sources: Typical Error Budget (in meters) (Hurn, 1993)

Per Satellite Accuracy	Standard GPS	DGPS
Satellite Clocks	1.5	0
Orbit Errors	2.5	0
Ionosphere	5.0	0.4
Troposphere	0.5	0.2
Receiver Noise	0.3	0.3
Multipath (reflections)	0.6	0.6
SA	30.0	0
Typical Position Accuracy		
Horizontal	50	1.3
Vertical	78	2.0
3-D	93	2.8

Table 3: Resolution and Accuracy of IKONOS (Fritz (1999)

Accuracy	Horizontal	Vertical
With GCP	2 m	3 m
Without GCP	12 m	10 m
Resolution (GSD)	Horizontal	
Panchromatic Multispectral	0.82 m 3.28 m	

2.4 Acquisition Accuracy

After sensor, the accuracy of objects depends on the process of data acquisition. The situation of environments such as temperature, air pressure and humidity would change refraction index or the character of a sensor optic. As well as the condition of ionosphere or the surroundings of high buildings will affect radio wave spreading in GPS. Except environment, the operator conditions are also of influence. These conditions include physics (e.g. exhaustion, eye sharpness), emotional (e.g. nervousness, patience, imagination), knowledge and experience.

2.5 Process Accuracy

After collection, data will be processed. The sensor amplifies the inherent error in the object which is influenced by the situation of acquisition and will experience the propagation influence, and will also be distorted by the relevant algorithm. In some geodetic and photogrammetry process for instance leveling or air triangulation; the propagation is easy to investigate because the whole process can be explained in matrix operation with a clear assumption of input accuracy, even when it is iterative. In geodesy the level of accuracy which will be obtained can be simulated before the network is designed (Stanek, 1990). For this kind of process, the accuracy can't be determined mathematically by using propagation calculation but will be easier empirically (statistic) by using a comparison. These are some empirical experiences with Indonesian Map Series RBI 1:25.000 which is claimed has the following accuracy:

Table 4: Claim of Accuracy for Digital Map 1:25.000

Partial Accuracy	Claim	Contract
GCP	$\sigma xy = + 10$ cm $\sigma z = + 50$ cm	Relative accuracy 3 ppm
Aerial Triangulation	1:30.000 photos : $\sigma xy = + 30$ cm $\sigma z = + 51$ cm	$\sigma xy = + 8$ µm x S ~ 0.3/0.5 m $\sigma z < 0.1$ ™ x H ~ 0.5/0,75 m
Photogrammetry (Stereo compilation)	1:30.000 photos : $\sigma xy = + 3$ m $\sigma z = + 1.5$ m 1:50.000 photos : $\sigma xy = + 5$ m $\sigma z = + 2.5$ m	Well defined point : 0.3 mm on plot = $\sigma xy = + 7.5$ cm Spot heights : $\sigma z < 2/5$ contour interval ~ 5 m Contour lines : $\sigma z < 2/5$ contour interval ~ 6.25 m
Total	1:30.000	1:50.000
Planimetry σxy	3.16 m	5.25 m
Height σz	2.69 m	3.78 m

The claim above is certainly something, which can be empirically examined for instance by using the recommendation of US National Map Accuracy Standard US Bureau of the Budget. But the experiment of this empirical accuracy (correctness) will be difficult to do in remote area. Because of this, so far the quality control of digital map product is more on the consistency aspect, that is seeing whether some objects in the map are logic according to the principle of geography (for instance in settlements there should be accessing road).

2.6 Visualization Accuracy.

Here are the main two questions which are often to be faced :

- How far (in what scale or resolution) the data with its accuracy may be used, this question commonly comes from the producers or data owners.
- If we want to produce a map in a certain scale or resolution, what is the accuracy of data should be afforded, this question commonly comes from the users.

According to Hake (1982), the highest accuracy of point position in map is identical with the accuracy of drawing (plotter accuracy or printer resolution or also called cartography resolution). It was found out from the experiment that the limit of human ability to read or digitize the map is when the refinement of pixels is maximum 0.1 mm and minimum 0.2 mm. When the map in that scale is digitized again, the accuracy of this digitizing (= acquisition accuracy) will not be as accurate as + 0.15 mm, but less than + 0.5 mm. So only from this, the position error becomes + 25 m. Then there is still an error from generalization.

The standard guides for USA map (= visual accuracy), written by Fisher (1991) who copied Tobler (1988) about "minimum discernible marks on a map assuming a minimum spot of 0.5 mm on map":So for this, the rms limitation is determined and can be calculated such as : Limiting rms error in m = 0.25 x map scale

3.8 Relation of Scale-Resolution-Accuracy

In the Government Regulation No. 10 (PP10), the map accuracy is simply quantified in scale. In the digital era, the map scale can be easily changed with Zoom In/Out. But this may not be done carelessly, because the map in a certain scale needs resolution and accuracy. To simplify the comprehension between scale, resolution and accuracy a relation diagram has been made as shown as following:

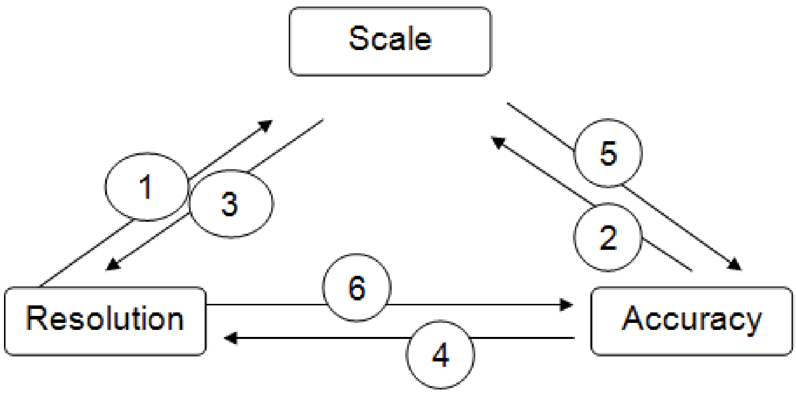

Figure 3: Relation of Scale-Resolution-Accuracy.

This diagram can be read by using a simple formula in Tabel-6, that is:

Table 5: Relation of Scale-Resolution-Accuracy

	The matched spatial data		
The needs of spatial data	Scale 1:S with	Resolution r(m) with	Accuracy σ with
Map scale 1:S	-	$r \leq S^* 0.2$ mm	$\sigma \leq S / 5000$
Raster data with r resolution	$S \leq r / 0.2$ mm	-	$\sigma \leq r / 4$
Vector data with σ accuracy	$S \leq 5000\ \sigma$	$r \leq 2\ \sigma$	-

3. Conclusion

Accuracy is a part of data quality. Many things like object, sensor, data acquisition, data processing and data visualization affect accuracy. Comprehensive investigation for accuracy and quality of data is absolutely necessary by all parties. In the future, the quality of information should be registered in meta data of all spatial data files. There was an idea to make a kind of scoring system for spatial data in order to make it easier for users to decide, which spatial data can meet their requirements.

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