Map Updating – an Urgent Issue to be Optimized with Modern Technology

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by

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1. Introduction – the Global Mapping and Updating Problem

In history mapping has always been recognized as an important tool for navigation, and the location of important objects of the human economic and cultural environment. However, precise mapping beyond the aims of navigation could not start, before precise surveying and mapping tools were developed. The French Academy of Sciences played an important role in the 18th century to determine size and shape of the earth, which made way to cover the earth with chains or networks of triangulation onto which a more precise georeferenced mapping by terrestrial plane table became possible. In this way at least the continent of Europe was able to establish cadastral mapping and registration systems and to use the geometric base for generation of topographic maps in the 19th century. But the precise map coverage achieved by these rather crude methods was very restricted in area.

The situation did not change until mapping became possible by the use of aerial photography in the 20th century. While the conservative survey methods used in Central Europe first made resistance to the wide spread of aerial photogrammetry, world war II, in which large parts of the continents of Europe, Asia and Africa were mapped by the military forces of opposed countries independently. The Americas had also already started their aerial ,aping programs, as it was clear, that the huge continents of North and South America could only be mapped by photogrammetric means. Also in the former Sovjet Union, the largest country in the world, mapping was declared important by Lenin, and photogrammetric mapping was developed independently.

It was Willem Schermerhorn, a pre world war II photogrammetrist, who had been active in the former Dutch colonies in Asia, who as a retiring prime minister of the Netherlands convinced the Dutch government to establish the ITC as a technical assistance venture to the developing countries in Africa, Asia, Latin America and Oceania. The more than 15 000 graduates of the ITC introduced the photogrammetric mapping technologies in their home countries.

At the end of the 20th century the United Nations published a summary of the mapped areas of the globe at different scales:

Table 1: Status of World Mapping 1990

Scale range	1:25,000	1:50,000	1:100,000	1:200,000
Africa	2.9 %	41.4 %	21.7 %	89.1%
Asia	15.2 %	84 %	56.4 %	100 %
Australia and Oceania	18.3 %	24,3 %	54.4 %	100 %
Europe	86.9 %	96.2 %	87.5 %	90.9 %
Former USSR	100 %	100 %	100 %	100 %
North America	54.1 %	77.7 %	37.3 %	99.2 %
South America	7 %	33 %	57.9 %	84.4 %
World	33.5 %	65.6 %	55.7 %	95.1 %

There is no recent information on the status of areas mapped, unless it is extrapolated. The table shows, that still only Europe and the former USSR are adequately mapped at the scale 1:25 000. North America and Asia are completing their 1:50 000 coverage, while Africa and South America have severe deficiencies at that scale. The 1:200 000 scale is the existing map scale covering the globe.

The UN documents still differentiate what was in digital data form and what was still on paper at that time. Nowadays it can be assumed that all analog data have been scanned into digital form for GIS use.

No information is given on the larger scale coverages between 1:1000 and 1:10 000.

As has been realized by photogrammetrists, vector line mapping is a tedious and costly process, which most developing countries still cannot afford at medium and larger scales. But instead orthophoto mapping has proven to be only 20% of the cost of line mapping, and it can be produces also in about 1/5 of the time.

This is the reason why novel companies such as Google and Microsoft have concentrated on products such as Google Earth and Microsoft Virtual Earth to provide information on the basis of existing imagery.

While they use arial imaging orthophoto products for densely populated urbam centers, especially in Europe, North America or Australia, where they can purchase orthophotos produced for mapping purposes, they use satellite imaged of various resolutions from ground sample sizes of 15m down to 0.5m for other, more remote areas of the globe.

The timely obtainability of images is yet another reason, why aerial and satellite images are preferred over line mapping.

The United Nations has at the UN Cartographic Conferenc of Beijing in 1964 published anither summary of world updating rates for maps:

Table 1.2: Update Rates of World Mapping

Scale range	**1:25,000**	**1:50,000**	**1:100,000**	**1:200,000**
Africa	1.7%	2.2 %	3.6 %	1.4%
Asia	4.0 %	2.7 %	0.0 %	1.9 %
Australia and Oceania	0 %	0.8 %	0 %	0.3 %
Europe	6.6 %	5.7 %	7.0 %	7.5 %
Former USSR	0 %	0 %	0 %	0%
North America	4.0%	2.7%	0.0 %	6.5 %
South America	0 %	0.1 %	0 %	0.3 %
World	5.0 %	2.3 %	0.7 %	3.4 %

In 1990 the update rate of 1:25 000 maps for Europe was about 15 years, in North America 25 years and the word average for a 1:50 000 map was about 45 years. No wonder, that Google Earth is preferred in Africa over outdated maps, even though it is not properly georeferenced and the date of imagery is not known.

This is illustrated by the images of a topographic map of Nairobi 1:50 000, a Google Earth image and the fast changes of the urban structures from decade to decade.

Fig.1 below: Topo Map 1:25 000

Fig.2 Google Earth Image

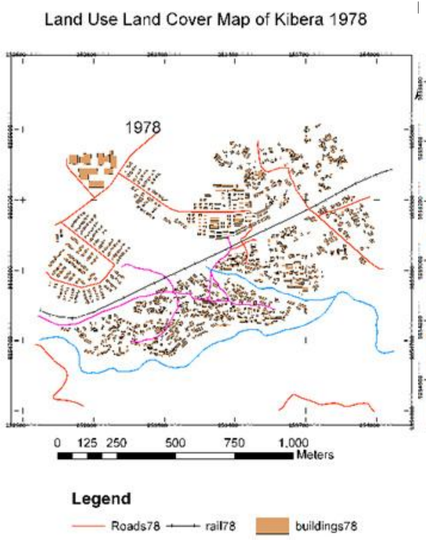

Fig.3 Kibera 1978

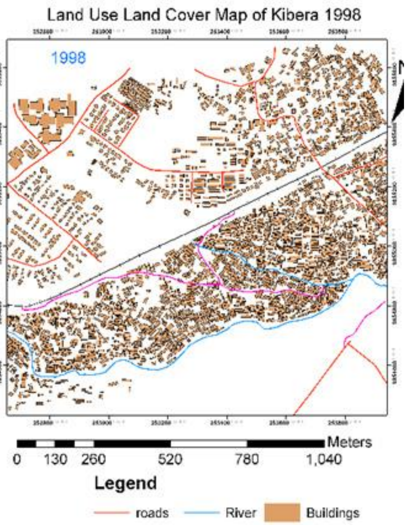

Fig.4 Kibera 1998

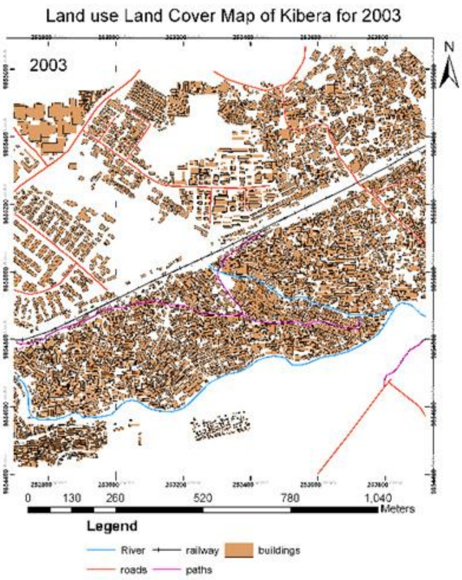

Fig.5 Kibera 2003

2. Mapping from Space

Mapping from space is the obvious answer for the global mapping and updating problem.

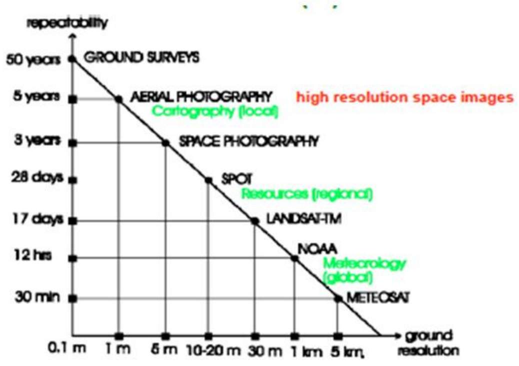

Fig. 6 Satellite Sensor Resolution and Repetitivity

While the high repetitivity meteorological satellites imaging every half hour only permit resolutions of 1km GSD, optical satellte sensors of up to 0.5m GSD permit successfully to compete with aerial imaging.

The history of civilian earth observation began with Landsat in 1972 with 80m GSD. Civilian higher resolution imagery in stereo was demonstrated with the German Metric Camera in 1983 on Space Shuttle with 10m GSD. The French Spot followed with 10m GSD in 1986. In 1993 the German MOMS-02 stereo scanner was demonstrated on the D2 Space Shuttle Mission and later on the MIR priroda Platform. It basically contained the elements of modern commercial satellite scanners, such as Ikonos, Quickbird, World View and Geo Eye, which now operate with up to 0.5m GSD. Satellite systems of many nations, such as Israel, India, Russia, China, Korea and Taiwan now offer high resolution capabilities.

It can be concluded, that mapping from space is necessary, and that it is also possible.

The Institute of Photogrammetry and Geoinformation of the Leibniz University of Hannover has undertaken many comparative studies in ISPRS working groups chaired by K. Jacobsen between the different satellite image sensor systems for the possibilities of object extraction, comparing mapping capability and updating capability at different GSD sizes, and also taking into account the influences of radiometric resolution, the sun anle and the pan sharpening of multispectral with higher resolution panchromatic channels.

While line map products from aerial photos for mapping are in general qualitatively better, these can only be applied, if the higher expense and time spent for obtaining the vector products do not play a role, as is the case in highly urbanized areas of

Europe and North America. In the developing countries mapping from space with appropriate sensor systems is possible up to a mapping scale of 1:4000.

3. Updating Issues

The updating capability is feature dependent. Area based features, such as industrial areas, built up residential areas, agricultural areas and forests can be extracted by hierarchical supervised texture based classification.

The updating of roads consists of the extraction of lines. Christian Heipke, the director od the Institute for Photogrammetry and Geoinformation of the Leibniz University of Hannover has initiated a number of doctoral dissertations for the automatic recognition and verification of different mapping features, such as the delineation of field boundaries (Butenuth), the extraction and verification of roads (Gerke), the extraction of pavement boundaries (Ravanbaksh). The automatic extraction was tested for different image scales and features in diggerent types of terrain (Germany, Brazil, Africa).

It became obvious, that a fully automatic extraction is not possible. But the verification could establish the reliability of the extraction with the reliable ones gained by automatic means and the unreliable ones, which needed visual interpretation. This reduced the manual effort requires by a factor of 3.

What is also very interesting, is that the reliability of area based features for high resolution satellite images was 72% with 1m GSD for Ikonos , while aerial RGB orthophotos with 0.3m GSD yielded slightly worse resulta with 68% reliability.

The corresponding values for road extractions were 62% for Ikonos imagery and 65% for 0.3m GSD RGB aerial images.

4. Conclusions

Already today the capabilities with high resolution space images offer a great potential for mapping and map updating of basic mapping information. With new satellite systems by many different countries thes possibilities will improve.

Small satellites give rise in hopes that the conditions for space imaging will improve and that cost will be lowered.

The visual interpretation of images will with concentrated efforts lead to more efficient automated possibilities of feature extraction for GIS uses. This is a new challenge for photogrammetrists.