DIGITAL MAP UPDATING FROM SATELLITE IMAGERY

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ABSTRACT:

Updating old topographic line maps has always been an headache for cartographers when using analogy processes .Nowadays, using both the flexibility of digital processing added to the repetitivity of earth observation satellites, map updating could be carried out quickly and efficiently. The purpose of the present presentation is to describe the different steps of the digital map updating process using satellite imagery.

1. INTRODUCTION

In any country up to date maps are necessary to master the development of rural and urban areas .

In developed countries the cost of map updating is generally included in the government budget as an infrastructure investment.

But in most of developing countries the yearly budget being restricted to the main priorities (Infrastructures, education, health ....) , maps have not been updated since decades and being out of date , they are useless .

Satellite imagery could be an **ad hoc** solution to solve this problem at a reasonnable cost .

1.1 The Commercial Earth Observation Satellite

Today more than ten E. O. satellites provide imagery which can be used in the map updating process. Whithin the next two years, the launch of at least 5 new E. O. satellites is expected:.

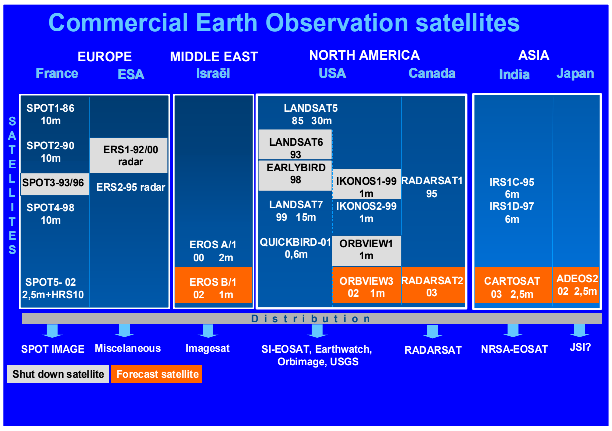


Figure 1. Satellites whose images are properly distributed and sold

2. THE BASIC DATA FOR MAP UPDATING

-The master films of existing maps to be updated.
-The raw satellite imagery and the DTM necessary to orthorectify the raw images.

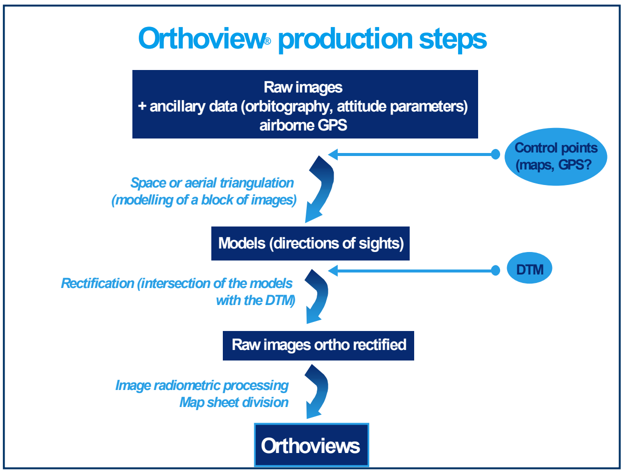


Figure 2. Orthorectification process

3. THE CHOICE OF SATELLITE IMAGERY

3.1 Map Scale and Map Design

The pixel size of the image will be chosen according the original map scale in order to preserve the planimetric accuracy of the map (i.e. 0.2 mm at the map scale):
- 10 m pixel size for 1: 50 000 scale mapping
- 5 m pixel size for 1: 25 000 scale mapping

But we should take into account that the map design has been elaborated from the features clearly visible on the aerial photography used to produce the maps:
- 1: 50 000 aerial photos corresponding to a ground pixel size of 2 m to produce the 1:50 000 maps

- 1: 30 000 aerial photos corresponding to a ground pixel size of 1m to produce the 1:25 000 maps.

And sometimes and especially in the developed countries , the 1: 50 000 mapping has been derived by generalization from the 1: 25 000 scale mapping with an intermediate map design .

3.2 The Main Types of Updating

selective
Only the main features of the map are updated: road and hydrographic networks, build up areas, high vegetation (woods, forests) … from High Resolution **(HR**) images (i.e. 5m to 15 m resolution)

exhaustive
All the features represented on the existing maps are updated (indidual buildings, small paths or tracks …..) from Very High Resolution **(VHR)** images (i.e. 1m to 3 m resolution).

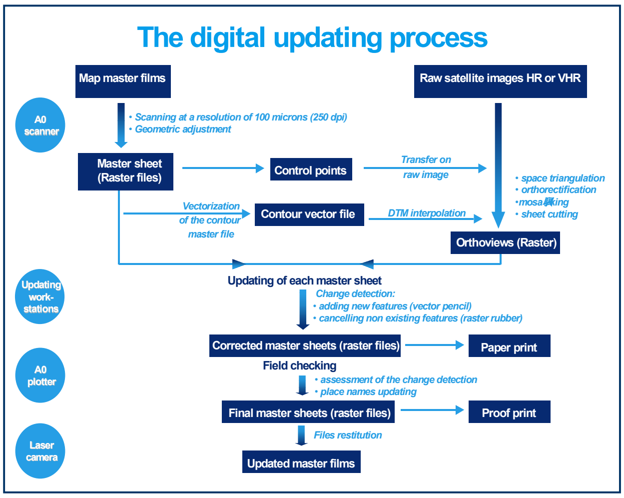
Selectivity means faster and cheaper : from 10m to 1m image resolution the price increases from 1$/Sqkm to 20 $/Sqkm and the investigation time spent for change detection increases in the ratio 1 to 10.

Identification and interpretation : according to the pixel size some features of the map could be identified or interpreted . For instance in build up areas, individual buildings are identified when the pixel size is less than 3 meters . This point should be taken into account with respect to the existing map design before choosing the satellite imagery.

E.g.: **SPOT4- 10 m** is sufficient to update **the footprints of build up areas** , but to update **the individual buildings** , at least **SPOT5 - 2,5 m** will be necessary.

4. THE DIGITAL UPDATING PROCESS

4.1 The Different Steps and the Tools



4.2 The Geometrical Accuracy of the Updated Maps

The updated features being captured from the "OrthoViews" the planimetric accuracy of the updated map is the accuracy of the production of the orthorectified satellite images .
The final accuracy will depend on :
- The image resolution (pixel size)
- The control points extrated from the map and their transfer on the raw image
- The internal geometric accuracy obtain after the image physical modelling
- The accuracy of the DTM used in the orthorectification process .

In the following example we suppose that a selective updating of 1: 50 000 maps has been carried out using SPOT P (10 m pixel size).

Influence of the control points and their transfer in the raw image

$$\sigma_{CP} = \sqrt{\sigma^2_{\text{map}} + \sigma^2_{\text{transfer}}}$$

$$\sigma map = 0.2 \text{ mm} \times 50000 = 10 \text{ m}$$

$$\sigma transfer = 0.4 \text{ pixel} \Rightarrow \sigma transfer = 0.4 \times 10 = 4 \text{ m}$$

Hence :

$$\sigma_{CP} = \sqrt{116} = 18 \text{ m}$$

Influence of the geometric modeling

From the geometric physical modelling derived from space triangulation the obtained internal geometry is :

$$\sigma_{IG} = 0{,}5 \text{ pixel} = 0{,}5 \times 10 = 5 \text{ m}$$

Influence of the DTM

$\sigma_Z = 1/2$ of the contour interval.

The standard contour interval of 1:50 000 scale maps is 10 m:

$\sigma_Z =$ 5 metres

and when using SPOT images:

$$\sigma_{DTM_{\max}} = 0.5\sigma_Z = 2.5 \text{ m}$$

Finally the planimetric accuracy of the updating process is the quadratic combination:

$\sigma_{XY} = \sqrt{\sigma^2_{CP} + \sigma^2_{IG} + \sigma^2_{DTM}} = \sqrt{116 + 25 + 6.25}$ hence $\sigma_{XY} = 12$ meters which is consistent with is a standard 1:50 000 scale mapping.

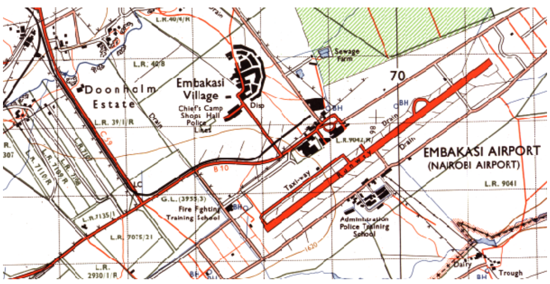
Influence of altimetry on planimetric accuracy

Oblique viewing (case of SPOT imagery)	Vertical viewing (Aerial photography)	
	$\Delta R_1 = \Delta Z \tan\alpha$	
$\Delta R_2 = \Delta Z \tan\theta$	Analog camera : film 24 cm x 24 cm with f = 150 mm	Digital camera 4000 x 4000 with f = 50 mm
$\Delta R_{2\,max} = \Delta Z \tan 27°$	$\Delta R_{1\,max} = \Delta Z \tan \frac{12\text{ cm}}{15\text{ cm}}$	$\Delta R_1 = \Delta Z \times \frac{20\text{ mm}}{50\text{ mm}}$
Hence :	Hence :	Hence
$\sigma_{DTM\,max} = \sigma_Z * 0.5$	$\sigma_{DTM\,max} = \sigma_Z * 0.8$	$\sigma_{DTM\,max} = \sigma_Z * 0.4$

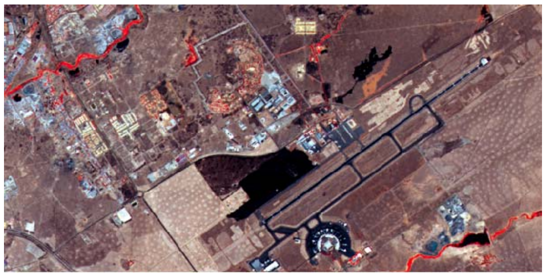
A case study : map updating of the 1: 50 000 scale map of Nairobi dated 1975 from HR Spot imagery dated 1995.

The proposed example is the 1:50 000 map sheet including a part of Nairobi in KENYA:
- OrthoView is derived from a merging of raw images SPOT P + XS .
(GC points taken from the map and the DTM derived from the map contour lines)
- According to the Orthoview pixel size (10 m) a selective updating has been carried out .
- SPOT P image is used to increase the final accuracy (10 m) and makes an easier identification of ponctual and linear features of the map .
- SPOT XS image (20 m pixel resampled to 10 m before merging with SPOT P image facilitates the identification of the land cover (végétation, water , urban area , etc…)
- Field checking has been carried out in order to assess the investigation phase as well as to update the place names .
In the following pages are displayed extracts from :
- The original map dated 1975
- The Orthoview SPOT P + XS dated 1995
- The updated map printed in 1996
We can notice the large amount of changes related to the road network, urban areas, the hydrographic network and the place names.

The old useless map ,after updating ,has been changed into a new useful map.



1975



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