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Assessment Integration of GF-1 MSS Multispectral and PAN Panchromatic China satellite Images for Producing Image Map and Updating Information Content in Egyptian Map Scale 1:25 000

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Abstract The investigation of interpretability of panchromatic satellite image GF-1 integrated with multispectral image with the purpose of producing image map and updating Egyptian topographic map topo has been described. A main objective of this research is to evaluate china GF-1 images for producing and updating topographic maps. The study has been chosen the area of the topographic map sheet at the scale of 1:25000 located in Cairo Governorates and made in 1977 and updated in 1990. In this study, the high resolution GF-1 MSS and PAN satellite images covering Cairo City, Egypt have been used. The proposed methodology based on producing image sheet map and evaluation updating topographic maps according to Egyptian specifications using GF-1 MSS, GF-1 PAN and the integration of GF-1 MSS and PAN. Results are discussed with reference to the specifications required for the scale 1: 25 000 Egyptian topographic maps. The results of these evaluations show that integration of GF-1 MSS and PAN images, from the point of geometric accuracy and Information content have the capability of 1:25,000 scale maps revision with difficulties in identification and extraction some features can be completed using other mapping methods.
Keywords *GF-1 Satellite Image; Image Map; Topographic Map Updating; Satellite Images; Feature; Extraction*

1. Introduction

Most developing countries have great difficulties in systematic updating of their maps. Maps are essential database for both planning and fieldwork operation. Up-to-date maps are necessary because obsolete maps creates so many problems to engineers, planners and other professionals who need to develop their work based on updated records (Ajayi, 1992; Abdel Mageed, 2000). In the past mapping using digital aerial photos has become very popular several years, but now the use of satellite images for cartographic and updating maps was limited by image resolution (Cheng, P. and Toutin, T., 1997). The application of remote sensing data could be an alternative method of supplying information relevant to topographic map production, revision, and updating, which is repetitive, cost-effective and relatively fast operational monitoring system (Pohl, 1996). In Egypt, National mapping agencies the Military Survey Department (MSD) and the Egyptian Survey

Authority (ESA), mare confronted with the problem of producing and/or updating topographic maps. Egyptian topographic maps are many years out of date more than 25 years old; the main issue is the rapid development of urban areas and lack of adequate and up to date maps. (Abdel Mageed, 2000). Nowadays, there is useful information, provided by remote sensing satellites, in the form of single and overlapped images, which can be used for the underlined purpose of large-scale mapping (Diefallah, 1989). The Chinese government pays great attention to the development of space industry. Many Chinese sensor types used for remote sensing applications. GF1 Images can be used for City management: urban and rural planning and monitoring, scenic and landscaping area monitoring, etc. The horizontal position of any terrain point on the map is usually expressed by 2D two coordinates of the point known as planimetric map. Topographic or contour map 3D coordinates produced from planimetric map by adding the vertical position of the terrain point, is usually expressed by one coordinate, relative to well defined vertical control datum, which is internationally adopted to be the geoid (Nassar, 1977). Horizontal or planimetric maps accuracy and standardization according to the American the National Map Standards Accuracy (NMAS), (NMAS; 1947) still the official standards for map accuracy. The cost of mapping generally increases rapidly with increasing scale and accuracy requirements. Higher accuracy and closer contour interval usually increases the cost of mapping so, it is very important to consider carefully what scale, contour interval and accuracy are necessary to satisfy the requirements (R.I.C.S, 1980). Revision of mapping can be made in three main methods: cyclic revision, selective revision and continuous revision (Jamebozorg, et al., 2003; Aisanont, S., 1990). Evaluations Egypt Sat-1 images show that from the point of geometric accuracy has the capability of producing and revision 1:25,000 scale maps (Yasser G.M., et al., 2012). Also, Information content and feature extraction capability from Egypt Sat-1 has been evaluated (Abd Elwahed, et al., 2011). Visual comparison of different images over the test area have been carried out for specific features such as roads, railways, watercourses and boundaries of urban areas (Abd Elwahed, et al., 2012). Geometric correction results and information contents of VHR space images are very important factor to get spatial information and extract objects from images. A comparison of information contents of high resolution Space Images has been done (Topan, H., et al., 2004). A Proposed Approach to update large scale maps in developing countries using IKONOS high resolution satellite imagery (Jacobsen, K., 2002; Shaker, A., et al., 2002). Large scale topographic databases have been updated and detection of urban features in urban areas with sub-meter QuickBird images and GIS (Marco, G., 2008; Marangoza, A.M., and Alkısb, Z., 2012). The urban features such as buildings and roads in the images have been detected, recognized and extracted visually by the method of on-screen digitizing using ArcGIS software. The proposed methodology includes producing image sheet map, updating topographic maps according to Egyptian specifications using GF-1 MSS, GF-1 PAN and the integration of GF-1 MSS and PAN. Also, the methodology includes evaluation information extracted from GF-1 images; find the solutions to extract all requirements a according to Egyptian specifications.

2. Used Satellite Images GF-1 Satellite

2.1. The Technical Specification of GF-1 (GF= Gao) Satellite Images

P/MS Camera

- P/MS camera has four multi-spectral bands and a panchromatic band. The multi-spectral data with a spatial resolution of 8m which contained Red band (R), Green band (G), Blue band (B) and Near Infrared band (NIR).

- The panchromatic band has a spatial resolution of 2m.

WFV Camera

Four wide field view (WFV) camera has the same design in spectral rang with the P/MS camera, whereas it has a wide swath which covers no less than 800 kilometers after the four cameras data combined.

GF-1 Satellite

- GF-1 launched 26th April 2013
- 5-8 years design life
- Life time: 5-8 years
- Platform: CAST-2000
- Orbit Sun synchronous recurrent frozen orbit
- Altitude 645km
- Inclination 98.0506°
- Repetition cycle 41/4 days
- Descending node (Local time) 10:30 AM

MSS Bands

0.45—0.52μ m 0.45—0.52μ m
0.52—0.59μ m 0.52—0.59μ m
0.63—0.69μ m 0.63—0.69μ m Spatial Resolution (m) MSS 8m

PAN Bands

0.77—0.89μ m 0.77—0.89μ m
Spatial Resolution (m) PAN 2m, 16m
(Wei Xiangqin, et al. 2015; (Lei Wang, et al., 2015) Figure 1 Shows Chinese GF-1 Satellite.

Figure 1: *Chinese GF-1 Satellite*

3. Study Area ND Used Data

Cairo city is one of the fastest growing urban areas in Egypt. The study area consists of various land covers such as, urban, rural, water, mountainous and agriculture. This study is applied on part of Cairo city the capital of Egypt. Figure 2 shows location map.

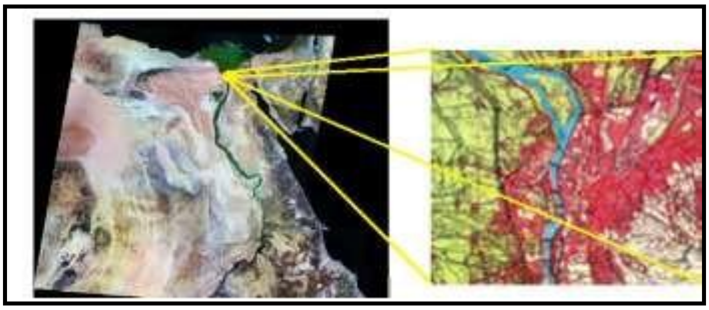

Figure 2: *Location Map*

3.1. Used Data

3.1.1. Used Satellite Images GF-1

In this study, the high resolution GF-1 MSS and PAN satellite images covering Cairo City, Egypt have been used.

Image date: 29/6/2014
PAN Resolution 2m
MSS data Resolution 8m
Figure 3 shows GF-1 PAN image and 2 images 1 & GF-1 MSS image 1 and 2

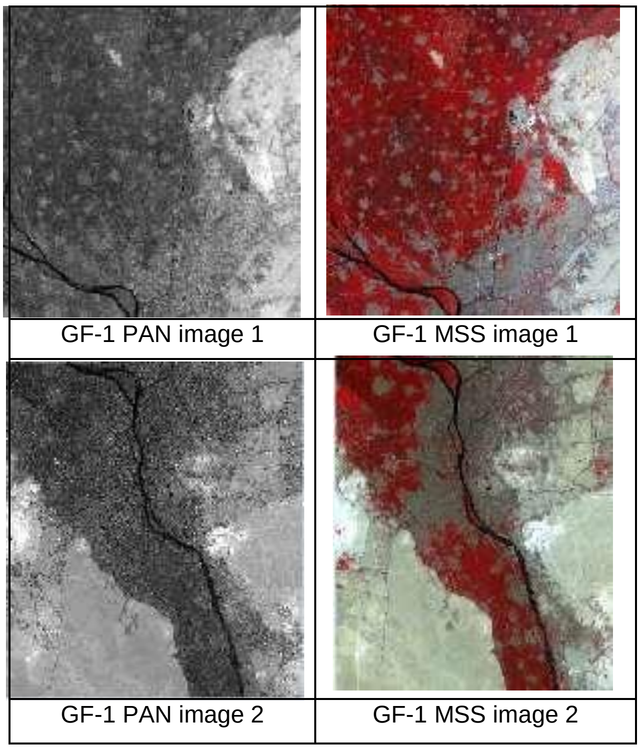

Figure 3: *GF-1 PAN image and 2 image 1 & GF-1 MSS image 1 and 2*

3.1.2. Image Support Data

4 DEM supplied with the data 2 for GF-1 image 1 MSS and PAN & 2 DEM 2 for GF-1 image 1 MSS and PAN. Figure 4 shows example of DEM supplied with the data.

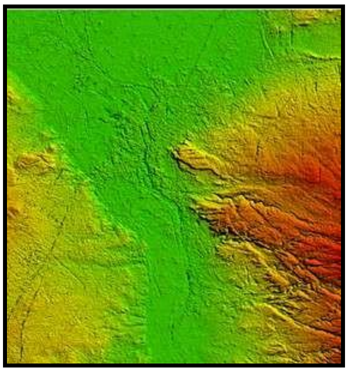

Figure 4: *Example of DEM Supplied with the Data*

3.2. Used Map

There is available in hand large scale map for the study area scale 1::5000, and 1:10 00. Also, there are medium and small scale topographic map compiled from aerial photographs at scale 1:25,000, covering the study area is obtained used as a basis for comparison and assessment.

- 1::5000 large scale map cover the same area of study produced in 2004 from aerial photographs acquired in 2006. The map is produced by the Egyptian Survey Authority (ESA).
- 1:10 000 large scale map cover the same area of study produced in 2004 from aerial photographs acquired in 2006. The map is produced by the Egyptian Survey Authority (ESA).
- A 1:25 000 topographic maps over the same area of study produced in 1930 from aerial photographs acquired in 1945. The map is produced by the Egyptian Survey Authority (ESA), two sheet maps are:

1- Sheet no. 81/630
Scale 1:25 000
Size 60cm x 40 cm cover area 15km x 10km
2-Sheet no. 82/630
Scale 1:25 000
Size 60cm x 40 cm cover area 15km x 10km

Figure 5 shows enlarged part of *two topographic maps sheets scale 1:25,000*

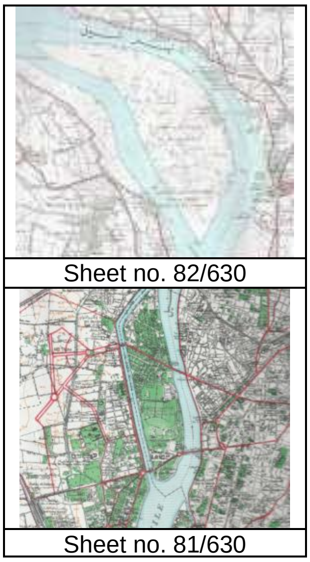

Figure 5: *Enlarged Part of Two Topographic Maps Sheets Scale1:25,000*

3.3. Ground Control Points

GCPs ground control points extracted from maps 1:5000 and check points CPs extracted from maps 1:10 000.

4. Methodology

The proposed methodology based on producing image sheet map and evaluation updating topographic maps according to Egyptian specifications using GF-1 MSS, GF-1 PAN and the integration of GF-1 MSS and PAN. In general, high accurate ground control points derived from DGPS. Taken into consideration the number of GCPs and CPs and the cost these points in additional to the other processing to produce image map and up-dating maps. In this study, Nine GCPs ground control points for planimetric features has been derived from maps 1:5000 taken into consideration these points well defined and clearly interpretable on the satellite image. Also, 15 check points CPs for planimetric features has been used derived from maps 1:10 000 taken into consideration these points well defined and clearly interpretable on the satellite image. The Methodology of producing and updating topographic map process using GF-1 satellite imagery main procedures as following:

4.1. Producing Up-To-Date One Sheet 1:25 00 Image Map

- Data collection
- Rectification of GF-1 PAN image based on DEM and ground control points extracted from maps 1:5000 RMS is ± 0.5m
- Best rectified PAN image based on RMS
- Producing rectified PAN image1&2
- Producing PAN mosaic
- Rectification of GF-1 MSS image based on DEM and ground control points extracted from maps 1:5000 RMS is ± 0.5m
- Best rectified PAN image based on RMS

4.2. Producing Rectified MSS Image 1&2

- Producing MSS mosaic
- Obtaining the image coordinates of *x*, *y*, *z* of ground points, ground control points (GCPs) and check points (CPs) from the rectified mosaics
- Accuracy check of GCPs and CPs, calculation of residuals in x and y directions and RMSE.
- PAN mosaic subset to meet 1:25 000 sheet map
- MSS mosaic subset to meet 1:25 000 sheet map

4.3. Map Updating

- Geo-reference 1:25 000 old sheet map
- Co-registration of MSS multispectral mosaic and PAN mosaic with old geo-reference 1:25 000 sheet map
- Subset co-registration MSS multispectral and PAN mosaic
- Vectrization of Geo-reference 1:25 000 old sheet map
- Overlaying co-registration MSS multispectral mosaic and old vector layers.
- Updating vector layer
- Assessment of cartographic potential nd information extracted from of Gf1 MSS mosaic
- PAN mosaic with old geo-reference 1:25 000 sheet map
- Overlaying co-registration PAN mosaic and old vector layers

- Updating vector layer
- Assessment of cartographic potential of information extracted from of GF1 PAN mosaic
- Studying integration of subset co-registration Gf1 PAN mosaic and MSS mosaic to complete the vector layers otherwise find the low cost and time solution to complete the vector map

4.4. After that

- Field Revision and Verification Purposes
- Data revision process
- Revision of map vector data Integration of vector and raster data Image processing Topology editing
- Contour line editing in built-up areas
- Production of the Final updating topographic maps

5. Results

The proposed methodology carried out step by step to achieve the objectives from this research.

Rectification of Geometric Correction of MSS and PAN Image

The planimetric allowable accuracy or Total root mean square error TRMS in coordinate (X or Y) m for different map scales based upon the specifications of the National Map Standards Accuracy (NMAS),

Total root mean square error TRMS in (E or N) = 0.50 mm * map scale

Dealing Since the main concern herein deals with medium scale maps, the lower limit of scale will be 1:25,000, and hence, the allowable limit for horizontal positioning error will be 12.5 m for this scale. For large scale maps, the lower limit of scale will be 1:10,000, and hence, the allowable limit for horizontal positioning error will be 5.0 m for this scale. Several experiments were performed to rectify PAN image using models 2D-first order polynomial, 2D- second order polynomial non-parametric mathematical models with different distribution of GCPs. The best geometric accuracy of PAN GF-1 PAN and MSS was obtained using 2D second order polynomial with15 GCPs.

5.1. Accuracy check of GCPs and CPs

5.1.1. Accuracy check of GCPs

Accuracy assessment of using 9 GCPs well distributed.

- The RMSE of GF-1 PAN in GCPs in X and Y directions RMSEx, RMSEy and TRMSE are 1.285m, 1.012m and 1.636m respectively.
- The RMSE of GF-1 MSS in GCPs in X and Y directions are RMSEx, RMSEy and TRMSE are 3.667m, 3.267m and 4.911m respectively.

5.1.2. Accuracy Check of CPs

Accuracy assessment of the produced image map and validated have been done using 15 CPs well distributed check points.

- The RMSE error of GF-1 PAN in CPs in X and Y directions RMSEx, RMSEy and TRMSE are 2.625m, 2.334m and 3.512m respectively which meets large scale map 1:10 000 or smaller according to specifications.

- The RMSE error of GF-1 MSS in CPs in X and Y directions are RMSEx, RMSEy and TRMSE are 7.114m, 6.961m and 9.953m respectively which meets large scale map 1:25 000 or smaller according to specifications.

GF-1 PAN mosaic and GF-1 MSS mosaic have been produced from rectified image 1 an image 2. Figure 6 shows produced GF-1 PAN mosaic and GF-1 MSS mosaic. Sub set of GF-1 PAN mosaic and GF-1 MSS to meet one sheet from topographic map 1:25,000 have been produced.

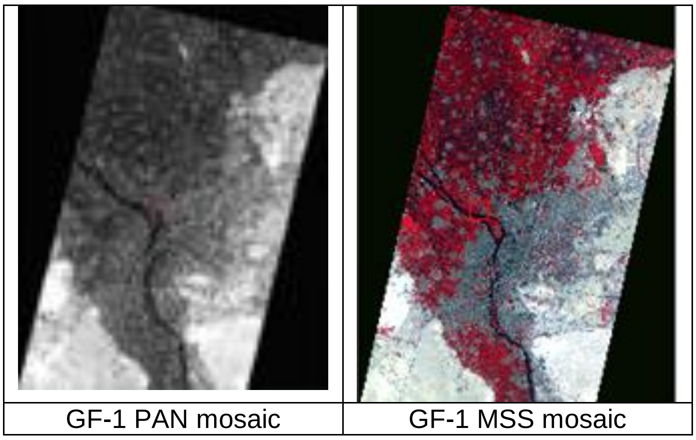

Figure 6: *Produced GF-1 PAN mosaic and GF-1 MSS mosaic*

5.2. Qualitative Evaluation of Information Content in GF-1 Images

Features exist on the actual surface of the Earth, within the area of interest can be classified as natural features (e.g. mountains, hills, rivers, deserts, forests…..etc) and artificial features (e.g. roads, railways, bridges, tunnels, buildings…etc. Features extracted from satellite images can be summarize as first: detect, second: identify and finally: recognize.

Main Information content in one sheet of topographic map is:

- Built up area
- Un-built Areas
- Bridge
- Wall
- Roads
- Rail Way
- Tower
- Boundary line
- Transition lines
- Water features
- Green areas

Figure 7 shows enlarged part of *two parts of:* GF-1 PAN mosaic, GF-1 MSS mosaic and part *topographic maps scale 1:25,000* Sheet no. 81/630 & Part of Sheet no. 82/630. Figure 8 shows example of information content appeared in the multispectral MSS and panchromatic PAN GF-1 image map. Degree of recognize features exist on GF-1 images can be categorized:

- Easy recognize
- Medium recognize
- Difficult recognize

- Impossible recognize

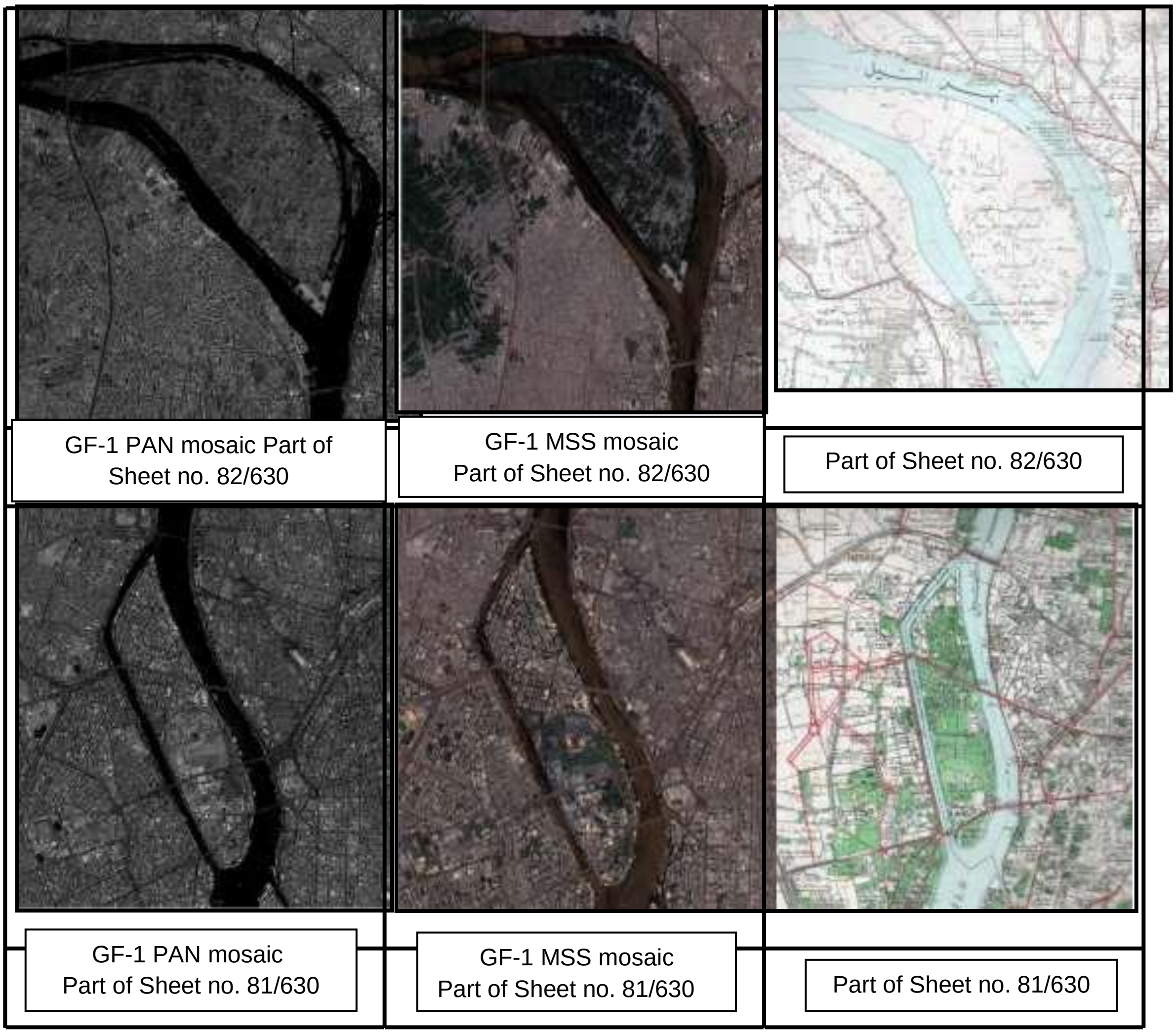

Figure 7: *Enlarged Part of Two Parts of: GF-1 PAN Mosaic, GF-1 MSS Mosaic and Part Topographic Maps Scale1:25,000 Sheet no. 81/630 & Part of Sheet no. 82/630*

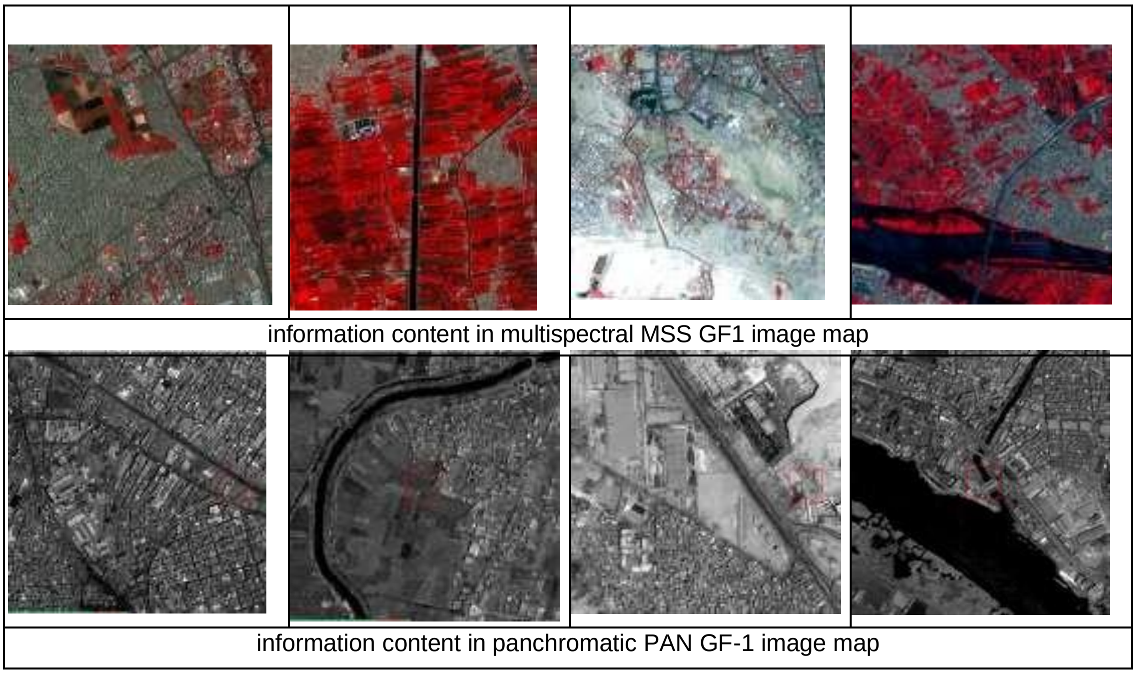

***Figure 8:** Example of Information Content Appeared in the Multispectral MSS and Panchromatic PAN Gf-1 Image Map*

The Results of Evaluation Information Content appeared in the Multispectral MSS and Panchromatic PAN GF-1 Image for updating maps at 1:25,000 scale showed that:

- The contrast between the features and background is relatively low.
- Features that is impossible to be detected and identified on the image such as overhead power transmission lines and the railway.
- In general ability of details by GF-1 MSS to be recognized such as building and building blocks with dimension less than 6m; linear future with width less than 6m.
- Also, ability of details by GF-1 PAN to be recognized such as building and building blocks with dimension less than 2m; linear future with width less than 2m.

Solutions

To product complete map from GF-1 images according to the Egyptian specifications, one must find alternative methods or solutions to complete the rest of requirements. The sources of information which can be used:

- Very high resolution satellite images or SAR data
- Field survey

6. Conclusions

In Egypt, the production or updating of large scale surveying maps is considered as an important topic to be investigated. The investigation should be oriented towards the best rapid, informative, and economical way, for the replace of out-of-date maps, as well as updating existing acceptable maps, on the medium and large scale level. On the basis of the research carried out about cartographic potential of GF-1 MSS multispectral combined with GF-1 PAN panchromatic china satellite images used for updating Egyptian map scale of 1:25 000, the following conclusion could be drawn:

- There is always an urgent requirement, for regular updating of information of basic topographic maps, needed for both economical reasons, as well as supporting scientific investigations.

- The geometric accuracy of China GF-1 MSS meet the requirement of 1:25 000 image map or smaller according to the National Map Accuracy Standards (NMAS).

- The geometric accuracy of China GF-1 PAN meets the requirement of 1:10 000 map or smaller according to the National Map Accuracy Standards (NMAS).

- Integration of GF-1 MSS and PAN provides a large amount of information that can be used for updating features exists on 1:25 000 Egyptian maps.

- There are difficulties in extracting some features from GF-1 MSS images such as linear features with width less than pixel size (gas lines, canals, power transmission lines and the railway extension in some area with weak contrast background)

- The comparison of information content China GF-1 PAN image with China GF-2 MSS image shows that still there are some features that remain impossible to be recognized. The remaining features may be added from other mapping methods such as very high resolution satellite images such as China GF-2 images or ground survey methods**.**

Recommendations

Next paper will focus on producing pansharpened image from GF-1 PAN and GF-1 MSS using different fused image techniques which expect improve the produced image map and extracted information content from it.

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