

OVERVIEW OVER THE ACTIVITIES OF THE GENERAL DIRECTORATE FOR SURVEYING AND MAPPING AND ITS FUTURE PERSPECTIVES

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ABSTRACT:

Surveying and Mapping in the Kingdom of Saudi Arabia became organized in the 1950's when the Ministry of Petroleum and the Ministry of Defense initiated their topographic mapping program at the scale 1:50 000, which is now completed. The Ministry of Municipal and Rural Affairs has the mandate for large scale mapping covering the urban areas and for cadastral mapping since 1976. At the beginning analog maps produced by photogrammetry were raster scanned. From 1994 vector mapping was carried out using Microstations. The more recent concerns are the creation of a new geodetic network based on ITRF using DGPS. The Kingdom now has 13 fiducial stations, which have been densified to 650 points to yield cm precision. New tasks are orthophoto mapping of urban areas and line mapping to shape files. A cadastral prototype is being developed for geocoded land registration. The raster and vector data for points, DEM's, topo maps, images (orthophotos, satellite images), and cadastral maps are being transported into an ArcGIS geodatabase to permit GIS/LIS uses in a wide area network to be established.

1. HISTORY OF SURVEYING AND MAPPING IN THE KINGDOM OF SAUDI ARABIA

Surveying and Mapping started during the Otoman Empire. It was continued with oil related surveys in the first half of the 20th century. It became organized in the 1950's with the establishment of the

- Aerial Survey Department at the Ministry of Petroleum. This was followed by the creation of the
- Military Survey Department at the Ministry of Defense for small scale mapping, and it was finally followed by the establishment of
- The General Directorate for Surveying and Mapping in the large scale sector, including cadastral mapping tasks.

The geodetic network was established by classical astronomic methods combined with traversing by electromagnetic distance measurement. It served the needs for the mapping of the Kingdom at the scale 1:50 000. This task has been completed.

The geodetic network, based on the Ain El Abd primary point, using the Clarke spheroid consists of 900 horizontal points with a relative accuracy of 1:100 000. For vertical reference based on tidal observations and spirit levels 2500 benchmarks have been established.

The 2500 map sheets at the scale of 1:50 000 are based on the UTM projection extending over 4 UTM zones 36 to 39. The responsibility for maintenance of these maps lies with the Military Survey Department.

2. SURVEYING, MAPPING AND CADASTRAL TASKS OF THE GENERAL DIRECTORATE FOR SURVEYING AND MAPPING (GDSM) AT THE MINISTRY OF MUNICIPAL AND RURAL AFFAIRS (MOMRA)

A Surveying and Mapping Department was established at MOMRA in 1976. At about the same time a Royal Decree was issued regulating land title registration. MOMRA commenced with a study on cadastral systems in 1985. In 1989 the mandate for cadastral surveys was given to the survey and cadastral departments of MOMRA.

In 2004 MOMRA established the General Directorate for Surveying and Mapping, which included cadastral tasks.

The tasks of the General Directorate are:

- geodetic engineering using GPS techniques
- large scale topographic surveying and photogrammetric mapping
- orthophoto production
- cadastral Mapping
- use of satellite imagery for mapping purposes
- the establishment of a geodatabase
- the development of a geographic and land information system
- the development of application software for mapping purposes

- the definition of geomatics standards, the preparation of manuals and the specification of procedures for the mapping tasks in the Kingdom of Saudi Arabia
- the archival of control of mapping and of imagery in the geodatabase.

3. PAST LARGE SCALE TOPOGRAPHIC MAPPING AT MOMRA

MOMRA began with large scale mapping projects in 1976. The result of the projects 101 to 110 produced until 1980 were analog maps produced on paper at scales ranging from 1:500 to 1:25 000 for the major cities of the Kingdom. A summary of these projects is given in table 1 with the km² of mapping produced. These maps were scanned with a cartographic scanner and they are available in digital raster format.

Table 1: Past MOMRA mapping projects of Saudi Arabia (1:500 to 1:25 000)/raster

| Project no. | Year | Location | | | | | |
|-------------|-------------|--------------------------------------------------------------------------------------------------------|--------|--------|----------|----------|----------|
| 101 | 1976 & 1977 | Riyad, Mekkah, Jeddah, Madinah, Sharqiyah, Qassim, Tabuk, Al Bahah, Al Jafw, Shamaliyah, Majran, Jizan | | | | | |
| 102 | 1978 | Madinah, Qassim, Sharqiyah, Al Bahah, Al Jafw | | | | | |
| 103 | 1978 | At-Taef, Jizan | | | | | |
| 104 | 1981 | Makkah | | | | | |
| 105 | 1983 | Makkah, Qassim, Hail | | | | | |
| 106 | 1983 | Shamaliyah | | | | | |
| 108 | 1983 | Tabuk | | | | | |
| 109 | 1983 | Al-Bahah | | | | | |
| 110 | 1980 | Madinah, Al Jafw | | | | | |
| Map scale | 1:500 | 1:1000 | 1:2500 | 1:5000 | 1:10 000 | 1:20 000 | 1:25 000 |
| Area | 254 | 508 | 2540 | 1270 | 25400 | 127000 | 127000 |

In 1994 MOMRA started with digital photogrammetric mapping in vector form, based on Microstation dgn vector format. Table 2 lists the projects and their km² coverage.

Table 2: Past MOMRA mapping projects of Saudi Arabia (1:1000 to 1:20 000)/vector (dgn)

| Project no. | Year | Location | Map Scale | Area, km ² | | | |
|-------------|------|----------|-----------|-----------------------|----------|----------|----------|
| | | | 1:1000 | 1:2500 | 1:10 000 | 1:20 000 | 1:25 000 |
| 112 | 1994 | Asir | 24.75 | 120 | 5232 | | |
| 112 | 1994 | Najran | | 168 | 1008 | | |
| 113 | 1995 | Madinah | 278 | 321 | 1488 | | |
| 115 | 1995 | Riyadh-S | 257 | | 6768 | | |
| 116 | 1995 | Riyadh-C | 656 | | | | 3066 |

4. CHANGES INTRODUCED BY NEW TECHNOLOGY

4.1 New Reference System

Through the rapid development of GPS satellite positioning technology tools have become available in the late 1990's to improve the accuracy of control networks and the subsequent use of a more efficient survey technology.

For that reason MOMRA introduced a geodetic project establishing 13 new geodetic fiducial stations based on the global international terrestrial reference frame ITRF of the year 2000. In simultaneous GPS observations over a period of 10 days the 13 new fiducial stations were tied to seven stations of the international IGS network.

The achieved accuracies at the 13 fiducial stations with reference to the seven IGS stations are shown in table 3. Their standard deviations are in the order of 2 mm in position and of 3 mm in height.

Table 3: KSA -2000 ITRF Network: GFN statistics

| Project | Date | Number | a(m) | b(m) | C(m) |
|---------|------|--------|-------|-------|-------|
| 401 | 2004 | RIYD | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | TBUK | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | JOUF | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | RAFH | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | HAIL | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | BURD | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | DAMM | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | YNBU | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | JEDD | 0.001 | 0.001 | 0.003 |
| 401 | 2004 | GZAN | 0.001 | 0.002 | 0.003 |
| 401 | 2004 | SHAR | 0.001 | 0.002 | 0.003 |
| 401 | 2004 | ABHA | 0.001 | 0.002 | 0.003 |
| 401 | 2004 | BAHA | 0.001 | 0.001 | 0.003 |

This permits now to establish 13 continuously operating reference stations (CORS) at which the changes of GPS signals due to ionospheric and tropospheric influences are continuously recorded. In this manner short duration observations at survey points in the vicinity of the 13 CORS stations may be corrected for the systematic effects through postprocessing or in real time via RTK (real time kinematic) procedures, when the corrections are directly transmitted.

This raises the attainable survey accuracies of about 1 m with classical procedures to the accuracy level.

To be independent of a CORS-network in its build-up phase a total of 650 geodetic control stations have been reobserved and tied within the accuracy of a few cm to the network of the 13 fiducial stations.

The result is that a new geodetic reference system of higher accuracy can now be used for the Kingdom. It can serve as a base for mapping as well as for navigation.

4.2 Orthophoto Mapping

In order to speed up the process of mapping from a three to five year interval to a one year period orthophoto mapping has been introduced for the present and new mapping projects. This is needed for a timely collection of information in a rapidly changing urban environment.

The present aerial survey contracts and orthophoto projects are listed in table 4.

Table 4: Present MOMRA aerial photography/orthophoto projects

| Project no. | Location | Photo scale: | | |
|-------------|----------|-----------------------|----------|---------|
| | | 1:20 000 | 1:45 000 | 1:5500 |
| | | Area, km ² | | |
| 117 | Jeddah | 2500 | | 8943 |
| 118 | Dammam | 2500 | | 9800 |
| 119 | Qassim | 1500 | 4000 | 22 000 |
| 120 | Riyadh-S | 1200 | | 19 000 |
| 121 | Taif | 950 | 2750 | 6500 |
| 122 | Jizan | 685 | 7250 | 15 000 |
| 123 | Jeddah | 1000 | 2500 | 10 000 |
| 124 | Hail | 685 | 7250 | 15 000 |
| 125 | Ahsa | 1000 | | 9000 |
| TOTAL | | 12 020 | 23 750 | 115 243 |

4.3 New Line Mapping

For GIS/LIS creation information in form of digital line maps is still required.

While the Microstation based dgn-format mapping satisfied the needs of a graphic visualization of mapped objects, it offers insufficient capabilities for GIS analysis and its integration into modern geodatabases.

For this reason new line mapping specifications have been drawn up which specifies object oriented topologically closed feature collection in the form of shape files.

Table 5 lists the presently tendered digital mapping projects delivering data suitable for GIS analysis.

Table 5: Tendered MOMRA digital mapping projects

| New Projects in Preparation: | | New Projects in Preparation: | |
|-----------------------------------------------------------|-----------|--------------------------------------------------|-----------|
| New projects for aerial photography, scanning and AT are: | | New projects for line mapping are: (shape files) | |
| Project no. | Location | 131 | Taif |
| 145 | Madinah | 132 | Jizan |
| 146 | Assir | 134 | Hail |
| 147 | Najran | 135 | Al Ahsa |
| New projects for orthophotos are: | | 136 | Al Bahah |
| 118/1 | Dammam | 137 | Makkah |
| 121/1 | Taif | 143 | Riyadh-W |
| 122/1 | Jizan | 154 | North KSA |
| 124/1 | Hail | 155 | Madinah |
| 125/1 | Al Ahsa | 156 | Assir |
| 126/1 | Bahah | 157 | Najran |
| 127/1 | Makkah | | |
| 133/1 | Riyadh-W | | |
| 144/1 | North KSA | | |
| 145/1 | Madinah | | |
| 146/1 | Assir | | |
| 147/1 | Najran | | |

Table 6 lists new projects in preparation for orthophoto mapping and line mapping

Table 6: New projects to be tendered

| Project no. | Location | Map scale: | | |
|-------------|----------|------------|----------|----------|
| | | 1:2500 | 1:10 000 | 1:20 000 |
| | | 1:1000 | | |

| | | | | | |
|-------|----------|------|------|--------|--------|
| 123 | Jeddah | 800 | 800 | 4 500 | 9 000 |
| 128 | Dammam | 1000 | 1000 | 6 000 | 9 000 |
| 129 | Qassim | 1150 | 1150 | 7 680 | 22 000 |
| 130 | Riyadh-S | 900 | 900 | 10 000 | 19 000 |
| TOTAL | | 3850 | 3850 | 28 180 | 59 000 |

5. CADASTRAL REGISTRATION PROJECTS

In the past cadastral registration occurred in a non-homogeneous fashion by the courts and the municipalities mostly without a proper georeference.

To make use of the geocoding possibilities of the new mapping a cadastral prototype is being developed, which can serve as a model for the Municipalities of the Kingdom to place uniquely defined parcel records onto geocoded information offered by the new mapping system.

In this way existing land conflicts may be significantly reduced or eliminated.

6. GEODATABASE

To make the existing geoinformation accessible to other departments, Ministries or users the concept for the creation of a geodatabase has been studied, and it is in the process of implementation.

The database will contain the following information:

- the geodetic network (all coordinates of established points in both the old and the new datum)
- digital elevation models (derived from existing large scale maps, from orthophoto mapping processes, and from satellite observation systems such as SRTM)
- topographic maps (in raster and in vector form with conversions from CAD-systems, such as Microstation to object oriented and topologically closed shapefiles included)
- imagery (orthophotos, Landsat and Spot images at medium resolution and Ikonos and Quickbird high resolution satellite maps)
- cadastral maps and plans (including cadastral maps, subdivision plans and local plans).

The key to the superimposition capability is that all data entered into the geodatabase are geocoded. In this respect the new geodetic reference frame plays a major role.

The geodatabase itself is based on the object oriented third generation data base model realized by ESRI's ArcGIS platform.

While the second generation ArcInfo database model which already included topology rules for GIS was still based on map tiles, the new ArcGIS platform constitutes a seamless database applicable to the entire Kingdom.

While the database is housed under an Oracle system its uses are managed through ArcSDE and by ArcEditor by the data managers and viewed by ArcView by the users. This necessitates the creation of a computer network which can be opened by ArcIMS to Internet or Intranet.

7. THE FUTURE ROAD

While the changes in new technology have been introduced in concept by the creation of the new geodetic network, the orthophoto and the new line mapping programs and the integration of cadastral issues into the geodatabase concept a number of implementation projects still need realization. These cover:

- the use of CORS and RTK services covering the entire Kingdom of a sufficient point density of every 100 km;
- the development of new thematic mapping outputs from the geodatabase;
- the extended use of new satellite imagery and the use of digital cameras for timely orthoimage creation;
- the extension of the geodatabase for other thematic and socio-economic data content;
- the creation and the management of computer networks for Kingdom wide distribution of data.

