GNSS and The Intersection of Geodesy and The Cadastre in Kingdom of Saudi Arabia

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SUMMARY

In The Kingdom of Saudi Arabia (KSA), the geodetic network has evolved from the 1966s with the introduction of the National Geodetic Datum (Ain Al Abd) and followed by the Global Positioning System (GPS) compatible Geocentric Datum of The Kingdom (MGD2000) in 2004.

With the advent of space based measuring techniques in particular GPS, The Kingdom of Saudi Arabia established a new geodetic network in 2004 based on the International Terrestrial Frame (ITRF) datum using Geodetic reference System 80 (GRS80) ellipsoid. This new geodetic network allowed cadastral connections to the geodetic framework.
The fundamental obligation of cadastral surveying in The Kingdom is to mark out the boundary of buildings as its current status and redefining the boundary of an empty land with surrounding properties based on all the available evidence. Cadastral surveying therefore works from the part to the whole in contrast to the fundamental role of geodesy: working from the whole to the part.

GPS techniques, and more recently, with the addition of modernized GPS, reinvigorated The Russian GLONASS, the European GALILEO, the Chinese BeiDou, the Japan QZSS, and the Indian IRNSS system and the rollout of Continuously Operating Reference System (CORS) infrastructure, Global Navigation Satellite System (GNSS) techniques have challenged the user community to change their thinking. Cadastral surveying has traditionally relied on angles and distances whereas GPS techniques produce coordinates. The implications of this intersection are profound. The cadastre can act as a significant layer of a Spatial Data Infrastructure for The Kingdom improving efficiencies and advancing new and innovative spatial applications. This paper will give an overview of the evolution of this intersection with particular emphasis on the situation of a case study in Huraymila region near Riyadh and the application of CORS networks in The Kingdom of Saudi Arabia.

1. INTRODUCTION

Land is the most important natural resource, upon which all human activity is based since time immemorial. The expansion of human settlements and infrastructure, and the expansion of urban centers emphasize the need for integrated planning and management of land resources. Land is a critical resource for any country; it forms the basis of its cultural, social and economic progress [1].

Thechnique of land measurement in old times were rudimentary. Directions were defined by magnetic compass and distances by chain and tapes. Often, an extra link was placed in the chain to deliberately give more land than was actually granted. Consequently, the dimentions and geographic locations between the boundery marks where often inaccurate and making it hard to relocate using the correct measurements. Land was sometimes transacted before it was marked on the ground. often, when surveyor visited a district to survey and mark a property, the owner was not there. In some cases the land was sold to another party before the orginal land was surveyed [2].

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The land system in The Kingdom was unorganized and incomprehensive; many individual departments were involved in the collection and maintenance of land records. The absence of a unified and complete land registration system had resulted in numerous conflicts over access rights and ownership rights; the whole system was prone to errors.

The incentive was to develop and implement a sustainable and productive land registration system that would provide a basis of conflict resolution and participatory decision-making process, as well as providing an enabling political, social and economic environment.

2. EVOLUTION OF GEODETIC NETWORK

The first order horizontal control network of The KSA, called The National Geodetic Network (NGN), was the fundamental reference frame from 1966 till 2004 for all geodetic activities (surveying, mapping and cadastral etc) in The Kingdom based on local datum, called AIN AL ABD (Figure 2.1). This initial network, covering about sixty percent of the country, was later densified and extended further to include remaining southeastern part.

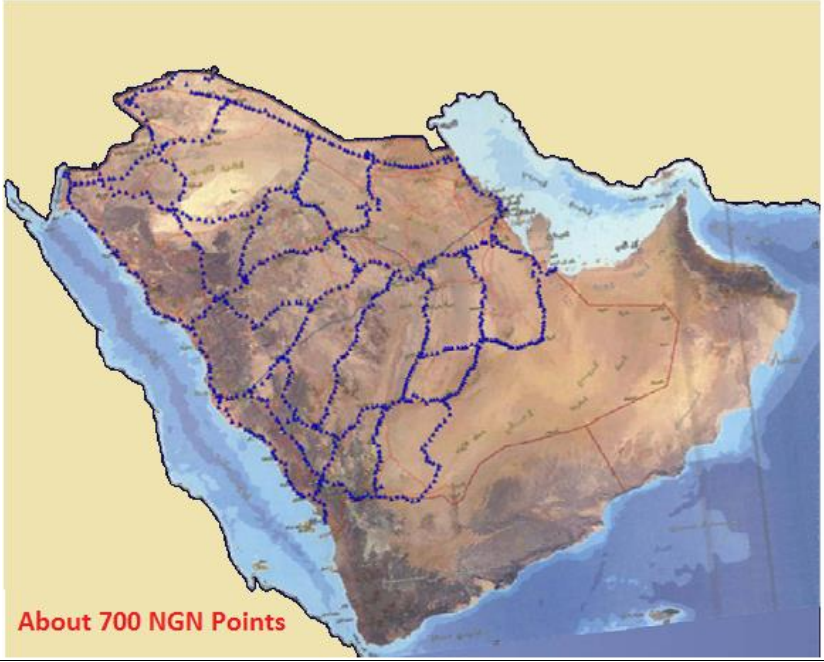

Figure 2.1 National Geodetic Network (NGN)of Saudi Arabia

The NGN was observed using different instruments at different stages and its extensions were adjusted by holding the earlier control as fixed [3].

The KSA has enacted new legislation and acquired new technology to modernize its land registration system. The new Cadastral Registration Act [4] has been moving the KSA from an archaic system to a system that secures and guarantees land ownership rights [1].

Ministry of Municipal and Rural Affairs (MOMRA) and the Ministry of Justice (MOJ) have been given the exclusive mandate for implementing the new cadastral registration system throughout the country; the MOJ looks into the legal aspects of the system while the MOMRA is responsible of the acquisition and production of all the necessary geospatial data for the system [5].

The new cadastral registration system necessitates high levels of accuracy both at data acquisition and production as well as at data verification phases. The MOMRA with its state-of-the-art mapping infrastructure and technology designed the entire processes and procedures of cadastral surveying and mapping [6]. The new cadastral registration system has been constructed upon a new horizontal geodetic reference frame of the KSA that the MOMRA established in 2004.

MOMRA Terrestrial Reference Frame 2000 (MTRF-2000) was based on the International Terrestrial Reference Frame 2000 (ITRF-2000), Epoch 2004.0, while MOMRA Vertical Geodetic Control (MVGC) maintained Jeddah 1969 mean sea level as its reference [7]. MTRF-2000 has a primary network of 13 CORS and a secondary network of around 600 permanent pillar stations distributed throughout the country (Figure 2.2).

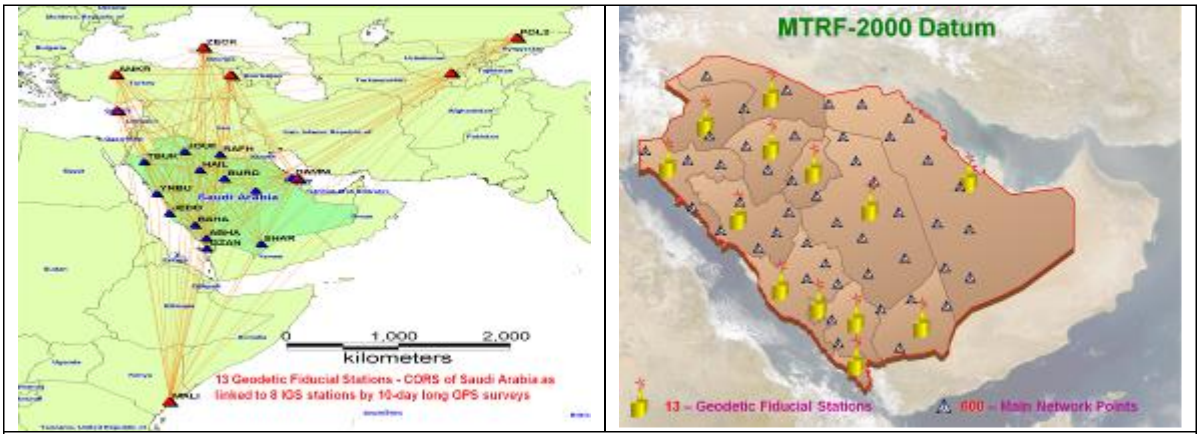

Figure 2.2: MTRF-2000. Left) 8 IGS Stations and Primary network of 13 CORS. Right) Primary network of 13 CORS and Secondary network of 600 stations.

The MTRF-2000 datum is based on the GRS80 ellipsoid. This is identical to the World Geodetic System 84 (WGS84) ellipsoid, except for minor difference with regard to the gravity model, which meant that GPS could be used directly in The Kingdom without need for transformations.

The MTRF network is densified with a network of stations with approximately 50 km spacing called the MOMRA Real Time Network (MRTN), (Figure 2.3) to provide real-time kinematic positioning and post-processing positioning throughout the KSA using this system together with rover GNSS measurements, to have full GNSS-CORS coverage over the entire Saudi Arabia in general and over the major urban & semi-urban areas in particular, providing real time GNSS corrections to rovers/surveyors, post processing services, and static data for scientific geodetic applications, and to fulfill all accuracy requirements of geodesy and navigation in centimeter and even millimeter-levels of accuracy in the post-processing mode; and centimeter and decimeter levels of accuracy in the real-time mode.

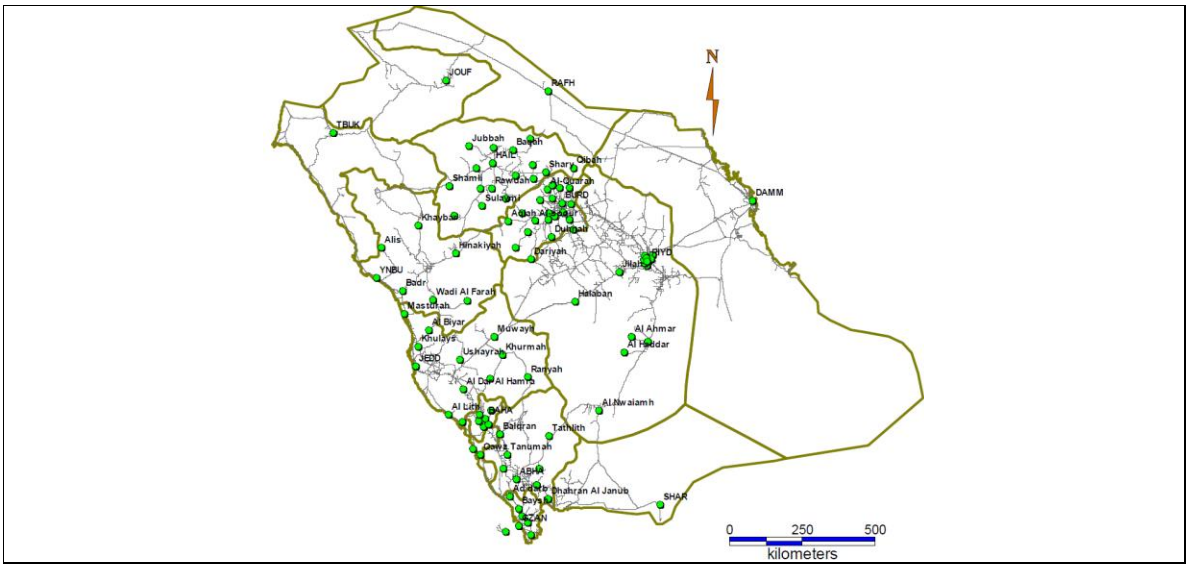

Figure 2.3 MOMRA RTN stations

These MRTN stations with MTRF stations are used to orthorectify aerial photographs and to control the delineation operations needed for the cadastral registration system. Using such geodetic referencing foundation, aerial photography at 10 cm Ground Sample Distance (GSD) ensures satisfactory Digital Elevation Model (DEM) generation. Aerial photographs are rectified using the 3-dimensional (3D) control points and DEM is generated from them. The output orthophotos have the geometric reliability needed for cadastral mapping. The orthorectified aerial photographs provide a base for cadastral base map generation with subdivision planning maps as reference.

3. INTERSECTION OF GEODESY AND THE CADASTRE

GPS techniques, and more recently, with the addition of modernized GPS, reinvigorated The Russian GLONASS, the European GALILEO, the Chinese BeiDou, the Japan QZSS, and the Indian IRNSS system and the rollout of CORS infrastructure, GNSS techniques have challenged the user community to change their thinking. Cadastral surveying has traditionally relied on angles and distances whereas GPS techniques produce coordinates. The implications of this intersection are profound. The cadastre can act as a significant layer of a Spatial Data Infrastructure for The Kingdom improving efficiencies and advancing new and innovative spatial applications.

Traditionally, cadastral survey work involving all aspects of field and office duties and surveyors are performing surveys on public lands from the part to the whole. With the advent of space based measuring techniques, in particular GNSS, is gently nudging surveyors toward a coordinates based approach and agencies see the long term benefit of combining the cadastral and geodetic information as a fundamental layer in a Land Information System. This was never possible before GNSS.

At present MRTN provides RINEX data and provides real-time positioning to cm level accuracy without the need for a base station for users. It is anticipated that many other applications with follow on from this infrastructure.

4. IMPLICATION FOR CADASTRAL SURVEYING

The KSA has been divided into units of cadastral areas in the new system. The new land registration system has been rolled out in Huraymila's first cadastral area in Riyadh region (Figure 4.1). The cadastral area of interest is approximately 3.0 km^2 and encapsulates around 1700 land parcels.

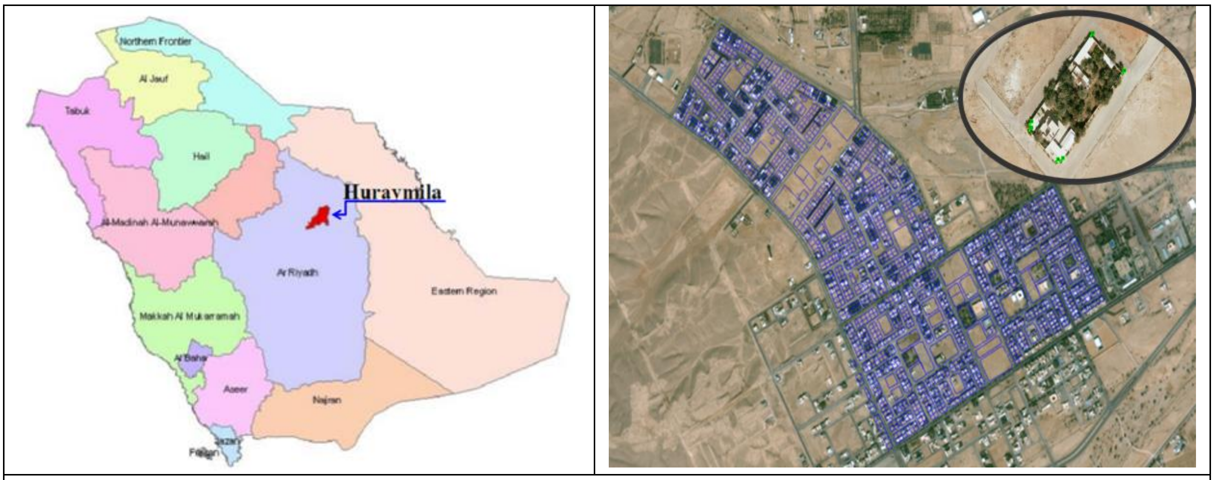

Figure 4.1 Huraymila. Left) Shown on KSA map. Right) Parcels of first cadastral area.

The MOMRA and the MOJ are working together in this new system to secure and guarantee land ownership rights. A new cadastral identification system has been developed based on MTRF-2000 such that each cadastral unit would be identifiable using its unique 14-digit Cadastral Unit (parcel) Pin Number (CUPN) which represents the latitude and longitude of the parcel centriod (Figure 4.2).

Figure 4.2 Cadastral unit PIN numbering system

The CUPN is to give each cadastral parcel a unique number so it will be the new deed number and it was used as a primary key for the spatial geodatabase of the cadastral system, which was designed so as to incorporate and enable both way data transactions and also to support a web-enabled interface.

Information and Computers Technology have revolutionized conventional cadastral surveying, mapping and land registration processes and are increasingly becoming significant components of any agency where automation plays part in improving production. The fundamental change envisioned in the new cadastral registration system will be manifested in unification of the methodologies for data capturing, storing, checking, and analyzing.

In this point of view, an online cadastral registration module has been developed using the capability of the Geographic Information System (GIS) and the web to disseminate information and provide services to its users and at the same time record of all the processes and procedures is been automatically generated and archived. The user has to initiate the process online by registering himself and submitting the necessary documents, wherein the user is given a unique identification number and his case is processed; the user is constantly updated of the progress.

Surveyors in The Kingdom are willing to use GPS/GNSS surveying technique for land survey. With the growth of CORS network in The Kingdom wide, it is anticipated that GPS/GNSS surveying technique utilization will grow considerably. In fact, MOMRA teams carry out field operations using GNSS/RTK in the presence of the owner and the MOJ representative by following the predefined process.

The process is initiated by the owner itself, submitting his pre-determined documents and credentials to the cadastral registration office of MOJ for registration of his cadastral unit. The cadastral registration office processes the information, then forwards it to the cadastral surveying department of local municipality, which has the responsibility of performing all field and office technical tasks. The cadastral surveying department teams carry out field operations using GNSS/RTK in the presence of the owner and the cadastral registration office representative. After that, final cadastral unit document is produced with final CUPN, and all data in incorporated into the spatial geodatabase. The cadastral surveying department forwards the final cadastral unit document and CUPN to the cadastral registration office, which carries out the adjudication process and issues final ownership certificate.

5. CONCLUDING REMARKS

This paper has given an overview of the evolution of the geodetic network and implementing GPS/GNSS techniques in cadastral surveying in The Kingdom. The authorities are working hard to modernize regulations and implementations of new Cadastral Registration Act to accommodate GPS/GNSS technology for land and cadastral surveyors.

The KSA has modernized the way of cadastral registration system that provides a complete peace of mind to the owner. A digital system has been developed in order to provide accessibility to the country's cadastre records from any online location.

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BIOGRAPHICAL NOTES

ALI ALOMAR gained his **MSc** in Cadastral from Riyadh, King Saud University. He has more than 10 years experience in GNSS, Geodetic Network and Cadastral Survey. He is now the manager of Cadastral Department at Ministry of Municipality and Rural Affairs (MOMRA). So far, he has published and contributed various papers and presentations at conferences and meetings.

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