

# **The ArabRef project – A New Geodetic Network for Arabia**

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## **SUMMARY**

KACST (King Abdul Aziz City for Science and Technology, Saudi Arabia) in collaboration with SEGAL (Space & Earth Geodetic Analysis Laboratory, Portugal), initiated recently a project towards the implementation of a dense network of GNSS (Global Navigation Satellite Systems) CORS (Continuously Operating Reference Stations) receivers in the Arabian Peninsula. This project is called ArabRef since one of its major goals is to create a network of GNSS sites that will establish and realize a common reference frame for the entire Arabian Peninsula. Since there are already some stations available in the Arabian Peninsula, these CORS stations will be added to the new stations in order to extend the ArabRef network to the entire Arabian Peninsula.

In addition, this project also intends to serve the Arabian and global scientific community by providing observations and solutions that can support research in a variety of applications like geodynamics, ionospheric, and tropospheric studies. This network will provide an excellent frame to accurately define the limits and quantify the angular velocities of the Arabian tectonic plate. Internal active deformations will be possible to be identified using this dense network.

At long run, ArabRef intends to create a permanent service that can be used by scientists and professionals (engineers, environmentalists, agriculturalists, mineral prospectors, etc) as reference at any place on Arabia for their geo-referencing activities.

We present here the initial stage of this project with the planned distribution of the ArabRef network and how KACST will implement the necessary infrastructure to provide to the end-users the technical and scientific products derived from this project.

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## **1. INTRODUCTION**

It is almost impossible nowadays to think in services that do not require knowledge about location. Services like land allocation and development permits, water connections, electricity and transportation require linking places where people live and/or do. Therefore, all development projects, applications, services and products need to be geo-referenced. Such geo-referencing require uniform coordinate systems which are materialized by the geodetic reference frames.

In the past, almost every country implemented different national geodetic reference frames for producing maps and other geographic information products. These reference systems are usually based on local origins or data, restricting their use to the particular country and making them impossible be used at transnational projects. Natural and human features like roads, watershed and ecosystem boundaries may show discontinuities when national maps are joined together for regional level planning. Furthermore, the lack of using the same reference system can create major issues on the correct definition of international and internal boundaries with the potential raise of conflicts.

KACST, as a major research center in Saudi Arabia, decided to promote the implementation of a fiducial reference network that intends to serve the entire Arabian Peninsula by creating a modern and consistent reference frame based on Space-Geodesy, namely on GNSS observations. This project, called ArabRef (Arabian Reference Frame), is being now prepared and its execution will start during 2010. SEGAL, a collaborative project between University of Beira Interior and Institute Geophysical Infante D. Luíz in Portugal, is scientifically supporting the definition and implementation of the project.

ArabRef will be fully consistent and homogeneous with the International Terrestrial Reference Frame (ITRF) and will therefore be part of the global geodetic infrastructure that includes other regional frames like the European EUREF, the African AFREF, the South American SIRGAS, and the North American Datum (NADREF). Such a global infrastructure is a prerequisite for many multi-disciplinary applications.

This fundamental reference system intends to further contribute for the understanding of the Solid Earth and assist and facilitate the solving of regional and global problems like climate monitoring, ground-based weather forecasting, and long-term sea level trends at millimeters level.

## **2. PROJECT OVERVIEW**

ArabRef will be based on current satellite positioning technologies. It will be materialized through a set of GNSS CORS observation systems that will be distributed by the entire Arabian Peninsula. The network would be at such a density that professionals (surveyors,

engineers, environmentalists, agriculturalists, mineral prospectors, etc) can use them as reference at any place on Arabia for their geo-referencing activities.

ArabRef will provide the geodetic infrastructure for regional and multinational technical and scientific projects requiring precise geo-referencing (e.g. three-dimensional and time dependent positioning, geodynamics, precise navigation, and geo-information). ArabRef will also contribute for international relations by helping to delineate and to demarcate borders between Arabian countries.

In addition, with the implementation of the ArabRef, there will be also an urgent need to determine the transformation parameters between the current existing traditional national reference frame or frames and its associated legacy geospatial data in order that the information based on traditional reference frames will not be lost or discarded.

To achieve all these goals, it will be necessary:

- 1) to establish a network of points to realize the peninsula reference frame;
- 2) to determine the best-fitting set of coordinates for those points;
- 3) to create an infrastructure (Center of Computation and Analysis – CCA) capable of permanently producing solutions and monitoring the quality of the network.

These are the three major objectives of the ArabRef project.

### **3. PLANNED NETWORK**

This project aims to support on-going activities and initiate new ones by establishing a network of permanent GNSS reference stations to be used for computing the parameters of an Arabian Geocentric Datum, and to be used as base stations for space-geodetic positioning in the Arabian Peninsula.

In the first phase, the goal is to cover Saudi Arabia with a complete network of permanent stations that it will establish the ArabRef fiducial network. In order to establish the link with the other Arabian countries, one CORS station must also be implemented in each of neighboring countries (Kuwait, Bahrain, Qatar, United Arab Emirates, Oman, and Yemen). When completed, it is envisaged that users will not be more than 500 Km from one such point any place in Arabia, to be eventually densified to reduce that distance to 300Km or less.

Modern GNSS CORS networks, if designed and implemented properly, are able to define and materialize the fiducial reference network of a country or countries with a significant higher accuracy than in recent past with classical networks. In addition, they are also able to provide, by streaming differential corrections, accurate reference points to carry out geo-referencing operations in real-time. Even if the observations are used only for pos-processing computations, CORS stations eliminate the need for a second equipment (acting as reference) with obvious advantages for public and private surveyors.

The ArabRef network will be designed in order to be fully compliant with the above mentioned characteristics. The selection of the locations are being carried out taking into account a uniform distribution all over the entire Peninsula in order to support the densification of the network with no-permanent stations when required by public and private projects.

Figure 1 indicates the designed optimal distribution of the ArabRef in order to accomplish the mentioned objectives. As discussed, the network contains stations distributed over the entire Peninsula. Nevertheless, the exact location of the stations can be modified attending to local logistical conditions. In fact, this figure intends to perform the first evaluation of the possible location of the ArabRef stations. According to the mentioned criteria, 25 stations will be sufficient to implement the optimal network configuration for ArabRef.

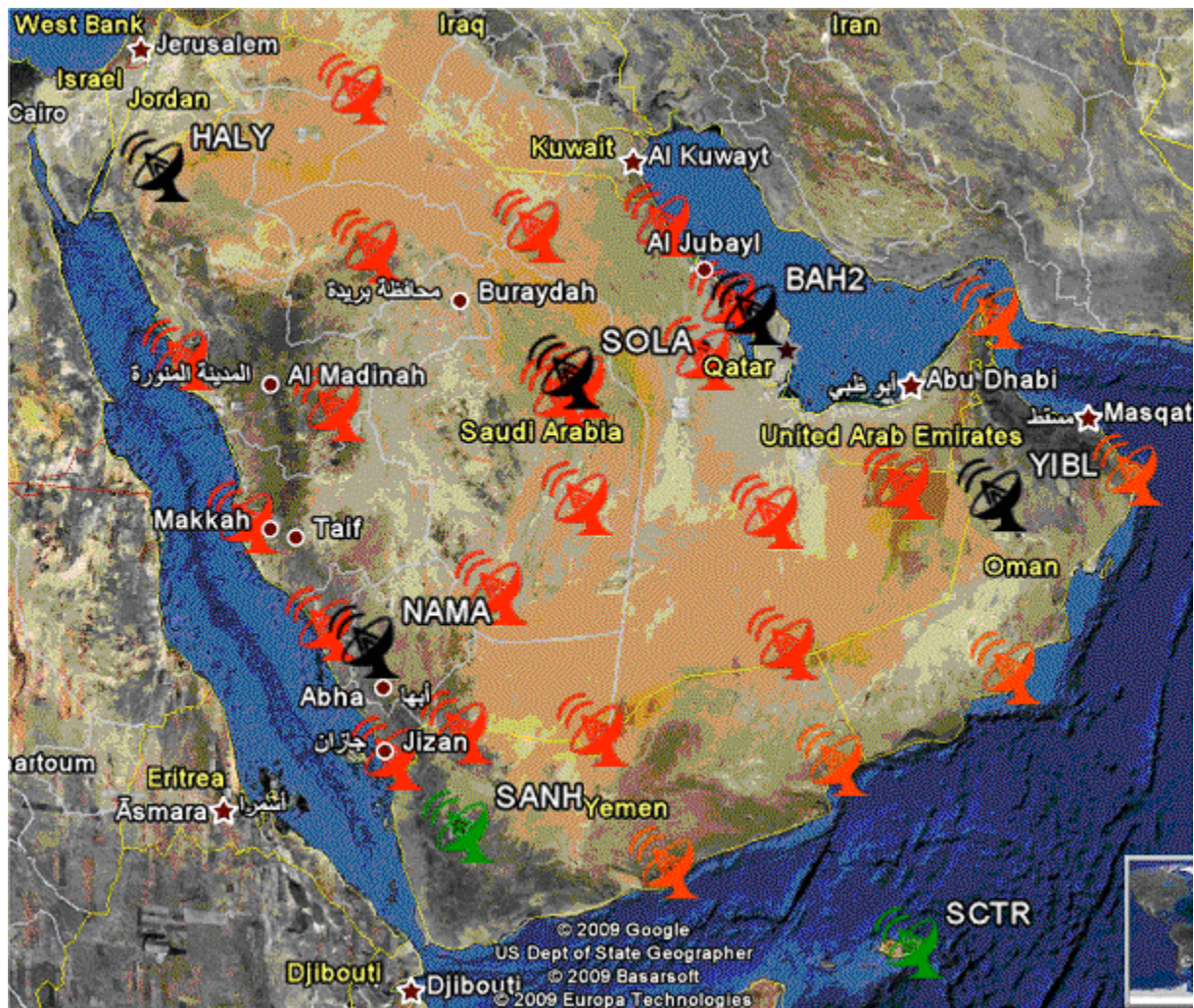


Figure 1 – Optimal distribution of GNSS stations to materialize the ArabRef realization. Red – new stations to be installed in Saudi Arabia in the first phase. Black – existing IGS stations that can be incorporated in the ArabRef network. Green – existing stations managed by SEGAL that can be incorporated in the ArabRef network. Orange – new stations to be installed in other Arabic countries.

The exact number of stations is also dependent of the collaboration established with the other Arabian countries (Gulf Cooperation Council and Yemen) in order to establish or use some existing stations in these countries in order to complete (and internationalize) the ArabRef network.

## BIOGRAPHICAL NOTES

**Nasr A. Al-Sahhaf** is Assistant Professor at King Abdulaziz City for Science & Technology. He holds a PhD. In Geography from the University of California at Santa Barbara in Geographic Information Systems and Remote Sensing. He also holds a Master's of Science in Engineering in Space Systems Design, as well as Master's of Science in Civil/Geotechnical Engineering from the University of Washington, Seattle. Dr. Al-Sahhaf currently heads the Satellite Laser Ranging Observatory - Riyadh, and is active in the research area of geodesy. He is a member of several scientific organizations such as the American Geophysical Union (AGU), the International Association of Geodesy (IAG), and the Association of American Geographers (AAG).

**Rui M. S. Fernandes** is Assistant Professor of University of Beira Interior and Associated Researcher of Center of Geophysics of University of Lisbon / Institute Geophysical D. Luíz. He obtained the MPhil in Geomatics Engineering by University of Coimbra, Portugal (1990) and he has the Ph.D. in Earth and Space Sciences by Technical University of Delft, The Netherlands (2004). His current research topics are focused on the application of Geodetic Space techniques to Geodynamics and Reference Systems. He belongs to some organizations like American Geophysical Union and is member of IAG (International Association of Geodesy) and EUREF (European Reference Frame) technical working groups.

**Sami Alhamidi** has obtained his BSEE from the King Fahd University for Petroleum and Minerals in 1988 with concentration on Electronics and Communications System. He worked as a communications system engineer for AEC and then joined the communications engineering department at Saudi Aramco. Dr. Alhumaidi obtained his MSEE from the California State University, Northridge, in 1993, where he concentrated his research on mobile communications systems. He obtained his Ph.D. degree in Electrical Engineering from the Florida Institute of Technology in 1997, where he focused his research in the Radar Remote Sensing field. He joined the consulting services department at Saudi Aramco where he served until joining King Abdulaziz City for Science and Technology in 1999. Dr. Alhumaidi has been working as a research assistant professor at KACST for over 10 years and has assumed several research positions. He is now the director of the national electronic, communications, and photonics research program..

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