ARABREF - A Vision for its Design and Implementation

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Key words: ARABREF, reference frame, GGRF, ITRF

SUMMARY

The world has never before seemed as small as it does in the 21st century. It has become a global village, with countries and individuals increasingly interacting in projects and enterprises within a global context. Although country-level geodetic reference systems with varying complexities exist for individual nation states, there remains a widespread lack of adoption of established regional and global geodetic systems and standards which would directly contribute to increased socio-economic activity and prosperity. The UN initiated efforts to create a Global Geodetic Reference Framework (UN-GGRF) to help with cross-border geospatial applications. Part of that effort is to create regional geodetic reference frames to increase socio-economic activities and regional collaboration. Arab States Geodetic Reference Frame (ARABREF) is one such regional geodetic reference framework for the 22 Arab countries straddling North Africa and South-West Asia. This paper describes the current state of the ARABREF and presents a possible vision for its design and implementation.

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1 INTRODUCTION

The fact that there are so many datums globally, naturally causes a large variety of data sources which makes producing aggregate services based on such data difficult. With the increase in the potential for geospatial services and excessive location data collection, there is a dire need to integrate such disparate data effectively from local to global levels. Due to the fact that there is a large variety of datums being used, a single location can be referenced in many different coordinate systems. To reduce this, the United Nations Committee of Experts on Global Geodetic Information Management (UN-GGIM) established a Working Group (WG) for a Global Geodetic Reference Frame (GGRF) in 2013 which formulated and facilitated a draft resolution for the GGRF, which was adopted by UN-GGIM in 2014 (UN-GGIM, 2023).

The GGRF enables global geospatial applications such as land ownership, construction, agriculture, smart transport, navigation, geodynamics, climate change, and sea-level monitoring. UN-GGIM experts have highlighted various benefits that can be derived through more precise locational applications. Simultaneously, experts have pointed out the urgent requirement for increasing global geodetic collaboration, emphasizing the economic benefits of constructing a GGRF. Not only does GGIM ensure the sustainability of the GGRF, but it also gives access to all countries to the GGRF.

The GGRF is important as it is the basis of so many earth science applications such as earth rotation, tectonic motion and deformation, seal level monitoring, and many more. Furthermore, it has many societal applications in positioning such as the creation of local, national, and regional reference frames, as well as navigation, surveying, precision agriculture, boundary establishment, and land management.

The GGRF framework equips experts to work precisely with any location on the globe. Through the GGRF, experts develop the ability to create an infrastructure that combines accurate and current geodetic networks. This enables experts to determine accurate horizontal positions and heights. GGRF provides the optimum model to enable experts to take advantage of georeferencing, with accurate spatial data. This accuracy in position and height enables us to manage all our spatial resources.

The GGRF provides an infrastructure that is a combination of a current and accurate geodetic network with accurate positions and heights, and a high accuracy geoid model. These fundamentals provide an optimum combination to ensure accurate georeferencing in both position and/or height. In addition, the availability of an optimally positioned network of Continuously Operating Reference Stations (CORS) can improve the efficiency/accuracy of positioning applications.

The National Geodetic Reference Frame (NGRF) is the geodetic reference system for each nation state. It manages the network, data, and infrastructure harmonization to establish an authoritative, reliable, highly accurate national geospatial referencing infrastructure that supports the collection, integration, and utilization of all other geospatial data.
Arab States Geodetic Reference Frame (ARABREF) was initially proposed by Al-Sahhaf et al. (2010), however the scope of the proposal has been limited by establishing a CORS network over the Arabian peninsula and an analysis centre for the computation of coordinates. In 2014 GGIM established the Arab State to include the 22 Arab countries spread over two continents (Africa and Asia) and three tectonic plates (Arabian, Nubian and Somalian), which are summarised in Table 1 in alphabetical order and shown graphically in Figure 1.

Country	**Continent**	**Tectonic Plate**	**Country**	**Continent**	**Tectonic Plate**
Algeria	Africa	Nubian	Morocco	Africa	Nubian
Bahrain	Asia	Arabian	Oman	Asia	Arabian
Comoros	Africa	Somalian	Palestine	Asia	Arabian
Djibouti	Africa	Nubian, Somalian, Arabian	Qatar	Asia	Arabian
Egypt	Africa	Nubian	Saudi Arabia	Asia	Arabian
Iraq	Asia	Arabian	Somalia	Africa	Somalian
Jordan	Asia	Arabian	Sudan	Africa	Nubian
Kuwait	Asia	Arabian	Syria	Asia	Arabian
Lebanon	Asia	Arabian	Tunisia	Africa	Nubian
Libya	Africa	Nubian	UAE	Asia	Arabian
Mauritania	Africa	Nubian	Yemen	Asia	Arabian

Table 1. List of Arab states.

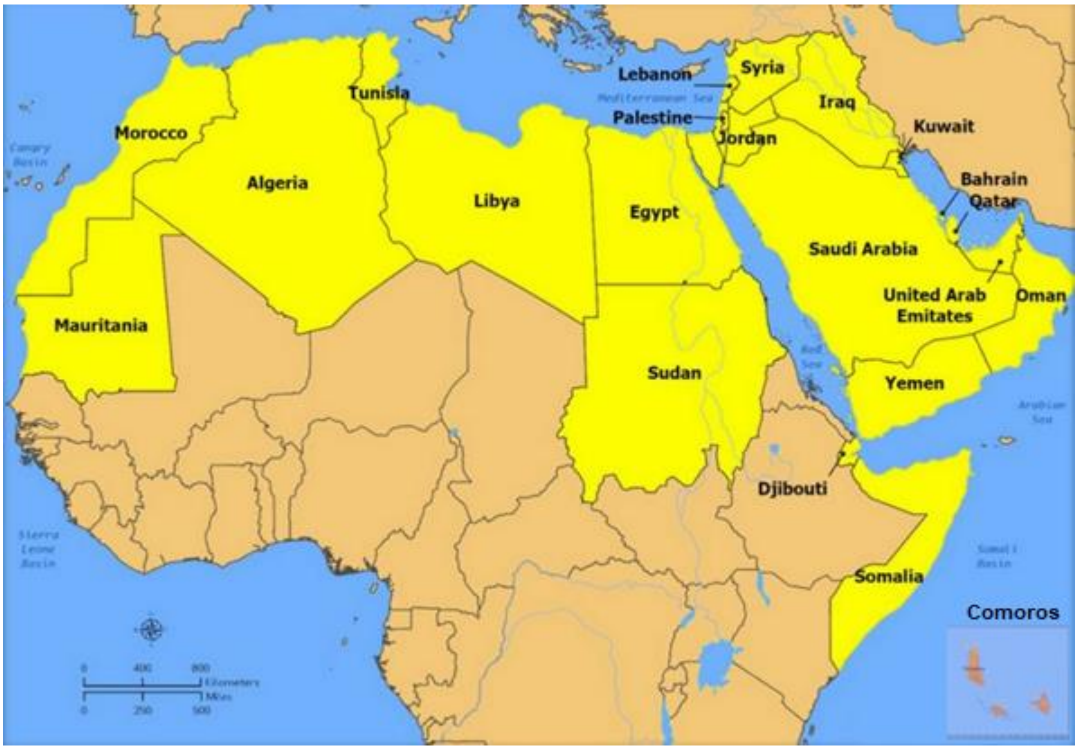

Figure 1. Map of the Arab states. Comoros Islands included as inset not to scale.

Its objectives include sharing the GGIM experience between the Arab member states, establishing accurate and reliable geodetic reference in the Arab Region, implementing GGIM policies, developing strategies and guidelines in each member country, achieving a level of consistency and geospatial maturity, to access, integrate and disseminate geospatial information between the member countries and global matters, to develop standards for geospatial data and services to achieve GGIM objectives and to share geospatial data among member countries of the Regional Committee.

Under the GGIM, the Arab States have formed the following working groups:

- WG1: Institutional Arrangements, Legal and Policy Issues, Awareness and Capacity Building
- WG2: Fundamental Data and Geo-Standards
- WG3: Geodetic Reference Frame
- WG4: Integration of Geospatial & Statistical Information

The objectives of WG3 include the establishment of the ARABREF for the 22 Arab states in accordance with International Terrestrial Reference Frame (ITRF); the realization of a unified vertical datum; the establishment of a precise Arab geiod; training of the Arab professionals to manage ARABREF; and determining the relationship between national reference frames and the ARABREF. Finally, it aims to establish permanent GNSS stations whose data is accessible to each user.

Building the ARABREF will encompass developing a number of goals such as - Policies, Standards, and Conventions; Geodetic Infrastructure; Education, Training and Capacity Building; Governance; and Communication and Outreach. The illustration below reflects GGRF elements to support future design and implementation of the ARABREF.

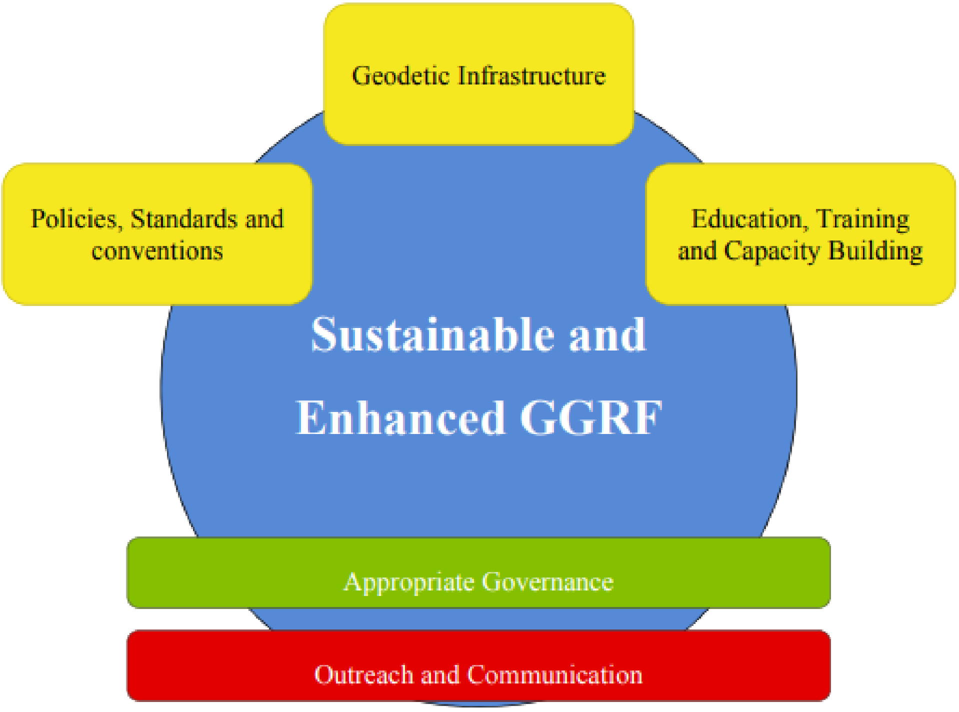

Figure 2. GGRF structure and vision. (UN-GGIM , 2018)

2 GRF IMPLEMENTATION TECHNIQUES

To implement the GRF a number of measurements systems and techniques are required. Four main measurement systems of the geodetic infrastructure include:

- Global Navigation Satellite System (GNSS), which uses permanent reference stations to establish accurate and precise coordinates and velocities for input into the ITRF
- Very Long Baseline Interferometry (VLBI), which provides information on the orientation and scale of the Earth
- Satellite Laser Ranging (SLR), which provides information of the centre of mass of the Earth and scale, and also a backup for orbit determination
- Doppler Orbitography and Radio positioning Integrated by Satellite (DORIS), which is used for determination of satellite orbits, as well as positioning of ground stations

Each of these observational techniques has unique characteristics, strengths, and weaknesses. VLBI provides the orientation of the ITRF relative to the celestial reference frame (i.e., the 'distant stars') and is also one of the two techniques currently used for accurately realizing the scale of the ITRF. SLR is used to locate the centre of mass of the Earth system and thereby defines the ITRF origin and contributes to the ITRF scale. GNSS contributes to the large number of sites that define the ITRF (contributing to its density) and contributes to precise monitoring of polar motion. GNSS, DORIS, and SLR are used to position space-orbiting platforms in the ITRF, and GNSS is used to position instruments on the Earth's land and sea surfaces (for example, tide gauges and buoys). The figure below shows the spread of all the GNSS, VLBI, SLR and DORIS ground stations used to derive ITRF2014 (Altamimi et al., 2016).

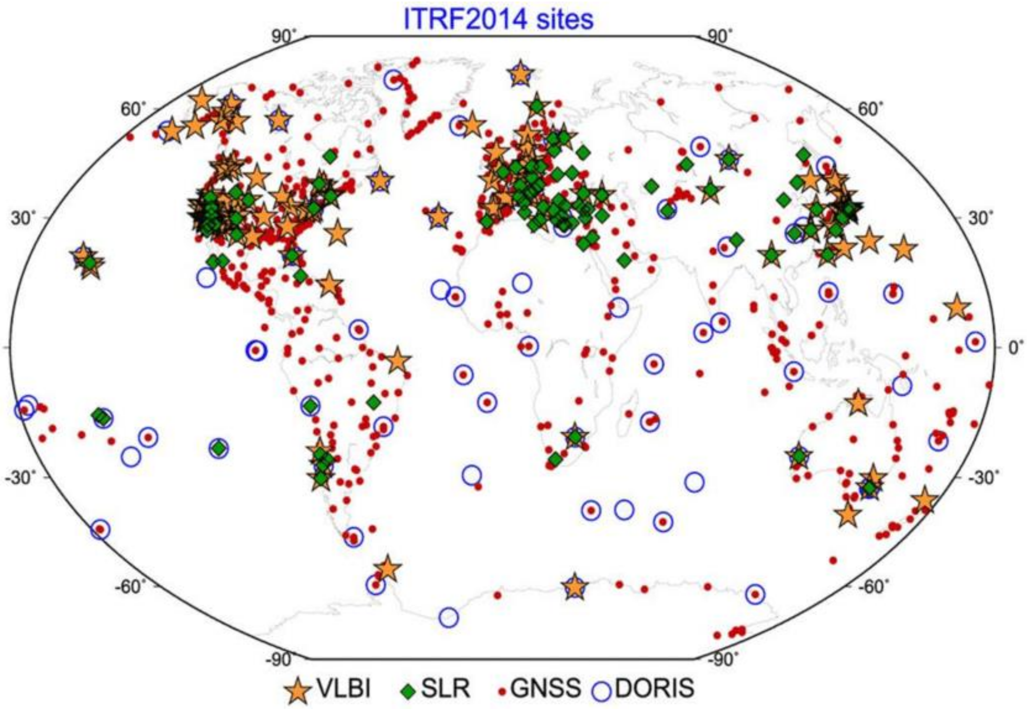

Figure 3. Map of the GNSS, VLBI, SLR and DORIS sites (Altamimi et al, 2016).

None of the space geodesy techniques alone is capable of providing all the necessary parameters for ITRF definition (origin, scale, and orientation). Thus, the ITRF is based on information derived from a combination of multiple geodetic techniques. Locating instruments for two or more techniques near each other at certain ITRF sites (a practice called “co-location”) enables connectivity between these techniques. From Figure 3 it can be seen that there is a limited number of GNSS and SLR station across the ARABREF states, while not VBLI and DORIS sites are available at all.

3 CURRENT STATUS AND IMPLEMENTATION ISSUES

The main goal for GGIM Arab States WG3 on Geodetic Reference Frame is the development of the ARABREF, which was to be done in two phases. The first phase is designed for GNSS data analysis of ARABREF CORS. Also, it has been recommended that member states establish data and analysis centres, and start sharing GNSS data for their selected CORS stations that satisfy international standards. The second phase involves performing physical geodesy data analysis of ARABREF vertical network (e.g. geoid, gravity, levelling, tide gauges).

The different Arab member states have different technical capabilities to help realize ARABREF. Saudi Arabia and Algeria have the most contribution for the ARABREF infrastructure with 10 CORS as well data and analysis centres. Egypt, Morocco, and Oman have four CORS and an analysis centre. Tunisia has three CORS, as well as a data and analysis centre. Qatar and Sudan both have two CORS and an analysis centre. Finally, Jordan and Lebanon both have one CORS and an analysis centre (see Table 2).

Country	Number of CORS	Data Centre	Analysis Centre
Algeria	10	Yes	Yes
Egypt	4		Yes
Jordan	1		Yes
Lebanon	1		Yes
Morocco	4		Yes
Oman	4		Yes
Qatar	2		Yes
Sudan	2		Yes
Kingdom of Saudi Arabia	10	Yes	Yes
Tunisia	3	Yes	Yes

Table 2. Contribution of each country to ARABREF (Al-Kherayef, 2019)

Saudi Arabia has contributed to the ARABREF by preparing the GNSS data sharing protocol & guidance, establishing of ARABREF FTP site for GNSS data storing and establishing data and analysis centres, see Figure 4.

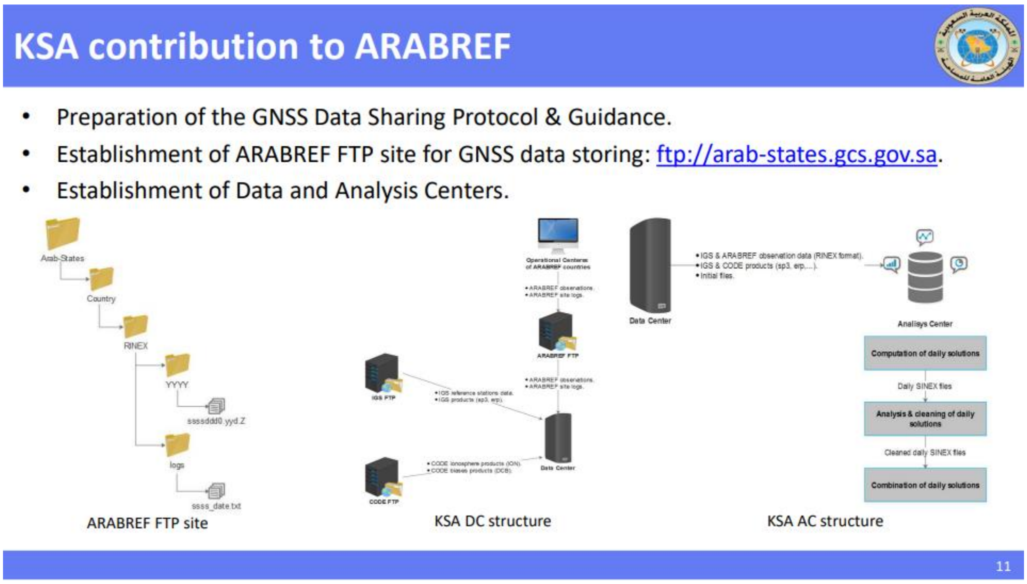

Figure 4. KSA contribution to ARABREF (Al-Kherayef, 2019)

A number of implementation issues need to be addressed in order to achieve the ARABREF. These are discussed in this section.

3.1 Tectonic Plate Velocities

Physically, the ARABREF member states are situated on the Arabian tectonic plate (ARAB), the Nubian tectonic plate (NUBI), and the Somalian tectonic plate (SOMA) based on the ITRF2014 Plate Motion Model (Altamimi, 2017), as illustrated in Figure 5. The tectonic plates of the Earth are moving constantly with different directions and velocities relative to each other. To manage many different applications (e.g. autonomous systems) we need a reference frame that is accurate in its position attributes in real-time and is coincident with satellite navigation systems such as GNSS. In order to achieve that, the reference frame needs to be dynamic or semi-dynamic, meaning that it incorporates the tectonic velocities of the various plates that it is based on.

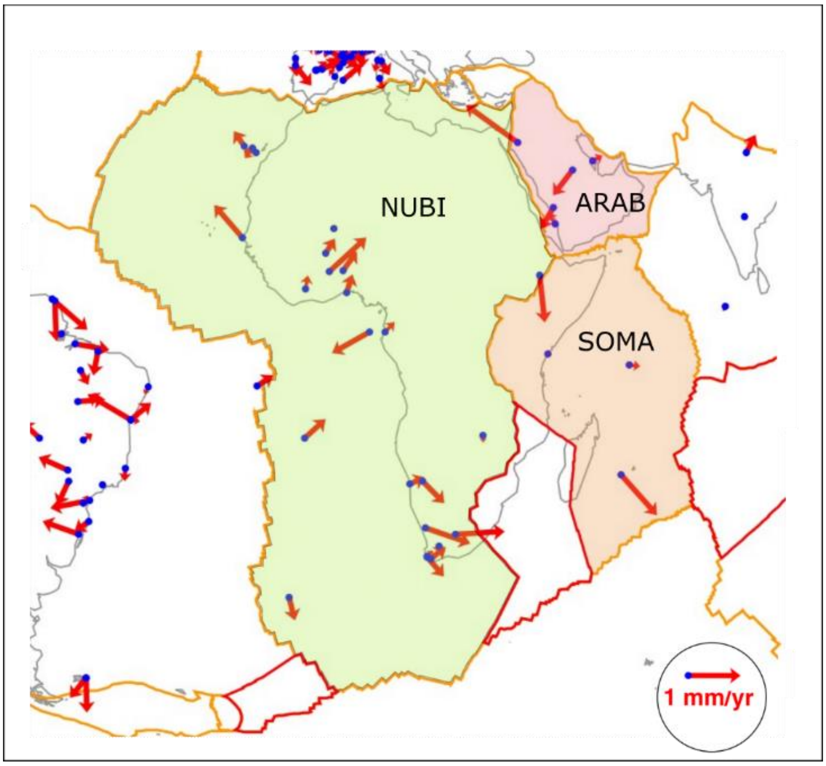

Figure 5. Arabian, Nubian, and Somalian tectonic plates including post-fit residual vectors based on ITRF14 plate motion model (adapted from Altamimi, 2017).

To the best knowledge of the authors, all individual Arab state datums are fixed. From a short-term perspective, the issue of dynamics can often be ignored. However, once we move more and more into the world of autonomy, these issues cannot be ignored anymore. Another problem is that with individual datums, the coordinates will change from country to country, which will also present problems in the long-term.

An alternative to the series of fixed datums is a datum that includes the motion of control stations and coordinate axes in the datum definition. Therefore, a dynamic datum is one where the coordinates of geodetic control stations change in some consistent and organised way. Such datum is considered 4D as the coordinates of a point are always defined with a time tag. Mechanisms for management of the fourth dimension (time) are built into the dynamic datum and must also be built into systems that depend on the datum for high accuracy positioning. This adds to the set-up costs for these systems. However, long-term maintenance costs will be reduced because the maintenance of spatial accuracy can be automated.

3.2 Horizontal Datum

Member states are keen to establish more data and analysis centres among them as well as more CORS for ARABREF. Members wish to develop a geospatial information exchange protocol among themselves as well as build capacity in the GRF. Finally, ARABREF members are motivated to develop a GRF roadmap that is uniquely right for them.

There is a limited number of IGS sites within the Arab states as shown in Figure 6. Many CORS sites are quite distant from urban centres in Arab states, due to the population density and the national coverage of the network. As a result, stations are often distant from broadband internet connections to transfer the GNSS data to a data management centre for public dissemination.

The development of ARABREF has been slow, with an emphasis placed by member states to provide increased CORS GNSS data collection, increase the number of data and analysis centres. The periodic updates from Arab states meetings with respect to this show little incremental progress and slow uptake by member states.

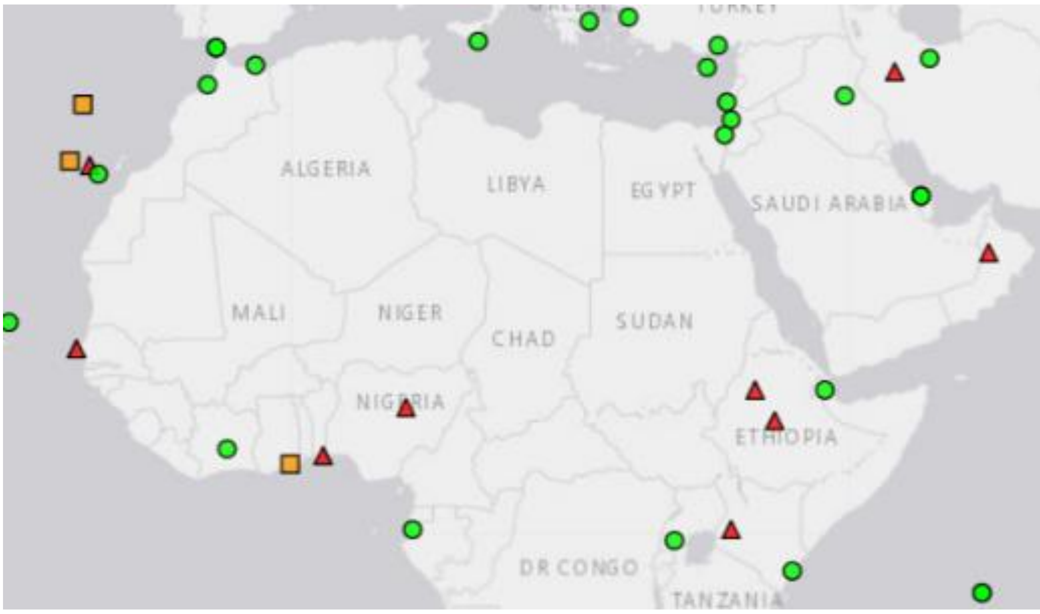

Figure 6. IGS GNSS stations in Arab states (source: https://igs.org/network).

3.3 Vertical Datum

There are over 22 independent height systems used by Arab states, which are based on levelling networks that do not have common marks and have not been adjusted together. Additionally, there is no coordination in tidal data measurements among these states, and the levelling networks have not accounted for rising sea levels. Each primary datum originates from independent tide gauge observations and requires examination. If efforts are made to bring all networks to a common datum, height differences may arise due to the disparate levelling networks. To accurately quantify these differences, an assessment that considers varying sea surface topography or dynamic ocean topography is necessary.

The current state of available gravity data in Arab states is unknown, but investigations into this and other sources could be used to compute an Arab State national gravimetric geoid model. Once the required accuracy is established for individual height systems, a consistent orthometric network among all member states can be derived. In the future, improvements to the ARABREF vertical datum could be anticipated, with the definition of a precise local and Arab state geoid referenced to a global vertical datum as a dynamic vertical datum.

3.4 Data and Standards

To develop ARABREF further, the member states will attempt to identify available technical source material on geospatial data and standards, assess existing fundamental data and geo-standards, fix the relevant geospatial data categories, compile existing specifications and geospatial datasets, identify/select fundamental subsets as well as define ways and objectives to complete/harmonize selected subsets.

4 A PROPOSED IMPLEMENTATION SCENARIO

By evaluating the current state of UN-GGRF, one can agree on its future state, and in doing so develop an implementation road map considering the following proposed scenario. Typically, a country has two national datums: the geometric datum used mainly for horizontal positions, and the vertical datum used for determining orthometric heights (elevations). Replacing the multiple Arab state datums will impact the geospatial community across Arab states.

Horizontally, it is proposed that three new datums are developed, each based on their respective tectonic plate (see Section 3.1). Since tectonic plates are continually moving, the horizontal datums will move at the same rate (or be “plate fixed”) to the rigid portion of their respective plates to maintain the accuracy of each TRF.

The new vertical datum is proposed to be called the Arab State Geopotential Datum (ASGD). It is called a geopotential rather than a vertical datum because the vertical component is only part of the new datum. That’s the part used to determine orthometric heights (elevations) and other gravity-based physical heights. It will also provide a model for the deflection of the vertical (the direction of gravity with respect to the TRFs), surface gravity, and other elements of the earth’s gravity field. Unlike the TRFs, there will be only one, and it will be built on a global geopotential reference model such as EGM2020 (Barnes et al., 2020).

From that global model, higher resolution and more accurate regional products will be built. These regional products will be in grids, covering the Arab state region. The data for building the geopotential datum will be identified and documented in the assessment of the future requirements for the ARABREF.

4.1 Arab States Geodetic Center of Excellence

The Arab States Geodetic Center of Excellence (AS-GCoE) aims to serve as a sustainable entity that provides leadership and expertise in geodetic research and development (R&D) services and solutions. To ensure the highest standards, the AS-GCoE will implement industry best practices and adhere to international geodesy benchmarks. With its expertise and industry leadership, the AS-GCoE is expected to sustain itself through Arab States funding and local investments. In return, the AS-GCoE will offer geodetic solutions and consultancy services to Arab state members. Its ultimate goal is to become the market leader by delivering regional positioning solutions and innovations under Arab States supervision. Therefore, it is recommended that the Arab states transfer its market facilitation role to the newly formed AS-GCoE to promote continued geodetic R&D growth.

The primary objective of AS-GCoE is to promote, market, operate, maintain, and continually improve the ARABREF. Additionally, the center will encourage collaboration to introduce new positioning technologies to the market and capture needs through efficient marketing strategies. It will also act as a trusted advisor to extend geodesy capabilities and enhance the capacity of government agencies to strategically harness technology and data for Arab states' benefit.

As the industry expands and demand for research and development increases, market facilitation will require an organization with competent talents and legal agency that can enter into contracts and manage substantial R&D funds. Thus, it is essential to establish the AS-GCoE to ensure continued vibrancy of geodetic R&D that contributes to industry growth. This center will serve as the focal point for geodetic information and data coordination and will maintain a network of geodetic observatories in Arab states.

4.2 National Geodetic Reference Frames

The NGRF is the reference frame for each nation in the Arab state. Figure 7 below shows the concept of NGRF in the ARABREF. Some Arab states have additional geodetic reference frames, which would be included in this analysis. Establishing a unified ARABREF is difficult because the maturity level of the NGRF is very different from one country to another.

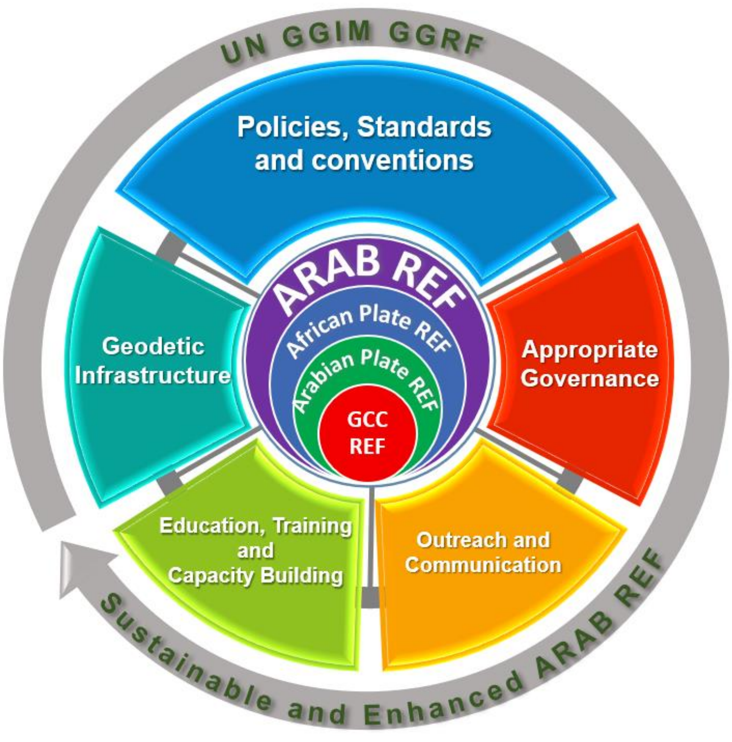

Figure 7. NGRF forming part of ARABREF.

Not much progress has been made since the concept of ARABREF was proposed and contributions from member states have been minimal. Thus, an approach to implement ARABREF gradually is proposed here. In the figure above, ARABREF is represented by the large circle in the middle while the NGRFs of Arab nation states are the smaller circles to the right, and the geiod/gravity reference of Arab nation states is to the left.

4.3 Stepwise approach towards ARABREF

It is proposed that the implementation be started with those Arab countries that have the most mature geodetic infrastructure and capability. The Arabian Gulf countries (Saudi Arabia, UAE, Kuwait, Qatar, Bahrain, and Oman) forming the Co-operation Council for the Arab States of the Gulf (GCC) are geographically contiguous and can have their similar geodetic infrastructure connected as the first stage of implementing the GCC Reference Frame (GCCREF) which will be based on UN-GGRF. This will result in socio-economic growth in the GCC and increased GCC geo-based projects. As a next stage of implementing the ARABREF, the Arabian countries on the Arabian plate such as Iraq, Jordan, Lebanon, etc. can be connected to the GCCREF one at a time.

Simultaneous to the development of the Arabian plate, the Arab countries in the Nubian and Somalian plates which are contiguous can connect their geodetic reference infrastructure until all of them have a common reference frame. Finally, the three separate reference frames can be merged into ARABREF.

At a local level, each Arab state will collect gravity data in attempt to cover the whole state and modernise their gravimetric networks and unify their height datums. This can be complemented by connecting the tide gauges to CORS sites to enable continuous monitoring of Tide Gauge (TG) benchmarks. This will contribute to building (at a regional level) the ARABREF gravity field and determine the gravimetric geoid. The unification of the height datums will contribute, at a global scale, to the International Height Reference System (IHRS) realization.

On the other hand, each Arab state will build new and upgrade existing CORS network which is a fundamental component of the ARABREF. A number of countries have installed their own permanent networks and have made data from these networks available to ARABREF. This will help in selecting ARABREF CORS sites, that can define and configure an optimal Arab states GNSS permanent sites and determine the relationship between the existing national reference frames and the ITRF to preserve legacy information based on existing frames, to enable building the ARABREF with alignment with the UN-GGRF and compatible with the European Reference Frame (EUREF) and African Reference Frame (AFREF) at a regional level and aligned with ITRF and thus contribute for the GGRF realization at a global scale.

Each state will unify, install, operate, and maintain its own permanent CORS networks. This can be done locally considering public and private organization involvement. ARABREF data and analysis centres will be established with a primary objective to monitor regional earth deformation caused by plate tectonics, and its effect on the dynamics of ARABREF. Arab states will share GNSS data for their selected CORS sites between them and with ARABREF data centre so in addition to the ARABREF analysis centres several processing centres are proposed to process the collected data and compute a set of static ARABREF coordinates.

The idea is not to wait for contributions from all countries. Rather, the five elements from the UN-GGRF (see Figure 2) can be built up gradually and simultaneously. When the project is started there will be ongoing public education, sharing the GCC experience with every Arab member state, encouraging them to do the same. The capacity of those who are not part of the initial GCCREF will be built up through the AS-GCoE, so that they might join. This can basically be done in four phases. The capacity of the five UN-GGRF elements can be built gradually throughout the proposed phases.

For the geodetic infrastructure element of the UN-GGRF, in the first phase, the ARABREF will encourage the member states to share their GNSS data and establish GNSS data and analysis centres at the state level. At the regional level the ARABREF Data and Analysis Centre will be set up and the GNSS data from CORS sites will be sent there. This will support and enable the development of an authoritative source of coordinates and their respective velocities for geodetic stations in the Arab region.

In the second phase, in the medium term, the ARABREF will develop the ARABREF GNSS Permanent Network, in close cooperation with IGS for the maintenance of the ARABREF, as a contribution to the ITRF and as infrastructure to support other relevant projects. This will enable the establishment of a dense velocity field model in the Arab states for scientific applications and the long-term maintenance of ARABREF. Each member state will contribute at the national level by setting up data and analysis centres and upgrade or build CORS stations meeting international standard which will be part of the ARABREF networks at a reginal level as well as building their capability on geodesy.

In the third phase, the ARABREF will develop the Arab state geopotential datum that will include gravity, geoid, and deflection of verticals models.

As discussed before, currently the contribution of the Arab states to the GGRF is limited to a few GNSS and SLR stations. No VLBI and DORIS sites are currently located within the Arab states. Thus, in the longer term, Phase 4, the ARABREF contribution to the ITRF will include provision of VLBI and DORIS stations across the Arab states, and increase the number of SLR sites as well. A number of super geodesy sites will be set up in the Arab region that will include all four space geodetic techniques. This contribution will be fundamental to the continuous ITRF development.

5 SITUATIONAL ASSESSMENT AND FUTURE REQUIREMENTS

The need to perform a situational assessment benchmarking of the ARABREF based on UN-GGRF framework is required in a number of areas including:

- Governance, policies, standards, and conventions
- Geodetic infrastructure
- Education, training, and capacity building
- Communication outreach

Each component of ARABREF has to undergo an in-depth analysis to identify the existing strengths and weaknesses including maturity. The current situational assessment of the ARABREF program will establish the foundation for ARABREF future state recommendations for how to:

- Combine each Arab state's horizontal control network into ARABREF
- Combine each Arab state's vertical control network into ARABREF
- Connect tide gauges to the vertical geodetic network by levelling and GNSS
- Perform tidal analysis at a number of tide gauges around the Arab states to define Lowest Astronomical Tide (LAT) and Mean Sea Level (MSL)
- Compute an offshore vertical surface (hydroid) based on LAT
- Connect the hydroid to the onshore vertical datum for a seamless transition between the land and the sea
- Compute an Arab States regional gravimetric geoid model
- Build an Arab States regional CORS network
- Carry out an extensive land and airborne gravity campaign and compute a regional gravimetric geoid model for the Arab states
- Collect airborne gravity data along the offshore areas of the Arab states and use data from the tide gauge network to compute a hydroid model for the Arab states

Assessment of the future requirements for the ARABREF in terms of the UN-GGRF elements is required. The future state requirement analysis of the ARABREF is determined by identifying a series of future opportunities and threats for the ARABREF synthesized from the situation analysis of strengths and constraints. This will enable the establishment of an overall maturity assessment of the ARABREF.

6 CONCLUSION

The ARABREF is the geodetic reference frame for the 22 Arab states which is aligned to ITRF. The GGIM created the concept of the ARABREF in 2014 to define the regional TRF for the Arab states.

We are leaving behind forever the idea of fixed disparate datums and unchanging spatial reference systems. New models, tools, and best-practice guidelines will need to be created for transitioning to and using the new reference frames and geopotential datum. Economically, the ARABREF leads to direct cost savings in a number of respects. For example inter-state construction projects like Etihad Rail and more that will follow them will reap the benefits on ARABREF. Military exercises among Arab states will also benefit from a unified reference frame. The governments and its people will benefit and there will be indirect opportunities for the public sector, private sector, and academia.

It will open up doors to resell and develop existing as well as new spatial datasets. This might include GNSS correction services and high accuracy elevation models. Among the direct benefits of ARABREF, include full consistency and availability of precise, accurate, and repeatable 3D positions and heights for the entire nation, for civilian and military cost-effective uses.

Indirect benefits may come for the private sector geospatial companies which would develop new products, services, and capabilities around the 3D positioning and navigation sector. They can develop services such as GNSS Correction and “Digital Twins”. Such initiatives will generate additional GDP.

Currently, ARABREF member states have disparate horizontal and vertical datums that are not linked to gathering using common networks. Such states are inconsistent with the new ARABREF reference frames and geopotential datum. ARABREF progress is mostly on paper with few practical steps to implement the ARABREF vision. Progress is very slow because of technical issues discussed in this paper. The maturity level varies tremendously among Arab states.

It is proposed that ARABREF follows a four phase approach. In the first phase the Arabic Gulf Countries develop a common reference frame as the geodetic reference is of similar maturity in those countries. Then, this can be expanded to the Arabian plate countries, perhaps incorporating the Levant. Similar steps can simultaneously be taken in the Arab counties on the African continent until a common ARABREF is developed tied globally to the GGRF and ITRF.

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