Developing Africa one CORS at a time

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Key words: Africa, CORS, GNSS, webmap, crowdsourcing.

SUMMARY

Continuously Operating Reference Station (CORS) networks have been established all over the world in the last two decades. They are used for static applications such as datum establishment, tectonic movement computations, geodynamic monitoring and more. They are also used to disseminate corrections to a variety of users in surveying, agriculture, construction and mapping industries to help them achieve real-time centimetre level positioning. More recently, with the rise of unmanned and robotic applications, CORS networks help in keeping driverless cars in a correct lane on the road, drones in doing vital medical deliveries and many other applications.

Most countries in Europe, Americas and Australasian region have been quick to realise the benefit of CORS and install national reference station networks in their respective countries. However, Africa has been far slower to adopt these technologies. Only a handful of countries have been able to establish and maintain national networks successfully. Most other countries have either none or some level of infrastructure, but it is difficult to know whether it is used and functioning correctly, since no information is publicly available.

The Corsmap project aims to compile and maintain a database of all available CORS infrastructure in Africa and make it available in a form of a webmap, which can be openly accessed online. The work is done to promote co-operation between the various African nations and contribute to the African Reference Frame (AFREF) project. This paper summarises the extent of the work completed up-to-date and the outlook for the future.

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1. INTRODUCTION

CORS is an acronym that stands for Continuously Operating Reference Stations. These are permanently installed GNSS stations that continuously record GNSS observables. In some cases they also disseminate these observables to the users in the form differential corrections via mobile internet, allowing the users to achieve high-precision positioning in real-time. CORS networks range from local networks covering a small territory, such as a state or a municipality within a country, to country-wide networks, to regional and global networks that are used to establish reference frames and monitor tectonic movement.

For most parts of the world CORS is a mature and established GNSS technology that has been around for almost two decades. Most countries have established their own CORS networks. In some countries like the USA, there are more than one thousand CORS serving professionals of all kinds from surveyors, farmers, geographers, researchers etc.

In Africa, the story is different. There is a sizable number of CORS networks installed, but there is very little information about them, which makes life difficult for a growing number of users that could take advantage of using this technology. The users range from scientific researchers to large multi-national surveying companies carrying out land, hydrographic and airborne surveys, all the way down to local surveyors that need to receive RTK corrections from a local base station.

The whereabouts of the various CORS sites in Africa were very hard to find and also had very little metadata about them until three geospatial professionals saw the gap and decided to do something about it. Clement Ogaja (USA), Eldar Rubinov (Australia) and Derrick Koome (Kenya) founded Corsmap, an initiative to put all the CORS sites in Africa under one roof and enrich their metadata. This has resulted in a webmap which is simply called Corsmap and can be found on www.corsmap.com.

Figure 1 shows the screenshot of the Corsmap webmap. The stations are currently colour-coded by four categories - real-time data streaming stations; stations that only collect static data (e.g. for seismic applications), stations that contribute to the African Geodetic Reference Frame (AFREF) and those that are part of the IGS network. Of course there are certain stations that fulfill more than one of these criteria, so in future a more sophisticated system will be required.

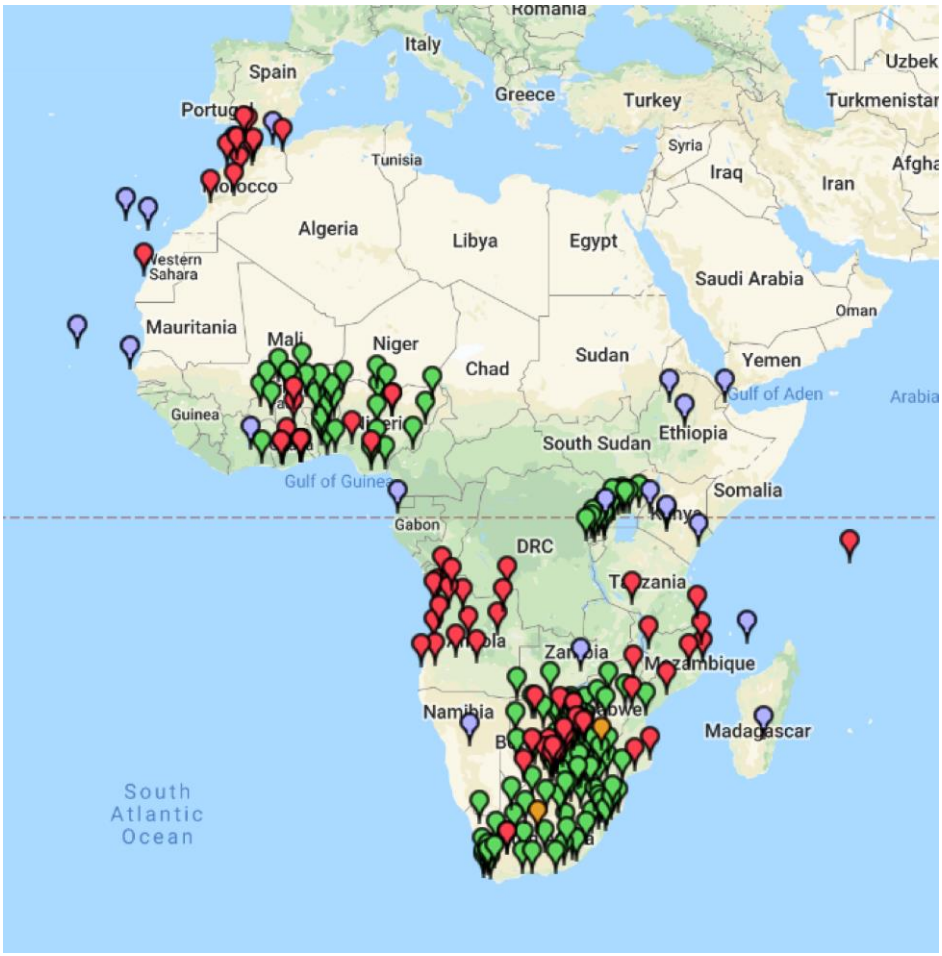

Figure 1. The current state of Corsmap as of 31 January 2019.

Some of the features of Corsmap include:

- Several ways of discovering station information quickly such as searching by keywords
- Easy and simple ways to add or edit station information by users
- Ensuring a lot of metadata is displayed once a station has been identified
- A station detail page giving a brief introduction about a particular base station
- Zoomable station locations which can be zoomed to street level
- A community forum which enables users to register and add station information

2. AFRICAN GEODETIC REFERENCE FRAME (AFREF)

It is interesting to note that there is already an initiative to encourage and lobby African states to put up these installations under the auspices of AFREF. AFREF is a project designed to unify the many African geodetic reference frames using observables from CORS installations as the

primary data for the realization of a uniform reference frame. It lobbies African states to do this through the national mapping agencies. Their progress is updated by an organization based in Nairobi called the Regional Center for Mapping of Resources for Development (RCMRD). Their last update was in June 2016. **Error! Reference source not found.** shows the AFREF map.

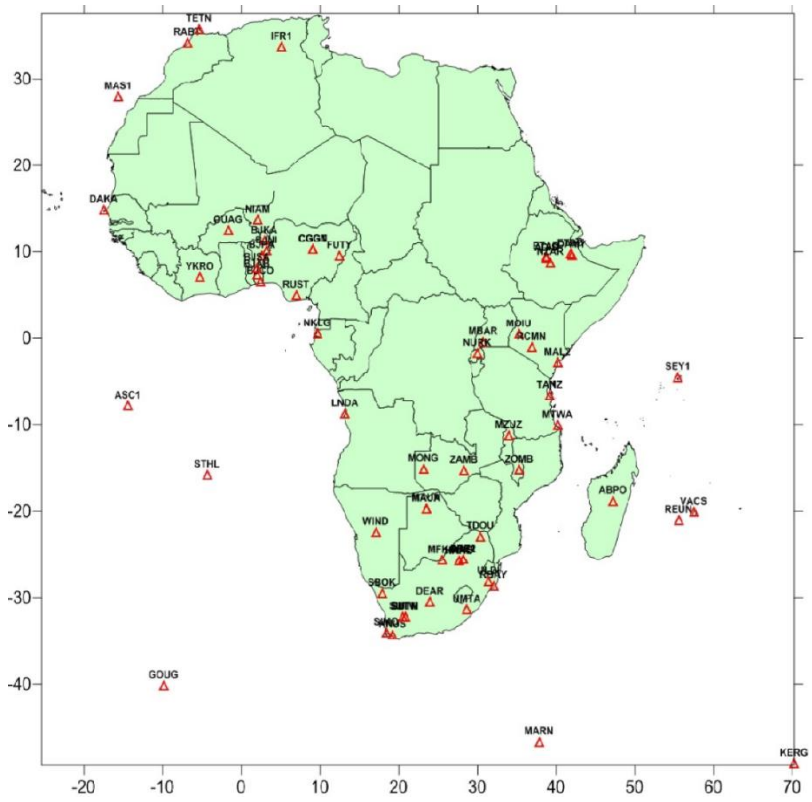

Figure 2. Map of the AFREF stations. Image courtesy of http://www.afrefdata.org.

The data from these stations is available from the AFREF website, however not a lot of information is available about the stations themselves. This is where the Corsmap project can help organisations such as RCMRD to keep track of the AFREF stations.

As an example, **Error! Reference source not found.** and **Error! Reference source not found.** show Windhoek IGS station in Namibia, which is also a part of AFREF. **Error! Reference source not found.** shows the pop-up window which comes up when clicking on the station and **Error! Reference source not found.** shows the actual page for this station including a large scale photo as well as all the necessary information about the station including the custodian, contact information, receiver and antenna models and so on.

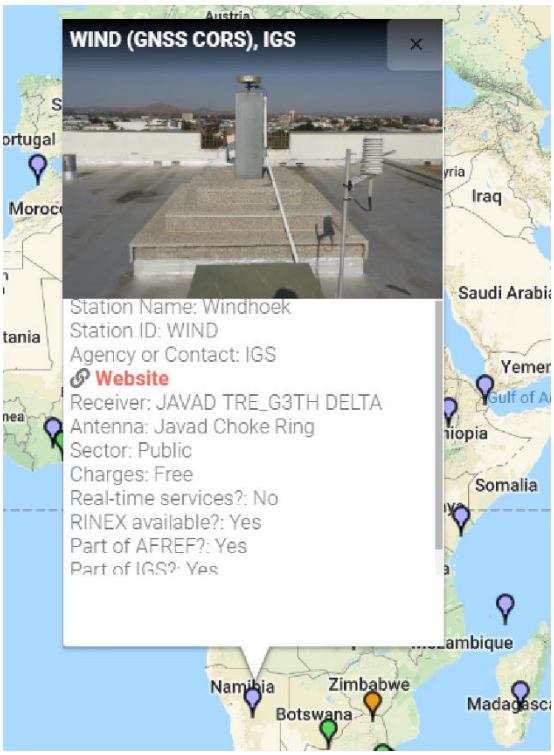

Figure 3. An example of the pop-up window of selected CORS site.

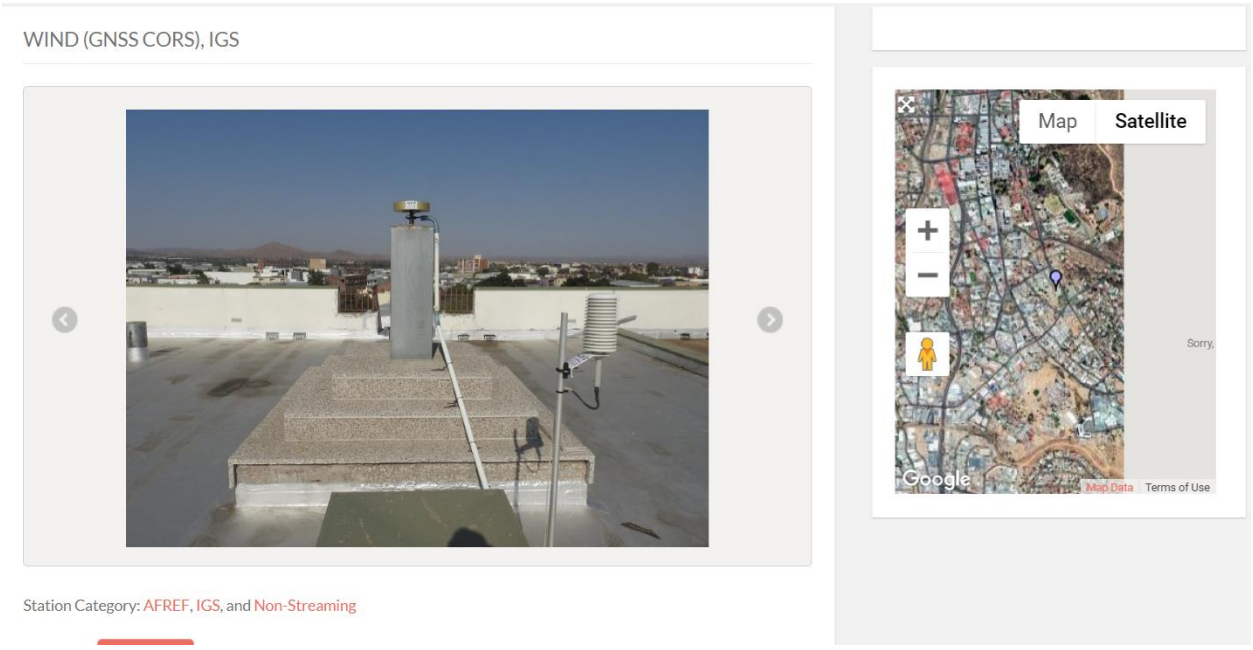

Figure 4. Each CORS has its own page with all the metadata included.

3. CURRENT PROGRESS

At the time of writing (January 2019) there are 253 stations from 27 countries included in the Corsmap. The information gathering is proving to be a painstakingly slow process and is completed using a number of different methods. The preferred approach is to get in touch with the custodian of the network and ask them to supply the information for the Corsmap. This can be done in two ways, the users can either fill out a questionnaire and send it back to the Corsmap team, or they can register on the website and input all the data themselves. The latter method is a preferred one and in future, this will be the only method. It has a number of advantages with the biggest one being that it is the custodian who is in charge of the data on their network. If more stations are added or some stations go down, it will be responsibility of the custodian to keep the information up-to-date.

The second way, is crowdsourcing, i.e. gathering the data from public sources. This is not a preferred approach, since most of the time the information is not complete and there is no guarantee that it is up-to-date, however in the absence of direct contact with the CORS network operators, this acts as a transitional step before such contact is made. The most common public sources include the CORS network websites such as Trimble Pivot or Leica Spiderweb shown in **Error! Reference source not found.** and **Error! Reference source not found.** respectively. Other public sources include research papers and conference presentations that contain information about various CORS installations.

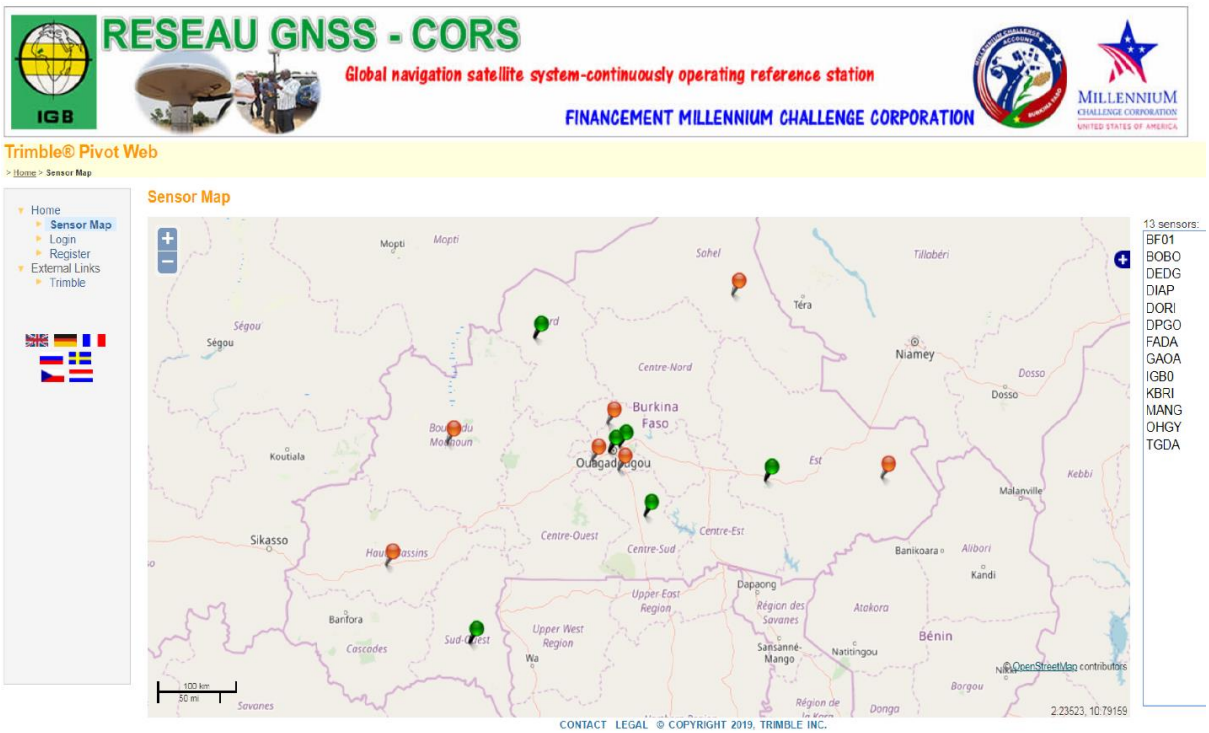

Figure 5. Trimble Pivot Web page of the Reseau CORS network in Burkina Faso [1].

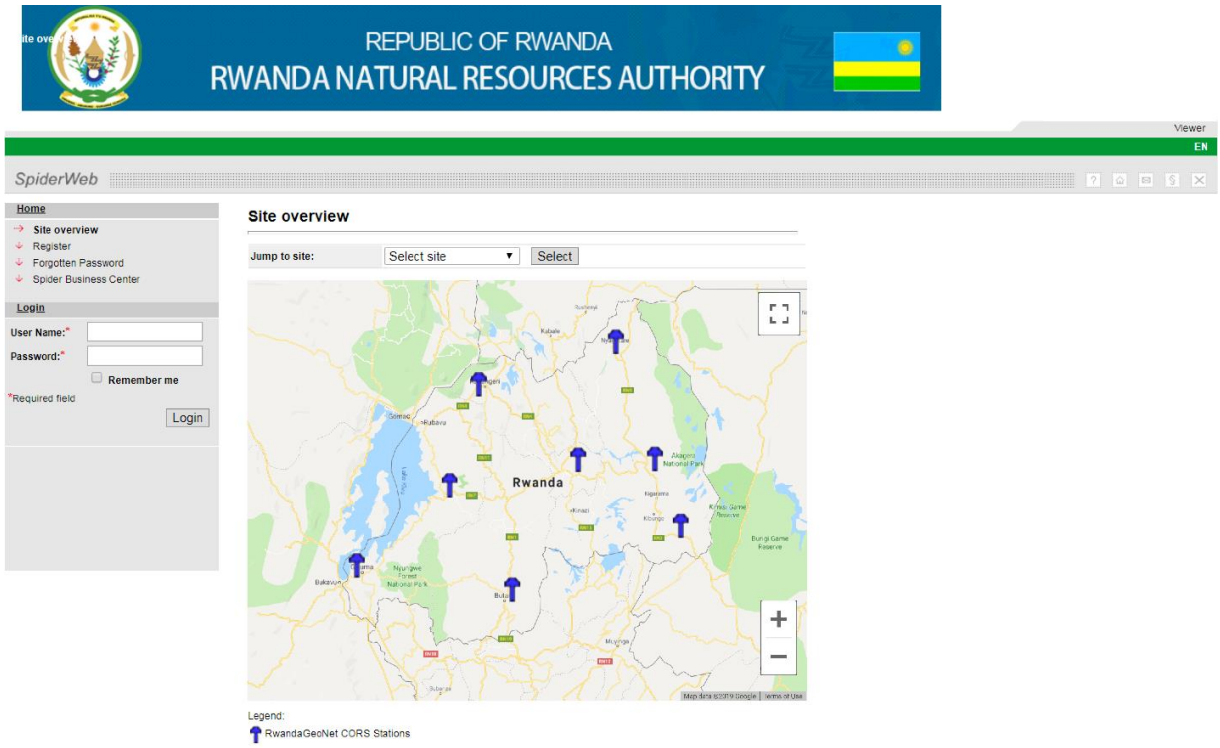

Figure 6. Leica Spiderweb page of the RNRA CORS Network in Rwanda [2].

Apart from crowdsourcing, the team is using other ways to disseminate their call to action. LinkedIn has proved to be a valuable tool which coincidentally is the platform that brought the Corsmap founders together. This is after Derrick wrote an article titled "The CORS network conversation in the continent of Africa" and published it on LinkedIn [3]. Clement and Eldar read the article and reached out to Derrick regarding the contents of his article and they together brainstormed over Skype and came up with the Corsmap brainchild. Since that time, subsequent articles have been published on LinkedIn [4] as well as in leading international magazines such as xyHt [5], GIM International [6] and XYZ [7].

As of January 2019 there are 61 registered users on the Corsmap website and additional 19 user accounts have been created by the Corsmap team for the stations that have been added from the public sources.

The countries for which the contact has been made and the information has been verified include South Africa, Mozambique, Zimbabwe, Uganda and Ghana. The countries for which information has been gathered from public sources include Botswana, Angola, Rwanda, Nigeria, Burkina Faso and Benin. Finally, some of the countries that have CORS networks, but are yet to be included on the map include Namibia, Ethiopia, Côte d'Ivoire, Morocco, Tunisia, Algiers and Egypt among others.

Even though a lot of countries are still missing, with the help of many geospatial professionals all over Africa who have seen this same need, Corsmap is slowly building a centralized database to cover all the CORS installations in Africa together with metadata. Though it is not a finished

product, Corsmap website is driving traffic of around a thousand visitors per month with sixty percent of the visitors having active sessions. Figures 7 and 8 are showing the number of page visits and number of users to the site respectively since the website went live in March 2018.

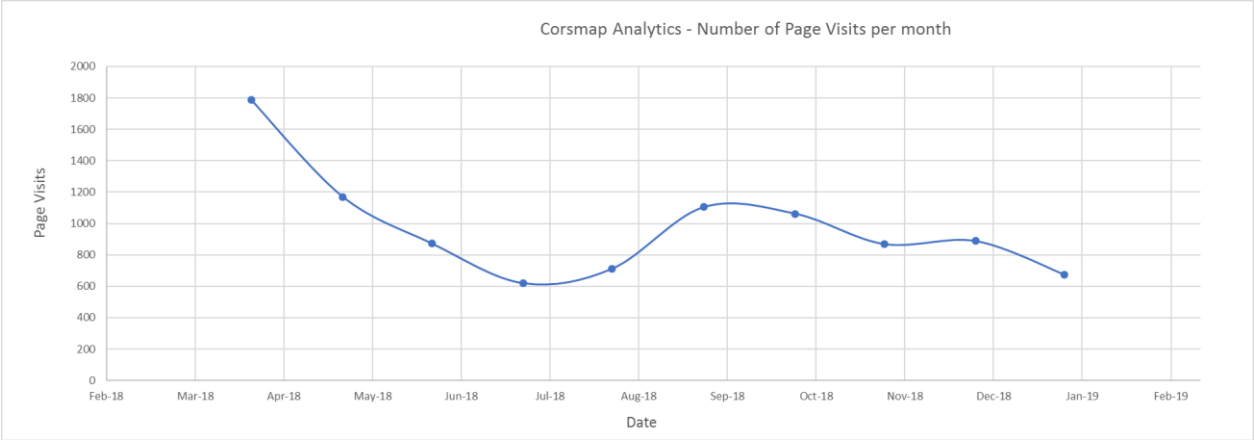

Figure 7. Graph showing the number of page visits since Corsmap went live.

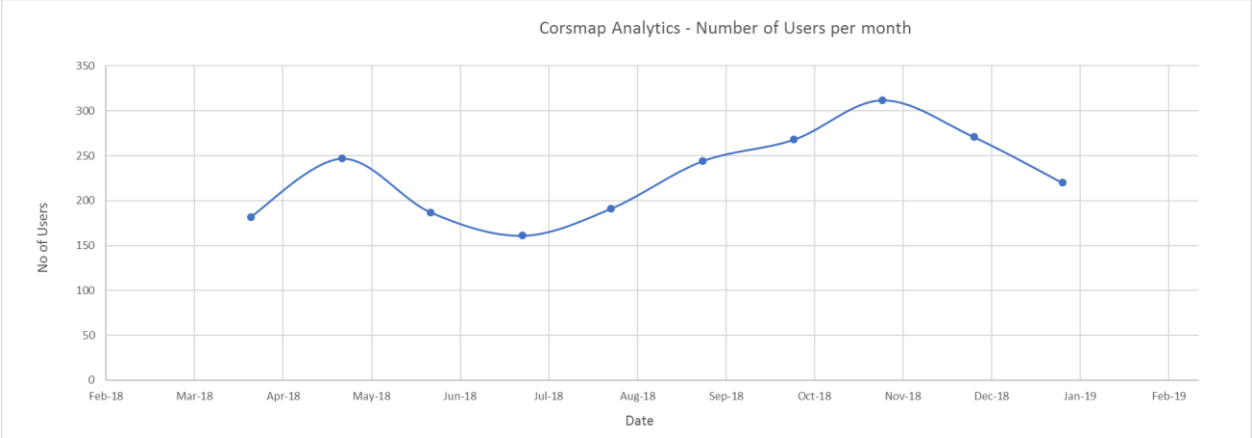

Figure 8. Graph showing number of users per month since Corsmap went live.

One caveat that must be made is that Corsmap does not provide coordinates, nor data access to any of the stations, but instead provides a link to the station provider so that such information can only be obtained from the custodian of the stations. That way there is no copyright infringement and the custodians of the stations still possess all the control pertaining to their base station. All that Corsmap does is to be a liaison between CORS providers and users.

4. SUCCESS STORIES

Whilst Corsmap is still young, it already has a number of success stories. Quite a number of users were able to locate CORS sites in the vicinity of their work areas through the Corsmap website and subsequently get in contact with the provider and get access to the data.

One such story was from Côte d'Ivoire, where a commercial CORS provider has registered and put a single station on the Corsmap and within a week received a query from a user who was about to engage in a bathymetric survey and needed to have real-time correction data as well as Rinex data for post-processing.

This example proves that it is beneficiary for CORS providers to have an up-to-date information about their stations on the Corsmap, since it can create various opportunities for business as well as research collaboration work.

5. FUTURE WORK

Whilst the Corsmap team has had a great success to date and has been able to gather information about a vast number of reference stations already, there are still many gaps that need to be acknowledged. There are a number of countries that have CORS networks, but are yet to be included on the Corsmap website. One of the key challenges in gathering information is the language barrier, since there are a number of French, Portuguese and Arabic speaking countries on the African continent and none of the authors is proficient in either of those languages. One of the ways to engage with the Francophone community is through the French Association of Topography (*Association Francaise de Topographie*) (AFT) [8] by publishing an article in their French speaking magazine XYZ [7].

Apart from the language, there are also some bureaucratic challenges, since some countries treat this information as confidential, even notwithstanding the fact that Corsmap doesn't publish coordinates of the stations, it merely acts as a link in a chain between providers and users of CORS data. Still, many e-mails go un-responded and many promises of feedback are not kept. It's a project that requires a lot of data mining and a lot of cooperation from geospatial professionals all over Africa.

A lot of information is also present in the scientific literature. Information about various CORS networks, both planned and deployed, was found in various research papers and conference presentations. These are mentioned below with a caveat that the information might be out of date, since some of the publications are a few years old.

Algeria has the REGAT (REseau Géodésique de l'Atlas) CORS network consisting of 56 stations deployed in the Atlas region from the coastal region to the Sahara platform [9]. This network is mainly used for seismic applications. Figure 9 shows the diagram of the REGAT network circa 2013.

Egypt has a network of 40 reference stations spread around Cairo region and all the way south along the river Nile. The stations are distributed at 50-70km spacing to provide network RTK for surveyors and help navigation around the river Nile [10]. Figure 10 shows the diagram of the Egyptian CORS network.

Tunisia has a fully deployed network of 23 reference stations covering the whole country for network RTK services [11]. Figure 11 shows the spread of the CORS sites around the country.

A reference from the FIG symposium in Sydney in 2010 pointed to a planned CORS network in Libya, which was to build a 50 station network along the coastline of the country [12]. Figure 12 shows the diagram of the planned network. No more references were found on this network, so the current state of this network is unknown.

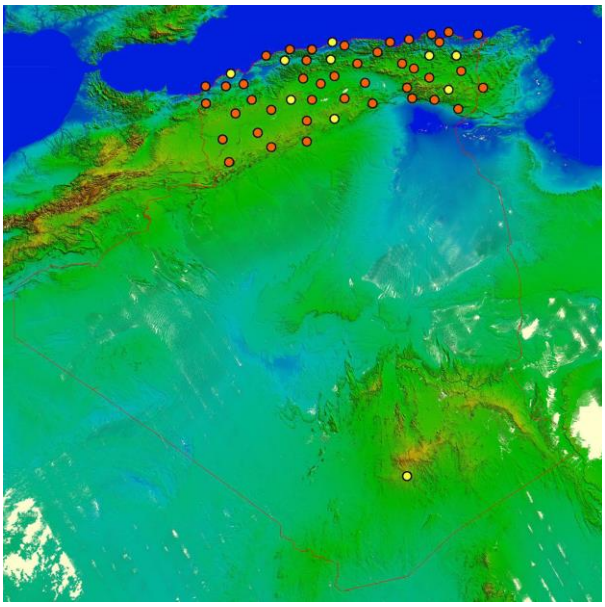

Figure 9. REGAT CORS network in Algeria [9].

Figure 10. Egyptian CORS network [10].

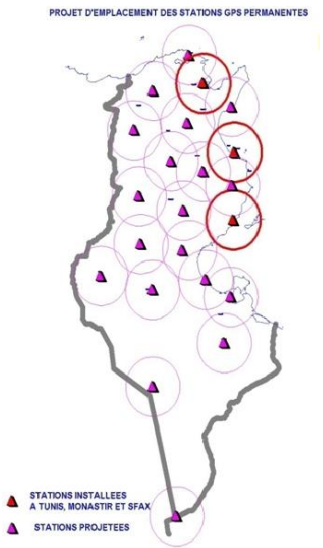

Figure 11. Tunisian CORS network [11].

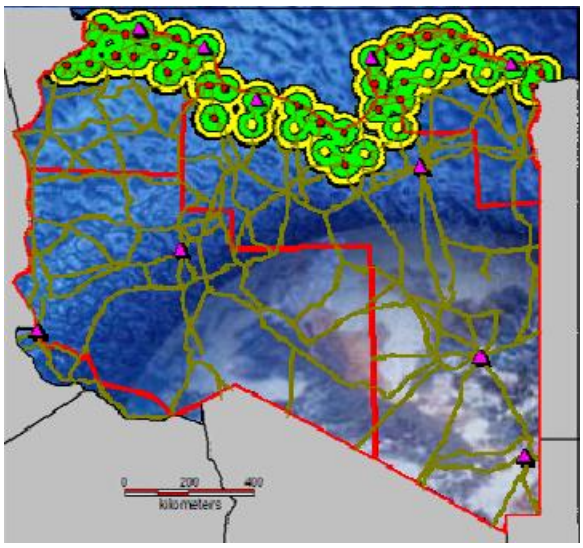

Figure 12. Planned CORS-Libya network [12].

It is the hope of the Corsmap founders that all of these networks of reference stations are included one the Corsmap website in the near future.

6. CONCLUSION

One may ask, what is the end game in all these efforts to bring all the GNSS reference stations under one roof? The answer is simple. To create a movement among geospatial professionals in Africa by establishing a symbol of unity where every professional in the furthest recesses of Africa will feel a part of. This is a grandiose way of saying that Corsmap will be a movement or initiative of geospatials by geospatials.

The Corsmap team wishes to bring all hands on deck. All the organizations that have anything to do with CORS networks and reference stations are in their crosshairs. All individuals setting up their own private CORS network are also in the mix. This is because they want those organizations and individuals to be custodians of the data on the website and make sure that it is accurate and up-to-date and that it can be exchanged between border stations of neighboring countries. In the final tally of things it will not be about the Corsmap founders, but all who heeded the call to build this centralized database that will bring profound benefits to the African continent.

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BIOGRAPHICAL NOTES

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