Establishing Ghana's Active Geodetic Reference Network as a Tool for Enhancing National Socio – Economic Development Buoyed by the Realities of a Pandemic

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Key words: Virtual RINEX, NTRIP, CORS

Abstract

As an infrastructure needed to meet the drive into digital world and enhance the socio-economic development in Ghana, the Licensed Surveyors Association of Ghana (LiSAG) has established a privately owned Geodetic Reference Network, LiSAGNet. This demand-driven, on-going privately owned project is operational in the southern part of Ghana and has eight Continuously Operating Reference Stations, (CORS) out of the proposed 27 stations nationwide. The station which is the control center LSA1, located in Accra -Spintex has been smoothly operating on the Spider software since 2018 and seven more have been established and are all operational. The network uses Networked Transport of RTCM via Internet Protocol, NTRIP, and data is stored virtually using cloud data storage. Currently the available product includes Static application, Real Time Kinematics (RTK), Virtual RINEX (VR) and Network RTK (NRTK). In addition to using the Spider software, LiSAG has developed a LiSAG Management System (LMS) software that caters for all the transactions by users who do business with the Lands Commission, online. This paper highlights on the performance of the network that so far been accepted by the stringent examination of the Survey and Mapping Division of the Lands Commission of Ghana. Cost effectiveness and the time savings made with the establishment of LiSAGNet and its expected impact on the sustainable development of Ghana has been highlighted in this paper. Additionally, enabling the deployment of IT to augment land services delivery for Surveyors and the public as a solution to address the realities of a global COVID-19 pandemic.

Key words

1. Introduction

In order to facilitate the movement from the conventional positioning of navigation methods into the digital world, the LiSAG embarked on the establishment of a nationwide network of CORS. This is to enhance the socio-economic development of the country which is hinged on the land delivery in the country, a network of Geodetic Reference Stations has been established by the Licensed Surveyors Association of Ghana. A bottom-up approach method was used by first establishing a single CORS whose cost was manageable by the association. A design of a nationwide network of CORS thus began after studying and finding solutions to the challenge posed by the first CORS which was located at Spintex in Accra. Studying the demand for the positioning in the country, seven more CORS have been established out of the twenty seven proposed for the nationwide network. The eight already established covers the

Southern part of Ghana with Network RTK covering greater part of the coast in southern Ghana with the proposed densification of CORS. With little assistance, an in-house team of experts was formed and monumentation, hardware and software have been installed with eight now in full operational capability mode. Due to challenges posed by power supply in Ghana, all CORS has been powered using solar energy which is abundant in Ghana. Another challenge was the protection of the CORS against lightning which is occurs during the tropical thunderstorm was mitigated by the installation of lightning arrestor. The major problem is the availability of stable internet which has affected the spatial distribution of the network. The use of modern technology like NTRIP however has been of tremendous help in developing the LiSAGNet applications. An innovative management system has been developed in line with the COVID-19 protocol with digitalization of the system such that human interaction has been reduced to the barest minimum. LiSAGNet therefore has come to improve the socio-economic development of Ghana in terms of land delivery.

2. Network Design

Locations for the CORS network were selected based on the demand for the service, availability of utility services especially stable internet connectivity, stability if the foundation and security (Poku-Gyamfi and Schueler, 2008). The density of the stations in the southern sector, which includes the Golden Triangle of Ghana is higher due to the relatively high economic activities (Fosu, Poku-Gyamfi and Hein, 2006), hence the demand for denser positioning. Figure 1A shows the distribution of 27 CORS nationwide with the 8 existing (green and red) and the 19 proposed stations (blue circles). The basic requirements for the establishment of CORS are adhered to. This includes no interferences from disturbing electromagnetic waves and avoidance of multipath. The blue smaller circles represent the proposed

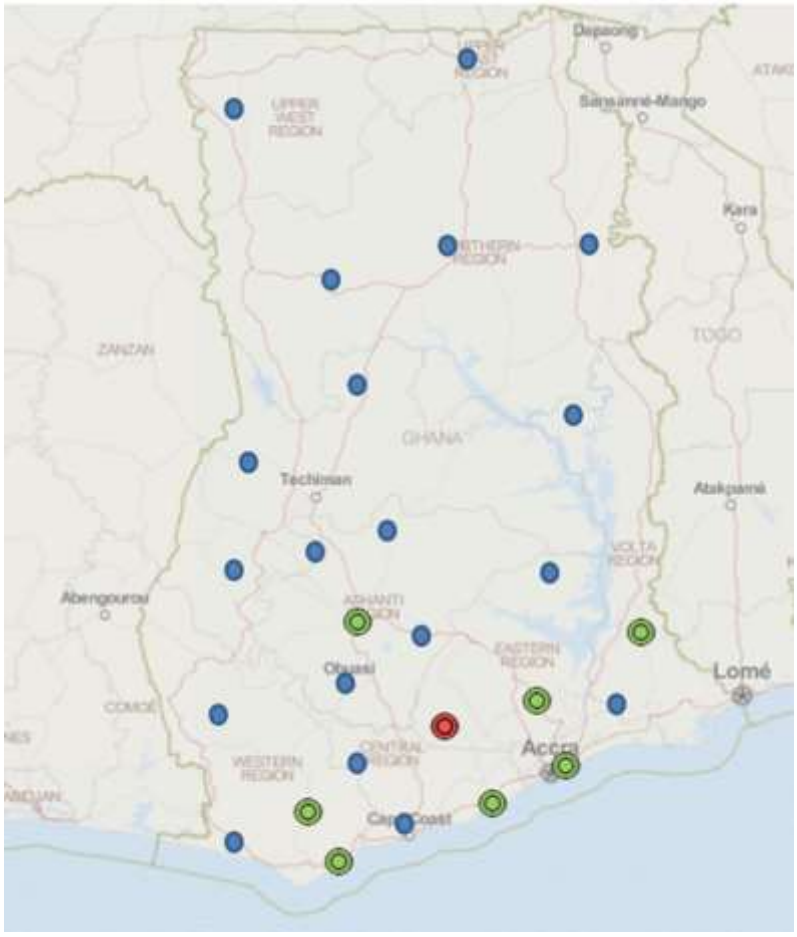

Figure 1: PROPOSED NATIONWIDE COVERAGE OF CORS NETWORK (LiSAGNet)

3. Installation

Monumentation

There have been various kinds of monuments designed to fit the location, most of them are located on rooftops and terraces, and are made of galvanized steel pipes and plates. These are located in Accra, Kumasi, Tarkwa, Koforidua, Winneba, Oda and Ho. A ground-based monument located at Takoradi has been constructed from the bedrock.

Figure 2LiSAGNet Monuments and their locations


Figure 3: A typical arrangement of LiSAGNet CORS components

System architecture

Figure 4: LiSAGNet System Architecture

The architecture for LISAGNET is as shown including the receiver, antenna, network switch, a router, a power source and a computer. The lightning arrestor is located between the receiver and the antenna. Figure 4

Power Supply

The Power system of LiSAGNet relies mainly on two modes, national grid and solar power system. For reliability, the solar power is used as the primary power source which runs through all the stations and none of the solar system has ever failed. The excess power at the stations is used to run the office equipment with the exception of the air-conditions

Lightning Protector

Due to the Tropical Rain which is usually accompanied by lightning in the Tropics, LiSAGNet CORS have been protected against the damaging effects of lightning. A surge protector is used to protect the receiver which provides a bypass in the electromagnetic pulse protector (EMP) to the ground through the earthing wire provided as a fuse in the EMP Breaks to cut the surge from the receiver.

Air conditioning

Air conditioning are provided in almost all the rooms of the CORS to increase the longevity of the equipment as excess temperature can cause damages to the receiver and accessories

Cabinets

Each receiver and accessories are located in cabinet which do not only prevent dust from getting into them but removes excess heat by blowing warm air out of the cabinet

Communication

Internet connectivity has been the main determining factor for the site selection LiSAGNet. Seven of the eight is on Fibre Optics medium and one is through Copper cable. These has been used to provide Public Internet Protocol (Static IP) for all the CORS. The absence of

reliable internet connectivity has been a major challenge. Major issues of note in the management of the system are stable internet to all the stations. The availability of access to internet with a public IP at the entire station site is so crucial to running a reliable CORs system.

Software

LiSAGNet is using Leica GNSS Spider Software Suite. This allows users to fill a form and request for an account. The account is then verified and then the user can request for the services that are available. Users have access to 90days availability of data from any of the station which is stored in a cloud environment. This software gives solution to all users of GNSS in a very convenient way, user friendly and very efficient. It provides web-based solution both in real-time and post-processing mode. It has Single RTK and Network RTK solutions in addition provides RINEX data for post-processing as well as Virtual RINEX. The Software provides real-time status to the user and one can have online baseline computation from RINEX upload. SpiderQC which is for Quality Control and Performance Analysis of the CORS Network is a multi-purpose GNSS software can be used for:

- Site Assessment and Quality Control
- Network RTK Performance Monitoring
- Reference Station Integrity Monitoring
- Deformation Monitoring
- RINEX data management.
- This software works with standard data formats including RINEX (2.x, 3.x), SINEX, IONEX and NMEA GGA, GNS, GGQ AND LLQ in addition to the proprietary formats.

4. Current Products

Currently the network has both Post-processing and Real-time applications. These are Static and Virtual RINEX, see Figure 5 for Post-processing and for the Real-time products there are the Single RTK and Network RTK products. In addition to these, the system is able to display the status of both the CORS and the Rover in real-time and online post-processing service can be provided. See Figure 6

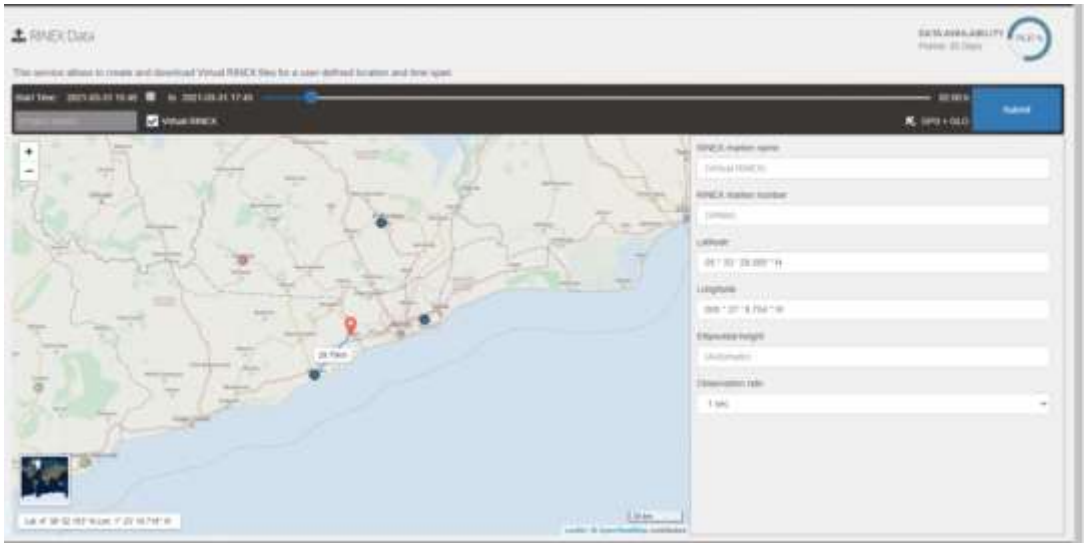

Figure 5: Screenshot of showing Virtual RINEX Data Download

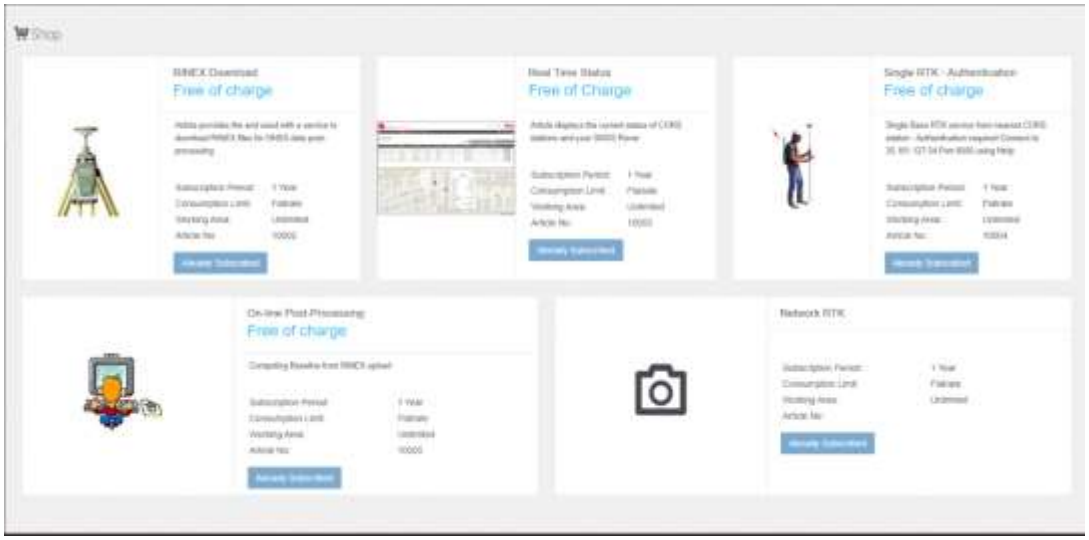

Figure 6: Screenshot of existing products of LiSAGNet

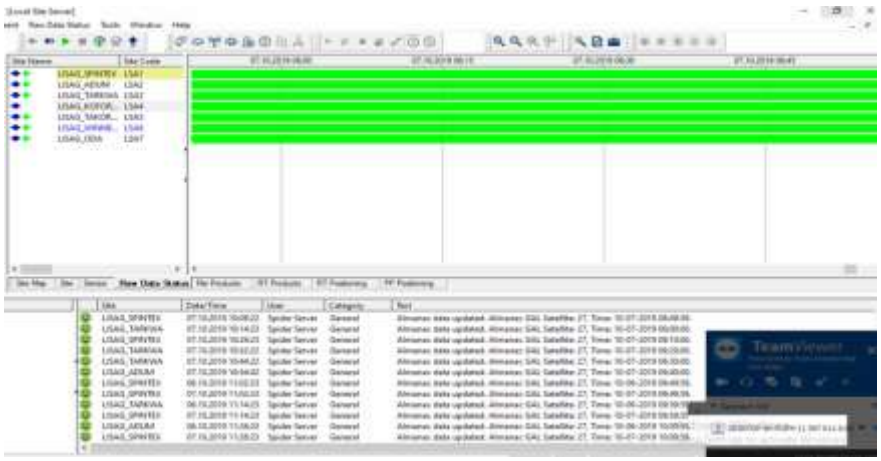

Figure 7: LiSAGNet Logging Status

5. Networked Transport of RTCM via Internet Protocol (NTRIP)

The use of NTRIP is to replace the use of the existing real-time correction services which included radio transmission or mobile communication systems line GSM, GPRS etc. with 'internet' protocol based on Hypertext Transfer Protocol, HTTP (Lenz, 2004). RTCM corrections are received with flexibility enabling a rover to achieve centimeter level accuracy for most of the applications LiSAGNet seeks to provide. The use of NTRIP is not only efficient but cost-effective, secure and convenient. The provision of the RTK service through this internet protocol (NTRIP) has helped our clients who need only one receiver and internet access to carry out meaning accurate surveys in the ITRF system.

6. LiSAGNet Management System Digitalization of Plan Approval

The LiSAG Management System has digitalized the manual process of transacting business with the Lands Commission for Cadastral Plan preparation and its related services.

The Manual Process

Regional Number Request

In the manual process of getting a Cadastral Plan approved, the Licensed Surveyor has to write a letter printed on his letterhead requesting for a Regional Number. He takes this letter to the Client Service Access Unit (CSAU) of the Lands Commission. There he gets his bills generated and makes a cash payment in the banking hall within the one-stop-shop center created. He then proceeds to submit the payment slip for the regional number to be generated for him at the counter after joining a queue for some time, where he is given the Regional Number and an acknowledgment slip.

Submission of files for Plan Approval

After the Licensed Surveyor conducts the field survey measurements, computations, plotting and printing of all records related to the acquired Regional number, he then has to travel back to the CSAU join the queue, gets a bill generated, move to the banking hall, join a queue, makes payments and back to join another queue to submit his files for approval of his Cadastral Plans and an acknowledgment slip is given for tracking the job.

The Digitalization of the manual process

To eliminate or limit human interactions as a precaution to the spread of the Covid-19 pandemic, the manual process of Cadastral Plan preparation and Approval has therefore been digitalized creating a portal where Licensed Surveyors can login from anywhere at any time. Various payment channels have been integrated to eliminate the handling of cash since that was identified as one of the sources of virus propagation. Mobile Money integration was done with all the Telcos. VISA was also included as an option for members who may struggle to walk into a bank, deposit bulk money into their wallets on the portal and continue their transactions at their offices.

The Licensed Surveyor is able to request for a Regional Number by logging into his/her account, entering the details of his/her clients; generating the bills and making payments right at the comfort of his/her office or even on the way to the site to undertake the field survey measurement.

Once he/she is done with the field survey measurement, he uses the reference data from the LiSAG CORS and processes his data to prepare his/her reports and plot the plans for approval.

To reduce the travel time and human interactions at the CSAUs, the survey data and reports are submitted to the Lands Commission in digital format through the LiSAG Management System portal.
On the portal, the Licensed Surveyor can monitor the approvals and if the files are queried, it is resubmitted. When approval is given for the hard copy plans to be submitted, the Licensed Surveyor is notified in his account, he/she generates an acknowledgement slip, prints the plans and submits same to the Lands Commission.

Courier Access Service (CAS)

As part of the LiSAG Management System, a Courier Access Service is added to assist Licensed Surveyors submit and pickup plans that have been approved by the Lands Commission at agreed fees.

7. Impact of LiSAGNet on National Development of Ghana

The introduction of CORS network in Ghana has really made a very positive impact in some sectors of the Ghanaian economy. These include the application of the network in positioning for the utility services in Ghana, the Electricity Corporation of Ghana, Ghana Water Company Ltd. Since the introduction of the network, Surveyors have been using RTK for land demarcation. The major users are the private Surveyors who use it for Cadastral Plans. The oil and Gas Industry, Ghana Boundary Commission and Lands Commission are among the list of users who have expressed interest in the use of the data of the LiSAGNet. There has been a great improvement in both delivery time and accuracy in positioning with the introduction of Real Time and Post-process in Ghana since LiSAGNet became operational. The robustness of the network has improved the availability and integrity of the system

8. Conclusion

The CORS network has been established in Ghana by the Licensed Surveyors Association of Ghana, LiSAG. This has been functional since 2018 when the first one was installed. This has served its purpose by providing seamless, consistent and uniform positioning services to users. Time and cost of survey has significantly improved for the GNSS user community. The steady increase in the demand for GNSS service from LiSAGNet makes useful to the nation. The development of LiSAG Management System has not only reduced the human contact in observance of the COVID-19 protocol but significantly improves delivery time for all projects that utilize LiSAGNet. Management System.

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