The establishment of CORS-LIBYA

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CONTINUOUSLY operating reference stations (CORS), especially those integrated as RTK networks, play a very important role in precise geodetic positioning. Coordinates can be determined quickly and economically without any need for static base stations. Geodetic surveys, including surveys for control, planimetry and cadastral boundaries, can be carried out very efficiently. The main goals of the Libyan project were the establishment of CORS functioning 24/7 and the determination of datum transformation parameters.

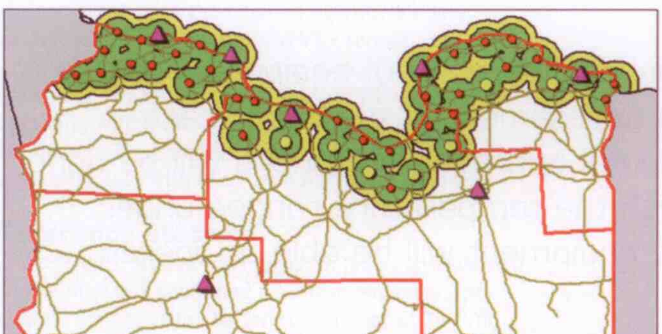
CORS-LIBYA consists of a network of multi-functional RTK and DGNSS reference stations providing signals that could be used for geodetic point positioning, land, marine and air navigation. CORS-LIBYA will fulfill all accuracy requirements of geodesy and navigation; centimetre and subcentimetre levels of accuracy in the post-processing mode, and centimetre, decimetre and metre levels of accuracy in real time. The CORS-LIBYA network will consist of 50 reference stations.

Geographic data plays an extremely crucial role in all kinds of spatial design, planning and applications. Mapping and engineering works necessitate the use of up-to-date geographic bases in order to manage and conduct all kinds of spatial works, including structural and infrastructural ones. Geographical/land information systems (GIS/LIS) evolved from the ability to evaluate and manipulate graphic and attribute data within the computer environment. Nowadays, GIS/LIS are an inseparable part of our life. Geoinformation has many uses, for instance in the administration of state, forest, environment and city planning, determination of land usage and agricultural policy, engineering, evaluation of infrastructure and natural resources, multi-purpose cadastre, e-government, e-municipality, e-commerce, plus all other activities that depend on spatial information.

As part of the national mapping project, the Surveying Department of Libya has established a network based Libyan RTK CORS.

The technology of a global navigation satellite system (GNSS) has opened a new era for the determination of positions. Despite the fact that GNSS technology entered developing countries in the 1990s, public and private establishments are still using uneconomical, old-fashion methods and techniques. The CORS-LIBYA project will substitute the old inefficient systems with a single, fast, efficient, economical, reliable and modern service for the northern region of Libya.

Libya has recently started national mapping, requiring significant geodetic positioning. It is required to carry out geodetic positioning and surveys rapidly, economically and precisely. This will be met by using the most recent GNSS techniques, through a network of real-time kinematic (RTK) continuously operating reference stations. As part of the national mapping project, the Surveying Department of Libya (SDL) has established network based Libyan RTK CORS, known as CORS-LIBYA. It will consist of 50 GNSS CORS with one control centre. The system will not only serve national mapping project surveys, but also all types of geodetic positioning, terrestrial surveys and mapping, engineering surveys, vehicle tracking, precise navigation, tectonic studies and the like.



CORS-LIBYA stations and coverage at 40-60km interstation distances.

Objectives

Goal 1

- Providing continuous real-time centimetre level precise geodetic positioning throughout northern Libya for collecting geographic data, including data for national mapping, military, development, engineering surveys and cadastre, by much faster, more economical and reliable means, all in the same format and standards. This system will aid SDL in the production of maps and associated data, such as the establishment of geodetic control points.
- Terrestrial mapping, land surveying and cadastral measurements.
- Other terrestrial measurements for GIS/LIS applications.

Goal 2

Providing decimetre and metre level positioning for navigation and vehicle tracking in air, land and sea.

Goal 3

Modelling the atmosphere (troposphere and ionosphere) over northern Libya and contributing to atmospheric studies and weather predictions, as well as studies on signals and communication.

Leachate is actually an example of 'water always wins'. A substantial proportion of the leachate generated in a closed and active trash decomposing landfill is caused by rainwater and melting snow filtering through it. In the process, the rainwater picks up many of the contaminants (chlorine, sulphur, various metals etc) remaining from the decomposition process. The resulting liquid requires special disposal provisions.

Politics over here take advantage of the common misconception that there is a lack of land suitable for landfill. In reality, if carried out correctly, landfill represents a usage of land that is not generally suitable for commercial development. Such land is not lost. Although the dome of a landfill facility will not support construction, there have been many instances where the site has been used for facilities such as ski-slopes, baseball and soccer fields, and public parks.

It has been my experience that demand for renewable electricity, under appropriated power purchase agreements, has in fact increased available sites. EPA reports that over the past 20 years the number of landfill sites has increased from 1,654 to 1,854.

There is no doubt that landfill offers flexibility, as well as a source of renewable energy. The site can be hundreds of acres with many cells (or tens of acres) with a few cells. Electricity production from decomposition gases can be from 1 to 100MW. The individual cells are constructed, filled and closed over a period of a few years and, as opposed to an incinerator, are then working unseen for 30 years generating electricity. Thus, the land itself has been recycled; there are no smoke stacks. In summary, trash to cash.

Regulation

EPA and the associated clean air and water acts of the 1970s are the source of most of the regulations affecting landfill. The *Public Utility Regulatory Policies Act* 1978 (PURPA) is the enabling legislation to allow landfills and others to install electric generation to sell electricity to a utility (renewable energy). In essence it created a market for non-utility electric power producers; forcing electric utilities to buy power from these producers at the avoided cost rate, which was the cost the electric utility would incur were it to generate or purchase from another source. The PURPA regulation provides for energy efficiency along with a source of revenue to allow the projects to be economically viable.

The positive side of the EPA regulations responds to the natural desire to treat the environment responsibly. Thus, a significant growth of landfills facilitating electricity generation commenced in the 1990s, with private enterprise matching a need to alleviate a projected shortage of generation capacity. The clean air regulations requiring landfill gas to be collected and burned provided the opportunity for profitable enterprise.

Unfortunately, new regulations specific to some states have actually prevented some projects from being constructed. For example, in California there was an existing landfill with closed cells generating electricity in accordance with the regulations applicable at the time of instigation. There was a need to expand the facility with new cells receiving trash, but despite the clean air regulations requiring all unused gas to be burned, the generation capacity could not be expanded to utilise the additional gas produced because an air permit for the added engine capacity could not be obtained from the applicable agency. The result was a 20% reduction in saleable electricity output of the existing plant which went toward powering gas compressors to transport the additional landfill gas via a pipeline for usage at another site! Historically all government activities grow and become more ponderous with time.

The landfill industry in the USA is not exempt from bureaucrats. Site permitting (licensing) is simply the implementation of the latest regulations, requiring the services of specialised firms to deal with the complexities of an application process, which, from an engineering viewpoint, bears little resemblance to the actual process.

Inter-state activity

Based principally upon economic considerations, there is considerable importation and exportation of MSW between states for combustion and landfilling. According to the 38 states reporting this activity, some 35.9 million tonnes were imported and 25.4 million tonnes exported in 2006. Principal importers of MSW from other states were:

- Pennsylvania — 7.3 million tonnes
- Michigan — 6.3 million tonnes
- Ohio — 3.8 million tonnes
- Indiana — 2.2 million tonnes
- New York — 2.1 million tonnes

There was an international dimension to the importation of MSW to Michigan. The city of Toronto paid Michigan landfill companies to receive Canadian MSW, which was used to generate electricity into the Michigan grid. The Toronto trash was trucked to Michigan landfill sites via the Bluewater Bridge at Port Huron, a round trip of at least 400 miles!

Principal exporters to other states were:

- New York — 4.5 million tonnes
- Maryland — 2.9 million tonnes
- New Jersey — 2.6 million tonnes
- Missouri — 2.5 million tonnes
- Illinois — 2.4 million tonnes

From 2006 to 2008, the average annual tonnage of MSW generated per capita increased nationally from 1.3 tonnes per person to 1.38 tonnes. At the low end of the spectrum were:

- Idaho — 0.85 tonnes
- North Carolina — 0.93 tonnes
- Connecticut — 0.96 tonnes
- New Hampshire — 0.97 tonnes

Top of the spectrum were:

- Indiana — 2.50 tonnes
- Illinois — 2.07 tonnes
- Tennessee — 2.01 tonnes

Perhaps one of our UK members in the field of waste management could inform us how the US figures compare with those of the UK?

There is no doubt that trash to cash is now big business in the USA. Despite patchiness of regulations and related activity across states and cities, public awareness of, and responsibility for, recycling is generally high and there is a lot of development activity in the field of renewable energy.

Next time we will be getting down to the specifics of some of the landfill gas renewable energy plants over here.

Barry Hiscox FCInstCES with Frank Woodbridge BSEE MSE PE
Frank Woodbridge spent 18 years of his career as a self-employed consulting engineer for the design and project management of industrial co-generation systems in respect of both electrical power generation and mechanical process heat recovery, specialising in the landfill industry.

Goal 4
Providing millimetre level accuracy for tracking plate tectonics, subsidence, measuring deformations and contributing to early warning systems.

In summary, the aim of this project is to provide fast, accurate and reliable means for collecting all kinds of geographic data; speeding up the activities of national mapping and cadastre, assuring organised urbanisation and constituting the spatial infrastructure for the relevant works of e-government and monitoring plate tectonics. When the project concludes, we will have the ability to acquire coordinate information with centimetre accuracy in a matter of seconds from any place and at any time in northern Libya. The project will play a major part in both civil and scientific applications.

The system will be web-based, assisting users with data post-processing and will be integrated into Libya's national geodetic network.

Civil applications
- Geodetic measurements.
- Mapping and GIS measurement.
- Planning and environment.
- Monitoring of engineering structures.
- Precise navigation and vehicle tracking.
- Infrastructure measurements and project applications.
- E-government, e-municipality, e-commerce applications.
- All other geo-information projects.

Scientific applications
- Earthquake engineering.
- Seismology.
- Monitoring and analysis of disturbances in ionosphere and troposphere.
- Meteorology.
- Smart transportation.

Scope of the work
The project requires expertise in geodesy, GNSS techniques, cadastral registration, telecommunications and management of IT projects. Within the CORS-LIBYA network the coverage of RTK is anticipated to be at most 50km from the nearest station. Therefore, the spacing between the CORS stations is thought to be 50-100km for all of northern Libya.

The CORS-LIBYA project will remove the necessity of ground monument construction in the field of mapping in northern Libya to a great extent. Each reference station within the system will hold the characteristics of the CORS network and will provide positioning within its own jurisdiction area. The system, at the same time, will be web-based; assisting the users with data post-processing and integrated into Libya's national geodetic network. As far as methodologies are concerned, the fundamental two activities are as follows:

- CORS-LIBYA system design (station location, monumentation, site preparation, software/hardware.
- CORS-LIBYA system installation and operation.

The scope of work consists of five major tasks:

- CORS design and monumentation.
- CORS site preparation.
- Selection of CORS GNSS receivers and antenna.
- Establishment of CORS control centre (CC) and selection of CC software.
- Establishment of CORS infrastructure and communication.

System design
The establishment of 50 CORS is estimated to cover the northern region of Libya. The basic requirements of the reference stations are:

- To be able to stream raw GPS data back to the control centre 24/7.
- To be able to continue operation in the event of a prolonged AC mains outage of up to 48 hours.
- To be located out of doors.
- The use of ADSL as the primary communications medium and EDGE or GPRS for backup.

Before any configuration of equipment can begin, an assessment of the worst case environmental operating conditions will be done to establish the temperature ranges under which the equipment will be expected to operate. After this is done, appropriate third party devices will be integrated into a reliable operational reference station configuration. In view of the requirements above, the system design will include:

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- Determination of station locations.
- Determination of GNSS receivers.
- Determination of software packages.
- Determination of CORS control centre.
- Determination of the requirements of communication and power.

When keeping in mind the other necessities, such as energy and communication, the selection of station locations will be dependent on the following criteria:

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When keeping in mind the other necessities, such as energy and communication, the selection of station locations will be dependent on the following criteria:

- In urban centres.
- On solid foundation (away from landslides).
- With electricity and communication facilities, including Internet access.

The main characteristics to be sought in the GPS receivers that will be deployed at CORS are:

- Must be dual-frequency GNSS receivers with choke-ring antenna or equivalent.
- Must be compatible with GPS, GLONASS and GALILEO.
- Must be web-based.
- Must be capable of all kinds of communication (such as radio, GSM/GPRS/Edge, Thuraya, NTRIP and Internet).

The selected software will be required to enable the implementation of three techniques being used worldwide:

- MAC (master auxiliary concept).
- FKP (flachen korrectur parameter) – for linear area correction parameters.
- VRS (virtual reference stations).

Monumentation

It is anticipated that most reference stations will be established on the roofs of government buildings (such as municipalities, universities and hospitals). Some public lands with open sky and communication infrastructure will also be considered. All reference stations will be monumented by using either:

- Solid steel structure on roof.
- Concrete pillar on ground soil.

Upon the conclusion of CORS construction, receivers and accessories will be set up and installed. The accessories consist of external batteries and chargers, fans, switches, lightning and surge arrestors and routers. The CORS sites require the connection of electricity and telephone/ADSL lines.

Reference stations

Each CORS set will consist of one receiver, one GNSS antenna and other accessories specified. The GNSS receivers at the reference stations will run continuously. The raw measurement data is usually logged internally in the receivers. Software running on the server downloads the data files automatically at regular intervals. The receivers can also stream raw data continuously to the server instead of logging data or even stream raw data at the same time as they are logging it, provided that it safeguards the loss of data. In the CORS-LIBYA project, it is intended that, using permanently open communication links, raw data will be streamed continuously from the receivers to the control centre. Software will process the data, including the computation of the required RTK/DGNSS data, continuously in standard RTCM V3.x format.

In order to be able to use the data, RTK rover receivers have to be RTCM V3.x compatible. All RTK rovers operating within the network can receive correction parameters. Nevertheless, the system must allow interoperability with other manufacturers' receivers.

Reference stations

The reference station shall be as simple as possible so as to minimise box count and maximise reliability. The charger maintains the batteries as a float of 26.7Vdc which powers the site. When the AC mains go off, the batteries will immediately drop to their normal full charge voltage of ~25.7Vdc. The GPSNet alarm will be set to generate an email if the power supply to the receiver drops below 26Vdc and will inform the system administrators that the AC mains has failed at a site. The system is designed to provide 48 hours of standby power for the reference station. Communications will be over ADSL primary and EDGE secondary. The router will establish its ADSL connection to the Internet and then immediately open up a VPN tunnel to the control centre.

Once the VPN tunnel is up, a GRE tunnel will be created inside. This technique has the following advantages:

- We do not care what the IP address of the reference station router is, which means we could be using the EDGE wireless interface or the ADSL, it makes no difference.
- It is secure. Outsiders cannot tamper, change or view the data.
- GRE tunnels support multi-cast and routing updates whereas IPSec VPN tunnels on their own do not.

The router at the control centre will not initiate VPN tunnels to the reference station but will only listen, waiting for the reference stations to contact it to initiate them. This is so the reference station can have:

- Dynamic IP addresses on ADSL and EDGE.
- Static IP on ADSL and dynamic on EDGE.
- One static IP on ADSL and a different static IP on EDGE.

Reference receiver system accuracy:

- The receiver shall provide full-wavelength precise carrier phase on L1 and L2 in the presence of A/S.
- The receiver must have precision better than 15mm RMS value both on L1 and L2 based on 24 hour observation.
- When the correct number of satellites is visible, there are minimal or no obstructions, there is minimal multipath or

ionospheric activity and the reference station position is correct, the system must yield:

Static/fast static mode
Horizontal: 5mm + 1.0ppm RMS
Vertical: 10mm + 1.0ppm RMS
RTK mode
Horizontal: 10mm + 1.0ppm RMS
Vertical: 20mm + 1.0ppm RMS

Network software control centre

There will be only one CORS-LIBYA control centre established at SDL. The control centre is the core of the entire project:

- Providing communication with CORS and rover receivers.
- Getting data from CORS receivers.
- Modelling errors.
- Calculating FKP, VRS, PRS, MAC and other corrections.
- Data screening.
- Creation of virtual data.
- RTCM output.

The project will utilise both one and two-way communication. A one way communication link receives all the necessary correction/reference data and determines absolute RTK position anytime/anywhere with geodetic accuracy. Whereas a two-way communication link receives rover data and communicates all necessary correction and reference data and determines absolute RTK position anytime and anywhere with geodetic accuracy.

In the CORS-LIBYA project, the raw data will be streamed continuously from the receivers to the server. Therefore, the communication links between the receivers and the server shall be permanently open. As a rule of thumb, the estimation for the required bandwidth at the control centre is:

50 stations x 10 kbit = 0.5Mbit for existing signals from GPS and GLONASS.

Accordingly, the control centre might need at least a 1Mbit DSL connection. Due to the aforementioned reasons, the trend today is to try to make use of the Internet to achieve permanently open links for streamed data between the receivers and the server. Running costs with the Internet are significantly lower than with telephone connections. Therefore, in this project, the GNSS data flows between the control centre and CORS sites via ADSL using Telecom fixed line or GPRS/EDGE provided by GSM or Thuraya.

Mobile phone modems (GSM, CDMA, TDMA, GPRS, EDGE, Thuraya satellite etc) can be used if standard telephones are not available at the reference station sites. The phones have to be powered and permanently switched on. However, running costs (call charges) will often be higher than with standard landlines. There is a rapidly growing interest today in using IP-based methods for communication between the CORS receivers and the control centre software, and also for distribution of RTK and DGNSS data. IP-based communication can be LAN, WAN, WLAN, Internet, intranet and radio IP. So, the servers are usually connected to the receivers by telephone, LAN, WAN or Internet. However, the most useful and economic communication is network transport of RTCM via Internet protocol known as NTRIP.

In order to access the Internet, the receiver at a CORS site will require a modem, a comms server or Ethernet port and a static IP address. The modem could be telephone, cable or broadband ADSL. There will be a main and a backup communication line for each CORS station. Main communication can be ADSL and the backup as GPRS/EDGE or vice versa. For this purpose a router should be used, which is capable of both communications with automated switching between them in case of failure.

The server will require a suitable modem and one IP port for each reference station from which data will be streamed. Thus, 50 IP ports are needed if data is to be streamed from 50 stations. The modem could be a telephone, cable, or broadband ADSL modem. Since the server at the control centre will receive continuously streamed raw data simultaneously from CORS, the best would be a broadband ADSL or cable modem with a suitably large bandwidth. So, RTK/DGNSS RTCM V3.0/3.1 data can be distributed to rovers using the following means:

- Internet (GPRS, UMTS).
  Bidirectional or uni-directional.
  NTRIP.
- Fixed and mobile phones (GSM, Thuraya, etc).
- Broadcast media.
  VHF, TV, radio, satellite communication.

If radios are used, the RTCM V3.x network data stream will probably have to be redistributed via repeater stations or transmission stations in order to ensure full coverage over the network area.

If phones are used, all rovers should be able to dial a single number for the RTCM V3.x network data stream. A suitable router will be needed to ensure simultaneous multiple user access. If the Internet is used, all rovers should be able to access the same IP address for the RTCM V3.x network data stream. Multiplexing software running on the server will allow simultaneous multiple user access.

Providing DGNSS and network RTK correction data via the Internet is the standard provisioning procedure of CORS-LIBYA for real-time applications. It makes it possible to establish these sub-services with moderate costs, based on available communication infrastructure. In order to access the Internet and obtain the required data, RTK and GIS rover receivers have to be equipped with Internet capable devices, such as GPRS or CDMA phone modems.

The CORS-LIBYA project is in the tendering process and will be completed six months after contract signing.

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