

# **GNSS CORS Infrastructure and Standard in Indonesia**

**T. Aris SUNANTYO, Indonesia**

**Key words:** GNSS CORS, infrastructure, BAKOSURTANAL, BPN, master station.

## **SUMMARY**

GNSS CORS have been growing to be used in Indonesia. Many government institutions and private companies have operated GNSS CORS at their office to service their need. Several institutions who are operating GNSS CORS in Indonesia are BAKOSURTANAL, several universities, BPN, and private companies. The National Mapping Agency (Badan Koordinasi Pemetaan Nasional or BAKUSURTANAL) has maintained about 30 GNSS CORS mostly for early warning system purposes. National Land Administration (Badan Pertanahan Nasional or BPN) has operated 1 GNSS CORS in Jakarta capital city. BPN is planning to install GNSS CORS for all of BPN province, in Indonesia. It means that BPN will need more than 100 GNSS CORS in Indonesia region. Land and Building Taxation (Pajak Bumi dan Bangunan) has installed about 9 GNSS CORS in several big islands in Indonesia such as in Sumatra, Java, Bali and Kalimantan. Several oil companies and mining companies have also managed more than 30 GNSS CORS to be operated in Sumatra, Kalimantan and Irian islands.

All of their GNSS CORS have been used to service for their own need. The first problems appears that there have not had collaborations yet. The second problem is that there is not a primary authority yet who will really manage GNSS CORS in national community. The third problem is that there is no standards in Indonesia yet.

The number of institution who have managed and maintained a single GNSS CORS are only about 6 institutions) and the number of GNSS CORS as master stations (mostly in Java island) are also still very limited to service users for all of Indonesian islands.. Most of institutions who have managed a single GNSS CORS have used their own purposes or project so sharing their experiences of GNSS CORS operation in Indonesia have not been done yet. Based on the several GNSS CORS activity in Indonesia, it is necessary to discuss deeply among the institutions who have operated GNSS CORS such as for standardization, sharing data and research for national purposes.

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## **INTRODUCTION**

It is well recognised today that a reference network comprised of permanent stations operating Global Navigation Satellite System (GNSS) receivers on a continuous basis provides the fundamental infrastructure required to meet the needs not only of geodesy and the geosciences, but also of professional GNSS users in areas of surveying, mapping and navigation. A wide variety of applications are strongly dependent on GNSS applications including land, air, sea and space navigation, positioning, surveying and mapping, military, personal location and location-based services (LBS), and etc. Depending on the type of GNSS receivers used and the procedures followed, GNSS technology could be used to provide information of the location accuracy from a few centimeters to tens of meters. In the meantime, there have numerous tests and calibration procedures on GNSS receivers and more and more researches are carried out nowadays to ensure the collection data by GNSS receivers providing a better level position accuracy whatever in all conditions and environments. The surveying and mapping industry has been revolutionised by the use of Global Navigation Satellite Systems (GNSS) involving satellites, ground reference station infrastructure and user equipment to determine positions around the world including geodetic and cadastral surveying, road and bridge construction, monitoring of earthquake, tectonic plate movement, deformation of engineering structures, analysis, scientific research, mapping troposphere and ionosphere for meteorological studies. GNSS is a common acronym encompassing all existing and planned satellite-based navigation systems (<http://www.mycoordinates.org/feb09/dangers.php>). The Global Positioning System (GPS) from the USA is the best-known, currently fully operational system. **GPS**, launch by USA started in 1978 and full configuration was completed in 1994. As of January 2009, there are 32 GPS satellites. The GPS satellites broadcast the following radio waves: L1, L2, L5 carrier frequencies; C/A and since 2005 L2 civil codes, and after 2012 L3C civil code; P code on L1 and L2 frequencies. Russia also runs its own GNSS called GLONASS. **GLONASS**, launch by Russia started in 1982 and full configuration is yet to be completed.. As of January 2009, there are 17 GLONASS satellites. The GPS satellites broadcast the following radio waves: L1, L2 carried frequencies; L1 and L2 C/A codes; L1 and L2 P-codes. Fuelling growth in the coming decade will be next generation GNSS that are currently being developed. The USA is modernizing GPS, Russia is revitalising GLONASS and Europe is moving ahead with its own Galileo system. **GALILEO**, launch started in 2006 and full configuration

may be completed by 2015. The GPS satellites broadcast the following radio waves: L1, E1,E2,E5 and E6 signals. These GNSS include China's **Compass**, the Indian Regional Navigation Satellite System (**IRNSS**) and Japan's Quasi-Zenith Satellite System (**QZSS**) [http://c4g.lsu.edu/joomla/index.php?option=com\\_content&task=view&id=42&Itemid=2](http://c4g.lsu.edu/joomla/index.php?option=com_content&task=view&id=42&Itemid=2).

The signals from all these GNSS are subject to a myriad of errors and may not always tell the truth. The GNSS augmentation infrastructure includes Continuously Operating Reference Stations (CORS), RTK Networks, RTK Clusters, Differential GPS (DGPS). GNSS augmentation infrastructure monitors the accuracy, availability, continuity and integrity of navigation satellite signals by analysing their performance at known points on the earth's surface called reference stations. GNSS augmentation services then transmit error corrections and integrity information to user equipment in a timely and reliable manner. Many government, private sector and academic organizations around the globe are involved in the development of CORS facilities. Although basic commonalities between these different programs exist, there are many variations on the CORS theme. The specific requirements that are motivating a CORS development effort will determine the details of the configuration. In developing a CORS, a variety of issues pertaining to the configuration of the hardware must be addressed. These issues include the characteristics of the GNSS receiver: the antenna, model, and type; the selection of an on-site computer, if necessary; peripheral equipment such as an uninterruptable power supply, a weather station, an accurate timing reference, and miscellaneous sensors; and the mechanism for connecting the facility to the outside world, such as modem and telephone line or network connection. Issues of redundancy and reliability must be carefully considered as they will have a significant impact on many hardware-related decisions (Wiliam, 2009).

## **CORS PRINCIPLE**

A challenge to CORS network establishment procedures is to make the spacing of reference receivers as great as possible, without sacrificing user accuracy and solution reliability. Most CORS networks currently offering NRTK services have reference station spacings of a few tens of kilometres at most. Internationally, research is being undertaken to extend the station spacing, primarily through improved atmospheric (Ionospheric and Tropospheric) bias modeling (Maunder, 2007). Continuously Operating GNSS Reference System is called Permanent Reference Station, which including one or several fixed Continuous Operating GNSS Reference Stations. The system is comprised of satellite navigation positioning technology, modern computer management technology and internet technology. System will provide automatically inspected diverse GNSS observation data (Carrier phase, Pseudo-range), different kinds of corrections, status information and other related GNSS information which are round-the-clock and real time for users in different types, with different requirements and on different levels. Continuously operating reference system has advantages including wide coverage area, high working efficiency and long beneficial period after one investment. Single base network CORS is comprises one permanent continuously operating reference station, one

CORS data server and several GNSS rovers. Reference station connect to CORS data server by wireless network or cable network. Rover login the server using GPRS/CDMA. CORS data server transmits the difference data from base to rover, carrying out the RTK work under CORS system (see Figure 1). The CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically. Continuously Operating Reference Stations (CORS) of GNSS receivers currently support many high accuracy applications in surveying, mapping, navigation and geodesy. CORS networks are being established at an ever increasing rate around the world, and this infrastructure will be used for long-term geoscientific studies as well as provide the basis for GNSS-RTK (Real-Time Kinematic) positioning and augmentation services (including Assisted-GNSS or A-GNSS). CORS system provides obvious advantages for GNSS application: 1). Share one stable reference coordinate system for all users to set up criterion for basic surveying data. 2). Improve the coherence of accuracy in working area, reduce system error, improves data quality. 3). with improve working efficiency, single receiver survey become prevalent in GNSS working, and 4). broadcasting data transmit mode has no limit on terminal number, reduce cost from user. Application field of CORS such as :

1. Working distance:  $\leq 50\text{km}$
2. Large-scale construction project in fixed area
3. Repeated surveying and construction in fixed area for long time
4. Daily governmental survey for land surveying, programming and city planning
5. Monitoring Large-scale permanent construction such as bridge and dam

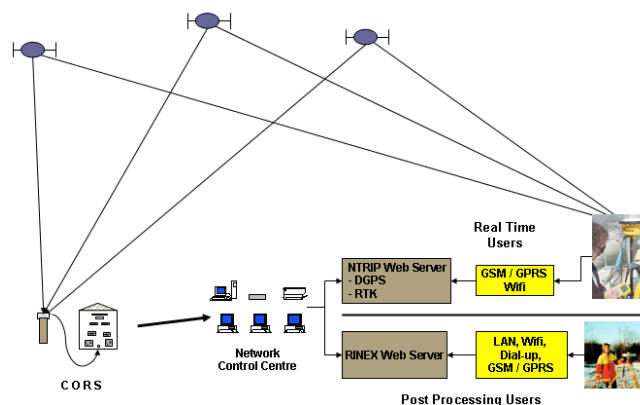


Fig. 1. Concept of one unit CORS system (Arianto and Sunantyo, 2009)

## INFRASTRUCTURE OF GNSS CORS

The main infrastructure of GNSS CORS depends on Security (attact by virus and hacker), Serviceability (to all of users), Electricity (stability of voltage, continuity of power supply and battery back up) and Communication Links ( Serial Link, Telephone Line - Dial Up or Constant, Cellular i.e GSM, Network :TCP/IP or Etherne, Radio Link, Coverage

(bandwidth and quality of signal), Frequency Regulations, Satellite : Inmarsat; VSAT or Regional Spot Beam Services). The infrastructure of GNSS CORS is distinguished by two main components (see Figure 2), the two components are master station and remote station. These components and performance between them are significant differences.

1). Master station as a Base station of GNSS CORS :

a). Hardware :

antenna GNSS, receiver GNSS, router, server, UPS, power supply and internet connection (for public services) without (never) interruption, UPS, IP address, password and user name which can be accessed by many users, and cable connection among the components,.

b). Software :

recording of GNSS CORS at the server station, download data and differential correction via FTP and HTTP to all of users.

2). Remote station as a client station of GNSS CORS :

a). Hardware

antenna GNSS, receiver GNSS, power supply and internet connection in 24 hours (for public services) without (never) interruption, UPS, IP address, password and user name which can be accessed by many users, and cable connection among the components,.

b). Software :

recording of GNSS data, download of differential correction from master station using FTP and HTTP, internet connection during GNSS observation without interruption and differential correction from GNSS CORS master station

Service of GNSS CORS master station to remote station can be carried out by FTP or NTRIP services.

### 1. FTP service.

File Transfer Protocol (FTP) is used to transfer files from Master station server to client computer. When you click on either the dual frequency link or the single frequency link from server of Master reference, it will be possible automatically be directed to the appropriate section using FTP mode. Files are named by the date and time when they are closed. RINEX file sessions contain data from a one hour time period. There are two components to each RINEX session, a navigation file and an observation file. Each of these components use the following naming conventions: *nnnnddd.yy.t*, where *nnnn* is the 4-character station name, *ddd* is the Julian day of the year, *s* is the RINEX session code, *yy* is the last two digits of the year, and *t* is the file type (**n** for navigation or **o** for observation).

## 2. NTRP service

**NTRP** is a protocol that enables streaming of DGPS, RTK or network RTK corrections over the internet (Maunder, 2007). CORS networks have a variety of benefits which have pushed the GPS community towards using Network Real Time Kinematic GPS (NRTK). They encourage the uptake of GPS as a positioning technique for a wide variety of users due to their accessibility. NRTK with CORS networks is simple to use as all that is required is the knowledge of the process of using the roving receiver. The cost to the user of utilising NRTK is relatively small (when compared to the costing and implementation of a modern GNSS setup), as the only requirement is one GPS receiver. Maunder, 2007 writes that the justification for the establishment of CORS networks was initially in support of geodesy and other geoscientific applications, at the global and regional level, however, increasingly GPS CORS network operators have sought ways of making their network infrastructure the basis of a profitable business. This has arisen with the introduction of real-time centimetre-level accuracy services, carrier phase-based modes of operation generally referred to as GPS-RTK (Real-Time Kinematic). Despite these advantages, NRTK is still limited to some tens of kilometres from the reference stations (Rizos et al, 2003). Outside this range it is often not possible to obtain a NRTK position, thus presenting a problem for stations beyond this range. “Networked Transport of RTCM via Internet Protocol” (Ntrip) stands for an application-level protocol streaming Global Navigation Satellite System (GNSS) data over the Internet. Ntrip is a generic, stateless protocol based on the Hypertext Transfer Protocol HTTP/1.1. The HTTP objects are enhanced to GNSS data streams. Ntrip is an RTCM standard designed for disseminating differential correction data (e.g in the RTCM-104 format) or other kinds of GNSS streaming data to stationary or mobile users over the Internet, allowing simultaneous PC, Laptop, PDA, or receiver connections to a broadcasting host. Ntrip supports wireless Internet access through Mobile IP Networks like GSM, GPRS, EDGE, or UMTS. Ntrip is implemented in three system software components: NtripClients, NtripServers and NtripCasters. The NtripCaster is the actual HTTP server program whereas NtripClient and NtripServer are acting as HTTP clients. Ntrip is meant to be an open none-proprietary protocol. Major characteristics of Ntrip’s dissemination technique are:

1. Based on the popular HTTP streaming standard; comparatively easy to implement when having limited client and server platform resources available.
2. Application not limited to one particular plain or coded stream content; ability to distribute any kind of GNSS data.
3. Potential to support mass usage; disseminating hundreds of streams simultaneously for up to thousand users possible when applying modified Internet Radio broadcasting software.
4. Considering security needs; stream providers and users don’t necessarily get into contact, streams often not blocked by firewalls or proxyservers protecting Local Area Networks

5. Enables streaming over any mobile IP network because of using TCP/IP.

## **CORS IN STANDARD PERFORMANCE**

In installing a CORS, a variety of issues pertaining to the configuration of the hardware must be addressed such as the GNSS receiver: the antenna, the selection of an on-site computer, an uninterruptable power supply, a weather station, an accurate timing reference, and modem and telephone line or network connection. The GNSS receiver is the heart of a GNSS CORS configuration. In order to support a wide realm of activities, the receiver must be a high quality geodetic unit capable of tracking and recording all components of the GNSS signal. In case of a CORS is required to provide real-time differential positioning capability, the receiver should be capable of generating the necessary correction information and outputting it to be broadcast. Finally, if a custom GNSS CORS configuration is being developed, the ease with which a receiver can be remotely controlled should be considered. Some receivers are more amenable to being remotely controlled and interfaced with than others. In addition to the GNSS receiver, many CORS installations include a computer located at the site. These CORS-dedicated processors are frequently personal computers. The computer may also be utilized to assist with the remote controlling and monitoring of the GNSS CORS. GNSS CORS facilities are generally designed to operate for a considerable length of time without the necessity of being visited by personnel. Ideally, a remote operator, perhaps located at the sponsoring organization's headquarters, should be able to monitor the operation of a CORS as well as have the ability of controlling functions of the GPS receiver as if working directly at the front panel of the receiver. The interface between the remote operator and the receiver is often provided by the on-site computer. Several GPS receiver manufacturers have produced receivers that do not require an on-site computer in order to operate in a CORS configuration. For a CORS facility to provide a high level of reliability, it should be able to operate during periods of power outage. This functionality is usually provided by an uninterruptable power supply (UPS), which is always ready to provide power for the operation of a CORS through power outages up to a few minutes duration. Some CORS are capable of operating for a much longer period, but often in a standby mode in which some of the components, such as the on-site computer, are not operational. In the event that full CORS functionality during extended periods of power outage is required, an emergency generator could be engineered into the system design. Such capability would be required, for example, when safety of property and human lives might be dependent on the timely availability of CORS data. Another aspect of the reliability of a CORS configuration is the amount of equipment component redundancy that exists. Equipment failures do happen and if this presents an unacceptable situation because of production or safety concerns, then safeguards must be built into the system. Ultimately, the applications for which a CORS is designed will dictate the levels of reliability and redundancy that are required. Most geodetic receivers available today that would be candidates for incorporation into a CORS facility are capable of recording data

as frequently as every second. This data rate should satisfy most applications of the GNSS CORS data.

## SEVERAL CORS ACTIVITIES IN INDONESIA

Increasingly GNSS CORS network operators have sought ways of making their network infrastructure the basis of a profitable business. This has arisen with the introduction of real-time centimetre-level accuracy services, carrier phase-based modes of operation generally referred to as GPS-RTK (Real-Time Kinematic). Indonesia is an archipelago country which consists of more than 13,000 islands. Big islands are Sumatra, Java, Kalimantan, Sulawesi and Irian, medium islands are Bangka, Belitung, Bali, Lombok, Madura etc and small islands are Alor, Solor, Seram, Natuna etc (see Figure 2).

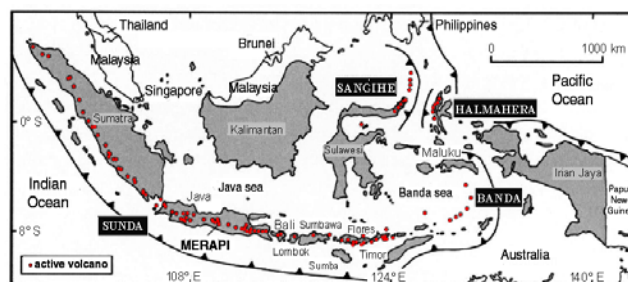


Figure 2. Distribution of islands in Indonesia (Sunantyo, 2008)

One approach is to try to recruit a core group of users who are prepared to pay for the GNSS-RTK services. But this is only feasible if the number of users, and the fees that are charged, are sufficient to generate a reasonable return-on-investment (ROI). This ROI (or at the very least “cost-recovery”) is important for many network operators in order that they may provide for the maintenance and upgrade of the CORS infrastructure. On the other hand, there are those who advocate that there is no need to recoup CORS investment, that the installed GNSS receivers should be seen as public infrastructure, in a similar manner to roads, bridges, etc. CORS efforts include: local government agencies interested in supporting relative GNSS positioning for a limited geographic area, such as a city etc. Many government, private sector and academic organizations around the globe are involved in the development of CORS facilities. Although basic commonalities between these different programs exist, there are many variations on the CORS theme. The specific requirements that are motivating a CORS development effort will determine the details of the configuration. Individual CORS facilities and networks of many CORS stations in Indonesia have been operated and developed by a number of government offices (BAKOSURTANAL, BPN, etc), private sector (i.e. PT. Almega, Jakarta etc) and academic organizations (Geodetic Dept., Engineering Faculty, Gadjah Mada University, Geodetic Dept., ITB, and Geodetic Dept., Engineering ITS).

## 1. CORS at BAKOSURTANAL

CORS stations are being established for a wide range of applications across the archipelago of Indonesia. Bakosurtanal has operated permanent stations at Medan (north Sumatra), Cibinong (west Java), Pare-Pare (south Sulawesi), Kupang (west Timor) and Biak (north Papua) as part of the Asia Pacific permanent GPS tracking network for GIS infrastructure. The distribution of CORS belongs to BAKOSURTANAL can be seen at Figure 3.



Figure 3. Present status and plan of CORS stations in Indonesia ( Roberts and Stanaway, 2009)

Indonesian CORS networks at BAKOSURTANAL at present are predominantly scientific and used in near-real-time or post processing modes. The CORS stations are therefore stations and service applications such as national datum maintenance, geodynamic studies, volcano and landslide monitoring and earthquake studies. Although land administration is a fundamental task of land authorities in Indonesia, CORS networks are not yet used for these operations in a routine manner.

## 2. CORS at PT. Almega Geosystem, Jakarta

Leica Geosystems partner in Indonesia, PT. Almega, Jakarta has operated one GNSS CORS in Jakarta metropolitan region. The communication to get GNSS CORS data can be used via <http://indonetwork.co.id/Almega/>. The purpose of installation and operation of GNSS is used especially in his business and also to service several users who purchased GNSS receivers and operated GNSS receivers in Jakarta region. The antenna GPS type AT 504 Dorne Margolin has been installed at top of the main building PT. Almega, Sunter, Jakarta metropolitan (see Figure 4 left side), the server of GNSS CORS is inside of the main building of PT. Almega (see Figure 3 right side).



**Figure 4. Antena GPS type AT 504 Dorne Margolin (left) and Receiver GPS Leica GRX1200 dan PC Serve (right), Koesoema (2008)**

### **3. CORS at The National Land Agency (Badan Pertanahan Nasional)**

Speaking at the South East Asian Survey Congress (SEASC 2009, 4-7 August) in Bali, F.H. Adiyanto from the Badan Pertanahan Nasional – the national land agency – said the current program to update the accuracy of the control points is serious under-resource. The plan to fix the problem is to establish a nationwide Continuously Operating Reference Station (CORS) network. This has the potential to improve the productivity of surveyors, but only after a program of legal reform that makes it possible to use positions derive from GNSS receivers to mark cadastral and other points. Although government regulation 24/97 gave legal recognition to the WGS 84 datum used by the GPS, this did not confer the ability to use the CORS network (<http://www.asmmag.com/news/cors-in-indonesia>). Adiyanto (2009) states that the national land agency has started to carry out the Pilot project CORS and it will be fully operated 3 months later. Feasibility study was done to test reability hardware and software GNSS CORS. The test was installed at 7 base station in 7 land agency office ( 4 stations in region office of land agency Jakarta metropolitan, Bogor, Depok, Tangerang and Bekasi) and 3 stations in Banten (Cilegon city, city of angerang and Pandeglang city). The test has used Trimble receiver ( type of Net R8), Leica receiver SR1200+ series, South S86 receiver. For rovers have used mixed of these receivers (Trimble, Leica and South receivers), they still are doing the test to get good quality of these receiver for the national land agency. For software, the test has carried out realibility of Trimble GPSNet with VRS method and Leica SpiderNet with FKP and iMAX method.

### **4. CORS at Institute Teknologi Bandung (ITB)**

ITB (Institute Teknologi Bandung) has operated a CORS using Leica Geosystem. ITB is located in Bandung city, west Java province. The antenna has been installed at the top of Labtex IXC building. The purpose of CORS installtion as has been used for research and survey and mapping. The data will be shared to users with free of charge. To do the research purpose is to know about the plate movement in Java island. The Figure 5. shows the installtion of antenna belongs to ITB CORS.



**Figure 5. Leice GNSS antenna belongs to ITB CORS which has been installed at the top of Geodetic Department, ITB, Bandung**

The web address of GNSS ITB CORS for users can download via <http://corsgps.gd.itb.ac.id/rinex30s/>. High rate data can be received by the communication with KK Geodesi FITB. ITB is going to install several CORS (about 3 stations in west of Java island) and one station in Aceh region. .

### **5. CORS at Institute Teknologi Surabaya (ITS)**

ITS (Institute Teknologi Surabaya) has operated one CORS using Topcon. ITS is located in Surabaya, east of Java province. The purpose of CORS installation has been used for research and survey and mapping in east Java region. In the future the data will be shared to users with free of charge. To do the research purpose is to know about mud flow in Sidoarjo area, east Java province. The address of CORS at ITS can be seen from <http://geomatika.its.ac.id/archives/geomatika-menerima-hibah-gps-cors>

### **6. GNSS CORS at UGM**

Geodetic Department, Faculty of Engineering, Gadjah Mada University (GMU), since June 27, 2009 has operated a GNSS CORS, the antenna of Leica AT 504 Choke Ring has been installed at the fixed position at the top of Geodetic Dept., building, it can be seen at Figure 6. The web address of Geodetic Dept., Faculty of Engineering, Gadjah Mada University is <http://geodesi.ugm.ac.id/index.php?page=staff>. The high rate of GNSS CORS data can be received by the communication with head of geodesy laboratory, Geodetic Dept., Faculty of Engineering, Gadjah Mada University.



**Figure 6. The antenna of Leica AT 504 Choke Ring belongs to Geodetic Dept., UGM CORS which has been installed at the top of Geodetic Department, UGM, Yogyakarta.**

The purpose of CORS installation has been used for research, survey and mapping and sharing to other GNSS CORS in Indonesia. The data will be shared to users with or without free of charge. The several researches has been planned for monitoring (geophysical phenomenon i.e plate movement in Java island, structural deformation i.e dam around Yogyakarta region, deformation of Borobudur temple etc), the national land agency in Yogyakarta i.e for boundary reconstruction, land and building taxation purposes in Yogyakarta region etc. This figures show the installation of antenna belongs to ITB CORS. The component of GNSS CORS at geodetic department consists of Receiver : Javad Delta TRE-G3 PCB Assembly, antenna : Leica AT 504 GG Choke ring antenna, Server IBM system X3100, UPS, internet connection : fiber optic (has been maintained by Computer Center of GMU), software : GNSS spider version 3.20, Build 3217. The sampling rate of observation is 5 second and 15 second.

For the time being several GNSS CORS activities in Indonesia are not being able to be ready easily to be shared to other institutions who have operated a single GNSS CORS. There are several reasons why sharing of GNSS CORS data has not been carry out yet. The reasons are such as :

1. They have operated and maintained by their own budget,
2. They have installed to be used for their own project or purposes,
3. Not all of them have been ready because they still have tested to be a single GNSS CORS or a network GNSS CORS in Indonesia,
4. There is no institution yet who has to be the leader of maintaining GNSS CORS in Indonesia,
5. They have operated using their own standard and their own infrastructure so it could be not to be a simple case in GNSS CORS sharing data,
6. The number of GNSS CORS are still very limited and mostly the GNSS CORS as master station are in Java island.

## INFRASTRUCTURE OF INTERNET CONNECTION VIA PROVIDER MOBILE IP NETWORKS IN INDONESIA

The service of GNSS CORS service is really need the internet connection. The internet connection depends on the service of provider mobile IP networks. In Indonesia, several provider mobile IP networks are Indosat, telkomsel, XL, etc (see Table 1). Their services of provider mobile IP networks have been used support an internet connection for GNSS CORS. The list of provider mobile IP networks can be seen at Table 1. *Provider mobile IP networks* in Indonesia. The example of coverage area belongs to Telkomsel in Yogyakarta region can be seen at Figure 7. Telkomsel has launched HSDPA Coverage in 31 big cities in Indonesia (and may be will increased in the near future). Every user of HSDPA Coverage of Telkomsel Flash has been able to access internet connection with the speed od downlink up to 3.2 Mbps.

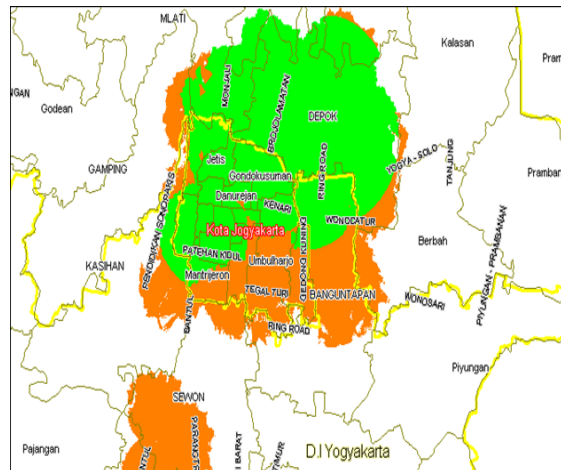
**Table 1. Provider mobile IP networks in Indonesia (Koesoema, 2008)**

No	Provider	Product	network
1	Indosat	Mentari	GSM
		Matrix	GSM
		IM2	GSM
		IM3	GSM
		StarOne	CDMA
2	Natrindo Telepon Seluler	Axis	GSM
3	Telkomsel	SimPATI	GSM
		KartuAs	GSM
		KartuHALO	GSM
4	XL	Bebas	GSM
		Jempol	GSM
		Xplor	GSM
		Jimat	GSM
5	Pasifik Satelit Nusantara	ByRU	GSM
		PASTI	GSM
6	Hutchison Charoen Pokphand Telecom	3	GSM
7	Mobile-8	Fren	CDMA
		Hepi	CDMA
8	Smart Telecom	Smart	CDMA
9	Sampoerna Telekom	Ceria	CDMA
10	Bakrie Telecom	Esia	CDMA

To estimate the receiving signal quality for every remote stations of GNSS CORS, it is necessary to know the map of coverage area where the *Provider mobile IP networks* has operated.

As the example, the explanation of signal receiving quality for Telkomsel provider is given at Figure 7. The Figure 7 shows that, it can be estimated that very good signal

quality is only just in the central of Yogyakarta city with the radius more or less 50 km. Koesoema (2008) did his research in Jakarta metropolitan area about comparison of using provider mobile IP networks Indosat, Telkomsel and XL for DGPS NTRIP observation to be used for parcel squares in building and land taxation. In his research, Koesoema mentions that internet of access velocity for Telkomsel has the highest range 32 to 64 kbps, than Indosat has the range 20 to 48 kbps, and XL has about 22 kbps.



**Figure 7. Map of coverage area Telkomsel provider in Yogyakarta where green and brown colour indicates the best and good quality of receiving signal**

Quality signal in all of island in Indonesia is different from place to place. In Java and Bali islands (see Figure 1), the quality of signal of Indosat and XL may be still good even are not stable. In Sumatra, Kalimantan, Sulawesi and Irian, Telkomsel may be has good coverage area even the prize is still high.

## CONCLUSION

- 1). The number of institution who have managed and maintained a single GNSS CORS are still very limited (about 6 institutions)
- 2). The number of GNSS CORS as master stations (mostly in Java island) are also still very limited to service users for all of Indonesian islands especially in the case of infrastructure for internet connection,
- 3). Most of institutions who have managed a single GNSS CORS have used their own purposes or project (not being ready to be shared easily)
- 4). Sharing their experiences of GNSS CORS operation in Indonesia have not been done yet.

5). Based on the several GNSS CORS activity in Indonesia, it is necessary to discuss deeply among the institutions who have operated GNSS CORS such as for standarization, sharing data and research for national purposes.

## REFERENCES

Adiyanto, F.H., Wibisono G., and Ardiantoro B., 2009, Roadmap of Developing GNSS CORS for Cadastral Surveying in Indonesia, The 10<sup>th</sup>, SEASC 2009, Bali, Indonesia.

Arianto T., and Sunantyo, T.A., 2009, Kemudahan Implementasi Rekonstruksi Batas Dalam Pelaksanaan Pendaftaran tanah di Indonesia, Seminar Nasional, Yogyakarta, Indonesia.

Anonym, <http://geomatika.its.ac.id/archives/geomatika-menerima-hibah-gps-cors>, access on August 01, 2009.

Anonym, <http://corsgps.gd.itb.ac.id/rinex30s/>, access on August 04, 2009.

Anonym, <http://www.asmmag.com/news/cors-in-indonesia>, access on August 6, 2009.

Anonym, <http://geodesi.ugm.ac.id/index.php?page=staff>.

Anonym, [http://www.ngs.noaa.gov/PUBS\\_LIB/GPS\\_CORS.html](http://www.ngs.noaa.gov/PUBS_LIB/GPS_CORS.html), access on July 17, 2009.

Anonym, <http://www.asmmag.com/news/cors-in-indonesia>, access on July 5, 2009.

Anonym, [http://searchmobilecomputing.techtarget.com/Definition/0,,sid7\\_gci213434,00.html](http://searchmobilecomputing.techtarget.com/Definition/0,,sid7_gci213434,00.html), access on August 10, 2009

Anonym, <http://www.mycoordinates.org/feb09/dangers.php>, access on July 25, 2009,

Anonym, [http://c4g.lsu.edu/joomla/index.php?option=com\\_content&task=view&id=42&Itemid=2](http://c4g.lsu.edu/joomla/index.php?option=com_content&task=view&id=42&Itemid=2), access on July 9, 2009

Koesoema, R.,Y, 2008, Penggunaan Provider Mobile IP Networks Indosat, Telkomsel dan XL pada pengukuran DGPS-NTRIP untuk pengukuran luas bidang tanah, Skripsi, Jurusan Teknik Geodesi FT – UGM.

Maunder, 2007, An investigation into the establishment of a Continuously Operating GPS Reference Station at Dubbo City Council, An investigation into the establishment of Continuously Operating GPS Reference Station at Dubbo City Council,

Meszaros, J, 2004, *Home Networks*,  
<http://www.gmat.unsw.edu.au/snap/publications/roberts&stanaway2009a.pdf>, access on July 20, 2009.

Rizos, C., 2007, The International GNSS Service: In the Service of Geoscience and the Geospatial Industry, School of Surveying and Spatial Information Systems University of New South Wales, Kensington, Sydney, NSW 2052, Australia.

Roberts, C., and Stanaway, R., 2009, CORS Growth and Applications in Australia and Indonesia, School of Surveying and Spatial Information Systems, University of New South Wales, Sydney NSW 2052 Australia,  
<http://www.gmat.unsw.edu.au/snap/publications/roberts&stanaway2009a.pdf>, access on July 21, 2009.

Sunantyo, 2008, Modeling of Local geoid Using Adaptive Scheme: A Case Study Around Merapi and Merbabu Volcanoes, Central Jawa, Indonesia.

William A , An overview of GPS Continously Operating Reference Stations, New Mexico State Geodetic Advisor, National Geodetic Survey Albuquerque, New Mexico, USA, [http://www.ngs.noaa.gov/PUBS\\_LIB/GPS\\_CORR.html](http://www.ngs.noaa.gov/PUBS_LIB/GPS_CORR.html)). Access on August 2, 2009.

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