

System Construction and Accuracy Test of Chengdu University of Technology

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SUMMARY

This article introduced the construction and function of CORS system of Chengdu University of Technology, which also called CDUTCORS. In this article, three aspects of CDUTCORS had been described in detail. Firstly, the construction of single reference continuous operates GPS which for the development survey teaching practice and the related scientific research. Then, the range coverage test of CDUTCORS; finally, the effectiveness and compatible of this system also carried on. The function of CDUTCORS system indicate that, this system complies with the design requirements and can provide centimeter level positioning services for our school teaching practice and the measurement of the scientific research work.

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1. INTRODUCTION

Continuously Operating Reference System (CORS) is one of the hot developments of GNSS at present. Its appearance has brought profound change to the surveying and mapping industry, and many cities and regions in our country have built several CORS systems now. However for the limitations of the cost of construction and operation, it is unable to promote multi-base station CORS system in a short time. Consequently, the single reference CORS system (referred as a single base station CORS) was born at the right moment. Single based station CORS has many advantages, such as flexible, simple structure, less investment, low operating costs, easy maintenance and management and so on. It can not only be used independently, but can always upgrade the grid Continuously Operating Reference Station network system for multi-based station.

The single reference CORS system in Chengdu University of Technology (CDUTCORS) is the first network RTK system in Sichuan province colleges. The system is the result of GNSS product testing and applied research which our university and UniStrong science and technology Co., Ltd carried out jointly in 2008. At present, the system has a comprehensive service in our school teaching practice and the measurement of the scientific research work, and could provide positioning services for practical measure production within the scope more than 30 kilometers which take the campus as center. This paper will recommend construction and precision testing of the CDUTCORS.

2. THE CONSTRUCTION OF CDUTCORS SYSTEM

2.1 constitutes of the system

Single based station CORS system is generally composed by the GPS base station, data servers, network communication module and the rover. The base station includes GPS receiver, antenna, lightning, power. Data server is both a control center and data center. It is divided into hosted and unmanaged categories; hosted server is provided and maintained by the supplier, non-managed system need to establish an independent data server, the base station and the server is connected directly. The CDUTCORS of Chengdu University of Technology is using the hosted server, base station receiver using the E650 dual-frequency GPS receiver which is produced by Uni-Strong,

the motherboard is produced by the United States Navcom NAVCOM 2100D GPS, antenna use the SWATGD dual-band antenna which produce by Navcom. The CDUTCORS select the free data management software e-config 2.0 of UniStrong to manage the entire system, the main interface shown in Figure 2; choosing the Ntrip Server as GNSS data transfer software, Ntrip Server can transfer the real-time base station observation data to the specified server. Network communications use the GPRS / CDMA / EDGE data transmission terminal module.

2.2 Base station construction

The location of CDUTCORS base station mainly consider the following precautions: 1. the base of base station must be solid; 2. stay away from strong magnetic fields and into water, and avoid strong electromagnetic interference and multi-path effects; 3. base station line of sight elevation angle should more than 10° for “Quasi-clearance”, that is to say the horizons over base station must broaden; 5. be sure to provide the secure, stable, continuous power. The eight-story south wing-storey of Chengdu University of Technology was built in the eighties of the last century, the building was concrete frame structure, has a solid foundation and roof open clearance, it was shown in Figure 1. Although the roof side has a China Unicom Communications base stations, through the observation data of GPS benchmark stand quality analysis, it shows that the base station of communication signals on GPS benchmark of received signal stand little influence; Lightning protection equipment is in the south of the roof with original device and lightning strikes. GPS observation data transfer through the host of the host on eighth floor and transmission into the host computer synchronously.



Fig. 1 CDUTCORS base station

2.3 Data quality analysis of base station

TEQC (Translation Editing Quality Checking) is developed by UNAVCO (University NAVSTAR Consortium), and mainly used for the GPS / GLONASS data preprocessing and quality check. TEQC is one of the world's most widely used applications of GPS data analysis software. The ionosphere delay of GPS data, cycle slips, data availability, the impact of multi path, SNR and other information can be obtained by the quality check.

In order to reflect the data quality of the base station more objectively, selected time CDUTCORS from 2009 to 2011 observation data to analyzed. GPS data quality MP1, Mp2, CSR values mainly through reflected in Table 1.

Table 1 data quality analysis of CDUTCORS datum station

Filename	Time length (h)	Elevation angle (°)	Mp1 (m)	Mp2 (m)	o/slps	CSR
CDUT1180.09o	25.26	5	0.31	0.41	76054	0.013
CDUT3210.10o	4.763	5	0.30	0.37	27775	0.036
CDUT3270.10o	12.48	5	0.31	0.40	75359	0.013
CDUT0690.11o	10.21	5	0.28	0.35	99104	0.010

In the table Mp1, Mp2 express L1, the L2 carrier multi-path effect separately; *o/slps* between expressed the observed value and the week jumps the ratio; between the observed value and the week jumps the ratio to indicate by other one form CSR^[1] that,

$$CSR = \frac{1000}{o / slps} \quad (1)$$

The Mp1 average value about 0.3, the Mp2 average value about 0.4, the CSR average value below 0.05, three targets is smaller than the mean value which global IGS stands. Thus it can be seen, the CDUTCORS system datum stands the data quality quite is stable periphery, the datum stands observes the environment to be good.

2.4 Transformation parameter solution

The CDUTCORS system datum station plane uses the national CGCS2000 coordinates system, the elevation uses 1985 national elevation system, through with Chengdu peripheral Dujiang weirs (DJYA), Guanghan (GHAN), Longquan post (LQYI) three national C the level GPS control point association measured gains, in addition gathered the audiences in Chengdu to UniStrong roof to build control point G03, five composition as shown in Figure 2 the observational network, carried on for 24 hours to observe continuously, uses GAMIT 10.4 to carry on baseline resolving, carried on the net adjustment with COSAGPS side, obtained the CDUTCORS datum to stand with the G03 three dimensional coordinates, after in the restraint adjustment

net most is weak the relative probable error is the 1/580000, CDUTCORS datum stand position the probable error is 0.40cm, The elevation the probable error is 2.2cm.

For further solves in this system sphere of action the coordinates transformation parameter and examines the CDUTCORS system the pointing accuracy, built static examination network as shown in Figure in the consideration to in the reference point distance and the length baseline situation 3. After the observation (Trimble 4600/5800) in the adjustment (TGO1.6) after net the most weakness the probable error is 0.79cm, the weakest side probable error is 1/60000. Then selects G02, G06, G09 as the spot uses seven parameter law to calculate WGS-84 and between the CGCS2000 coordinate system transformation parameter, uses in the single reference station RTK survey localization.

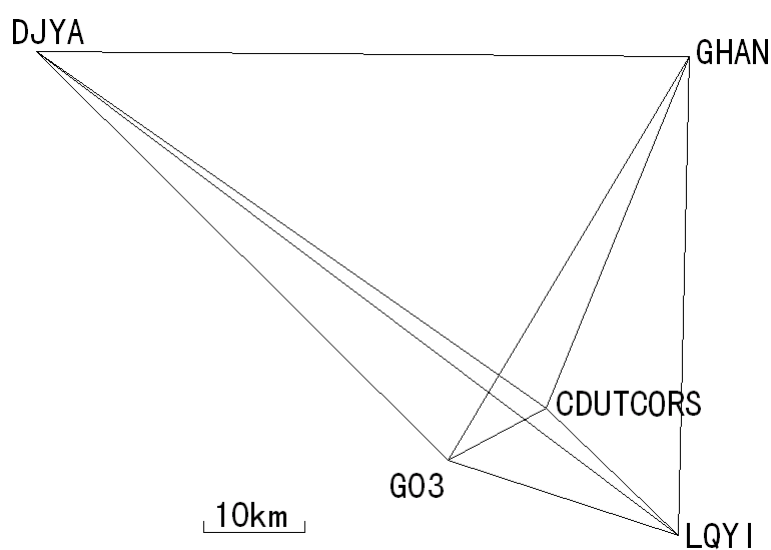


Fig. 2. The datum stands with the national GPS control point joint mapping

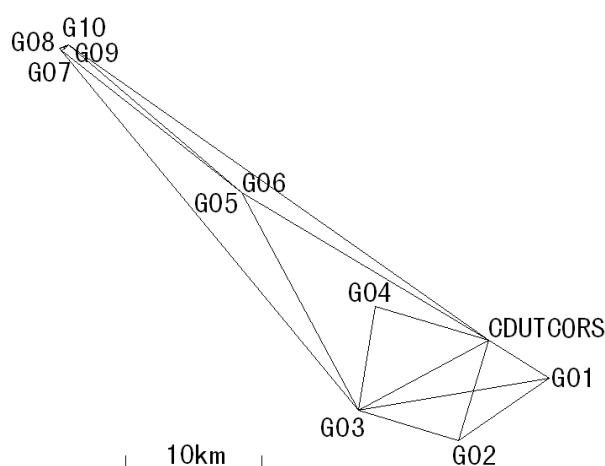


Fig. 3. Static examination network chart

3. ACCURACY TEST OF CDUTCORS

For confirms and appraises CDUTCORS technical specifications and so on the system reliability and measuring accuracy, selected the domestically produced sea to reach Chinese star A6, to gather the audiences separately to UniStrong company's E660 and import Trimble 5800, Leica GS09 altogether four kind of GPS receivers carries on the work to be away from the test, the time-limited test and the pointing accuracy test, simultaneously confirmed its compatibility.

3.1 The distance test

From the test with four kind of GPS receivers as the research center to be away from the test, the perigee distance is 0.088km, the ultimate distance is 38.2km, all 15 test point position all can obtain the fixed solution, selects the position distribution to see Table 2. Namely can real-time obtain the centimeter level pointing accuracy in the close 40km work scope.

Table 2 CDUTCORS system work is away from the test situation

Distance(km) integer/proportion	Distance(km)					Total
	0~5	5~10	10~20	20~30	30~40	
points	5	3	1	2	4	15
proportion	33.3%	20%	6.7%	13.3%	26.7%	100%

3.2 Effectiveness test

Effectiveness is to test the user terminal the initialization time which needs in the real-time locating process. This test still used four kinds of GPS receivers, recorded in the gain fluctuation solution to the fixed solution also the precision achieved when centimeter level this period of time was the initialization time. The test result sees Table 3.

Table 3 the results of CDUTCORS system effectiveness test (manual time unit: sec)

Receiver roll-call	The distance to the reference station (km)	Unistrong E660	ZHD Chinese star A6	Trimble 5800	Leica GS09
D02	0.088	11	10	15	13
D17	0.098	14	12	18	12
D01	0.102	21	20	25	18
D04	0.104	15	17	14	15
D03	0.153	19	22	20	19
G01	5.202	10	12	15	12
G02	7.701	9	12	11	13
G04	8.807	8	6	10	9
G03	10.927	10	12	19	13
G05	21.224	15	23	17	18
G06	21.271	18	22	21	24
G10	37.801	309	326	335	319
G09	37.830	324	347	352	348
G07	37.962	43	25	45	32
G08	38.222	45	36	44	42

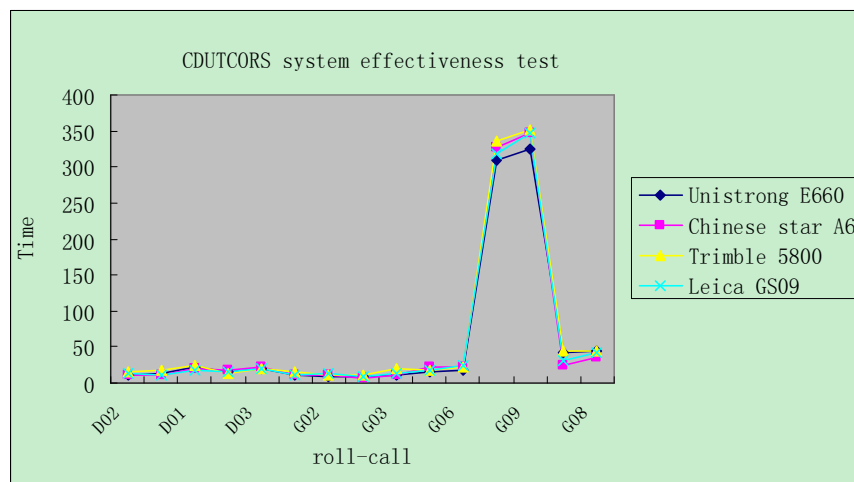


Fig. 4. CDUTCORS system initialization time and distance relational graph

Figure 4 has given in the system effectiveness test various brands GPS receiver initialization time and the distance relations.

And Figure 4 may know by Table 3, four kind of GPS receiver initialization time

compares the average as a whole, the initialization time grows along with the distance increase, in which is away from around reference station near D01, D03 has the big construction and the big tree covers the GPS signal, these two spot initialization time relative long; Stands the farthest four spot initialization time to the datum to be long, in which G09 with G10liang the initialization time achieved above 300 seconds, this should concern with the survey station around observation environment. The initialization time conforms to the system design requirement.

3.3 Positioning accuracy test

In order to test the CDUTCORS system the plane pointing accuracy, used four kind of GPS receivers real-time dynamic to survey separately had measured in the area 12 spots, counted each coordinates and difference of the static survey achievement which four kind of receivers obtained, discovered the ZHD Chinese star A6, gathers the audiences to UniStrong E660 and the Trimble 5800 three kinds of receivers measuring accuracies quite, the Leica GS09 measuring accuracy was slightly high, but also was a number magnitude, in which coordinates biggest interpolation is 3.6mm, the smallest interpolation was 0.0mm; Takes each interpolation mean value which four kind of receivers obtain to be listed in table 4; Is considered as the mean point position the probable error is 1.78mm. Results see by Table 4, this system each interpolation with is apart from the distance which the datum stands by no means to demonstrate some kind of obvious linear relations.

Table 4 known point examination precision statistical table

roll-call	The distance to the reference station (km)	$\Delta N(\text{cm})$	$\Delta E(\text{cm})$
D17	0.098	-1.8	-1.3
D01	0.102	-1.1	1.3
D04	0.104	-1.7	0.5
D03	0.153	-0.2	0.0
G01	5.202	-1.1	-1.3
G02	7.701	0.8	1.0
G04	8.807	1.5	-0.5
G03	10.927	-0.5	0.3
G05	21.224	1.7	-0.6
G10	37.801	1.7	1.7
G07	37.962	1.2	2.3
G08	38.222	0.7	0.6

Due to the limited conditions, check points of the CDUTCORS system have not been measured with the national elevation point. Therefore, the elevation precision examination on obtains using the Sichuan earthquake authority's CDVRS net between

various check points elevation difference and the CDUTCORS real-time dynamic survey corresponding elevation difference compares, takes the CDUTCORS system elevation precision the control standard. Between 15 check points composes 14 elevation differences compare the interpolation, most greatly for $\pm 4.0\text{cm}$, slightly for $\pm 0.1\text{cm}$, mean value for $\pm 0.2\text{cm}$. Explained the CDUTCORS system in the elevation conforms to the precision to be very good.

This test used four kind of brand GPS receiver to obtain the satisfactory result, proved the CDUTCORS system had the good compatibility.

4. CONCLUSIONS

By a number of tests and continuous running for three years show that the single reference station CDUTCORS system can provide the centimeter level accuracy real-time position service in the center about 30km. Its effectiveness and the compatibility also satisfy the expectations of the establishment requirements. This system already played the role in the school survey teaching practice and the scientific research, also might in the work scope for aspects and so on national territory plan, engineering construction, land management provide the localization service.

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