IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 10 ISSUE : 11 Print / Issue Publication Date: 18-Apr-2026

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2026.v10i11.003

Indexed In

WWW.IJEAST.COM

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International Journal of Engineering Applied Sciences and Technology, 2026
Vol. 10, Issue 11, ISSN No. 2455-2143, Pages 14-18
Published Online March 2026 in IJEAST (http://www.ijeast.com)

IMPACT OF ANTENNA SIGNAL PROBLEMS ON RTK-GPS ACCURACY: A FIELD STUDY

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Abstract: **RTK-GPS is widely used in surveying because it gives very accurate results in centimeters. But during field work, we often face problems like antenna getting disturbed, loose connections, or signal blockage from trees and buildings. This study was done to find out exactly how much these problems affect the accuracy of RTK measurements. I collected 34 GPS points using Leica GS18 T receiver in Dharmavaram region during February 2026. Some points were taken normally with proper antenna setup, and some were taken when I deliberately disturbed the antenna to simulate field problems. The results showed that normal points had accuracy around 1-2 cm, but when antenna was disturbed, the accuracy became very bad - around 5-6 meters error. This is almost 300-400 times worse than normal. The position also shifted by 2-3 meters horizontally and about 1 meter vertically. This clearly shows that antenna setup and signal quality is extremely important in RTK surveying. Field surveyors should always check antenna connection properly and make sure there is clear sky view before taking any measurement.**

Keywords: **RTK-GPS, Survey accuracy, Antenna problems, Field work, GNSS errors, Quality control**

I. INTRODUCTION

GPS technology has completely changed how we do surveying work nowadays. When I was working on field surveys, I noticed that sometimes GPS gives very accurate results (few centimeters) and sometimes it gives completely wrong results (several meters). The main difference I observed was the antenna condition and signal quality.

RTK (Real-Time Kinematic) is a technique where we get corrections from a base station in real-time, which helps us achieve centimeter-level accuracy. This is much better than normal GPS which gives only 3-5 meter accuracy. For RTK to work properly, we need good satellite signals and stable antenna connection.

In my field experience, I found that many times the antenna gets disturbed due to hitting tree branches while walking, loose connection between antenna and receiver, keeping the pole near buildings or under trees, accidentally moving the antenna during observation, or wind causing pole movement. But I never knew exactly how much these problems affect the accuracy. So I decided to do a proper experiment to measure this.

Let me explain RTK in simple terms. Normal GPS works by receiving signals from satellites and calculating position. But this has errors of 3-5 meters due to atmosphere, satellite clock errors, and other factors. RTK improves this by using two receivers - a base station kept at a known point sending corrections, and a rover which is the receiver we carry for survey. The base station calculates the errors and sends corrections to the rover through internet or radio. The rover applies these corrections and gets very accurate position, usually 1-2 cm. Nowadays we don't need our own base station. There are CORS (Continuously Operating Reference Stations) networks run by government or survey organizations. We can connect to these using mobile internet through something called NTRIP protocol. This makes RTK very easy - just need one receiver and mobile data connection. During surveys, I noticed several problems. Sometimes accuracy suddenly becomes bad, going from 2 cm to 2 meters. The receiver shows "poor quality" warning. Position keeps jumping around. Even after re-initialization, accuracy doesn't improve. Most of the time these problems happened when antenna connection was slightly loose, antenna was tilted or not vertical, nearby trees or buildings were blocking satellites, or someone accidentally touched the antenna during observation. But nobody has properly measured how much these problems affect accuracy. Most studies talk about satellite errors, atmospheric errors, and baseline distance effects. But practical field problems like antenna disturbance are not well documented.

My objectives for this study were:

1. To measure RTK positioning accuracy under normal conditions and under simulated signal obstruction conditions
2. To calculate the magnitude of accuracy degradation when antenna has problems
3. To provide practical recommendations for field surveyors regarding antenna care and quality control

A. STUDY AREA AND EQUIPMENT

I did this work in Dharmavaram area of Andhra Pradesh during February 2026. The area is mostly flat with some agricultural fields, roads, and small settlements. I chose this area because it has open terrain with clear sky view in most places, easy access by road, a good mix of open and semi-blocked areas, and good mobile network coverage for NTRIP connection. The survey covered approximately 15 km × 5 km area with points spread across different locations.

I used professional surveying equipment for this study. The GPS receiver was Leica GS18 T, manufactured by Leica Geosystems AG, Switzerland. This is a modern RTK receiver with tilt compensation capability. The field controller was Leica CS20 LTE, which is a rugged field controller with touchscreen display. It runs survey software and connects to the receiver via Bluetooth.

For the RTK corrections, I used GSM network connectivity. Both the base station and rover had SIM cards installed for data transmission. The base station SIM card was used to transmit correction data, while the rover SIM card received these corrections over the mobile network. This allowed real-time communication between base and rover without needing dedicated radio equipment. I used Airtel network which provided good coverage in the study area. The corrections were transmitted using NTRIP protocol. The correction format was RTCM 3.2 messages with VRS (Virtual Reference Station) method. The complete system setup worked as follows - the base station receiver was set up at a known control point and connected to CORS network via its SIM card. The rover receiver that I carried for survey also had a SIM card which connected to the same network. The rover received correction data from base through the GSM network connection. The receiver applied these corrections to calculate precise position. The controller displayed the corrected position in real-time and I could save survey points with all quality parameters.

For each observation, the system automatically recorded coordinates in UTM projection (Easting, Northing, Height), survey code, 3D Quality parameter which indicates estimated accuracy in meters, and date of observation.

II. METHODOLOGY

The basic idea of my experiment was very simple. I wanted to compare RTK accuracy under two different conditions at the same locations.

For normal operation (what I call Scenario A or "Good points"), I made sure GNSS antenna was properly screwed tight on survey pole, pole was held vertically using bubble level or tripod, there was clear sky visibility with no obstructions, proper RTK initialization until "Fixed" solution was achieved, 3D Quality indicator showed less than 0.05 meters, position was allowed to stabilize for 10-15 seconds, and then the point was saved with all data.

For simulated obstruction (what I call Scenario B or "Bad points"), I deliberately disturbed the antenna by loosening the antenna connection, temporarily removing antenna from pole then reconnecting, heavily tilting the pole during observation, or moving antenna around during measurement. These simulate the kinds of problems that accidentally happen in real field work. I saved the point even though quality indicator showed very poor values, and did not re-initialize to see the degraded accuracy. I used a systematic naming system to keep track. Points with names like PN0001, PN0002 were primary observations with normal setup. Names with R suffix like PN0002R meant first repeat observation at same location. Names with RR suffix like PN0002RR were usually second repeat with slight disturbance. Names with RRR suffix like PN0002RRR were usually heavily disturbed observations.

Here is the exact procedure I followed at each survey location. First, I selected the survey point and cleared any immediate obstructions like tall grass. Then I set up the equipment, mounted receiver on pole, and ensured antenna was screwed hand-tight. After turning on receiver and controller, I verified Bluetooth connection and checked that both base and rover SIM connections were active. I waited for satellite acquisition which usually took 30-60 seconds.

For RTK initialization, I observed the solution status on controller screen. Initially it showed "Searching" or "Float" solution. I waited until it changed to "Fixed" solution, which usually took 10-30 seconds. Only "Fixed" solution gives centimeter-level accuracy. Then I checked the 3D Quality value displayed on screen. For good observations, this should be less than 0.02 meters. I also checked number of satellites (should be at least 8-10) and PDOP value (should be less than 3.0). With everything properly set up and quality verified, I allowed position to stabilize for 10-15 seconds, ensured pole was perfectly vertical using bubble level, and saved the point. The system automatically recorded coordinates, quality, and date. Then I deliberately disturbed the antenna using one of the methods mentioned earlier. Important point - I did NOT re-initialize after disturbance. This allowed me to see how the system performs with degraded signals. Immediately after disturbance, without moving from location, I saved another point with appropriate suffix. I noted that quality value was typically very high now and position may have shifted significantly from first observation.

The 3D Quality parameter is the most critical value for this study. This value is computed by the receiver based on satellite geometry, number of satellites tracked, signal-to-noise ratio, quality of corrections received, age of corrections, and ambiguity resolution confidence. A lower 3D Quality value indicates better accuracy. For example, 0.008 m means ±8 millimeters accuracy (excellent), while 5.000 m means ±5 meters accuracy (poor/failed). The field survey was conducted on 15th February 2026, covering approximately 9 hours of field work. I collected 34 observations including both good and deliberately bad points.

III. EXPERIMENT AND RESULT

Table 1 presents the complete dataset of all 34 observations collected during the field survey.

Complete Survey Observations

Point ID	Easting (m)	Northing (m)	Height (m)	3D Quality (m)	Date	Category
PN0001	827114.029	2035159.449	6.453	0.009	15.02.2026	Good
PN0002	827114.322	2035157.682	6.444	0.008	15.02.2026	Good
PN0002R	827114.322	2035157.681	6.428	0.010	15.02.2026	Good
PN0002RR	827114.320	2035157.681	6.691	0.080	15.02.2026	Medium
PN0002RRR	827115.180	2035157.386	6.772	6.448	15.02.2026	Poor
PN0004	827115.752	2035158.378	6.772	6.448	15.02.2026	Poor
PN0004	826924.492	2033875.855	5.506	0.006	15.02.2026	Good
PN0004R	826924.491	2033875.855	5.606	0.006	15.02.2026	Good
PN0004RR	826924.491	2033875.854	5.506	0.006	15.02.2026	Poor
PN0004RR	826924.491	2033875.854	5.506	0.006	15.02.2026	Poor
PN0004RR	826924.492	2033875.855	5.506	0.006	15.02.2026	Poor
PN0004RRR	826925.225	2035876.019	4.297	5.680	15.02.2026	Poor
PN0005	827357.692	2031874.207	4.986	0.008	15.02.2026	Good
PN0006	827374.725	2031980.117	4.986	0.009	15.02.2026	Good
PN0007	827999.622	2031877.983	4.297	0.008	15.02.2026	Good
PN0008	827316.952	2031866.684	4.991	0.013	15.02.2026	Good
PN0009	827307.536	2031867.933	4.775	0.008	15.02.2026	Poor
PN0010	827294.106	2031851.341	4.775	0.009	15.02.2026	Poor
PN0011	822754.810	2030880.983	4.106	6.031	15.02.2026	Poor
PN00011	822456.575	2033110.723	8.827	0.011	15.02.2026	Good
PN00012	822400.668	2030488.438	9.704	0.011	15.02.2026	Poor
PN00013	822316.952	2030496.431	4.304	0.011	15.02.2026	Good
PN00014R	817916.586	2035560.423	9.966	0.013	15.02.2026	Medium
PN00013	817916.924	2035560.448	6.672	0.008	15.02.2026	Poor
PN00011	827899.822	2035199.212	11.794	0.011	15.02.2026	Good
PN00012	817990.658	2035187.252	9.704	0.011	15.02.2026	Good
PN00013R	827216.581	2036486.431	9.700	0.013	15.02.2026	Good
PN00014	817916.534	2035560.423	9.775	0.008	15.02.2026	Medium
PN00015R	818916.207	2035117.745	12.297	5.625	15.02.2026	Good
PN00017RR	818219.207	2035117.645	5.329	5.645	15.02.2026	Poor
PN00018	819580.832	2035199.212	11.849	5.645	15.02.2026	Poor
PN00022	819580.524	2035220.932	10.930	0.013	15.02.2026	Poor

Table 1: Complete Survey Observations

Based on the 3D Quality values, I classified all observations into three categories.

Classification by Quality

Category	Quality Range	Count	Percentage
Good	0.006 – 0.050 m	23	67.6%
Medium	0.050 – 1.000 m	2	5.9%
Poor	Above 1.000 m	9	26.5%
Total	–	34	100%

The bar chart demonstrates that antenna disturbance causes approximately 430 times accuracy degradation compared to normal operation.

Table 2: Classification by Quality

The classification shows that more than two-thirds (67.6%) of observations achieved excellent quality under normal conditions. Only two observations (5.9%) fell into the transitional medium category. Nine observations (26.5%) showed poor quality due to deliberate antenna disturbance.

International Journal of Engineering Applied Sciences and Technology, 2026
Vol. 10, Issue 11, ISSN No. 2455-2143, Pages 14-18
Published Online March 2026 in IJEAST (http://www.ijeast.com)

Figure 1 shows the comparison between good quality points and poor quality points. The chart clearly demonstrates the massive difference in accuracy between normal operation and disturbed antenna conditions.

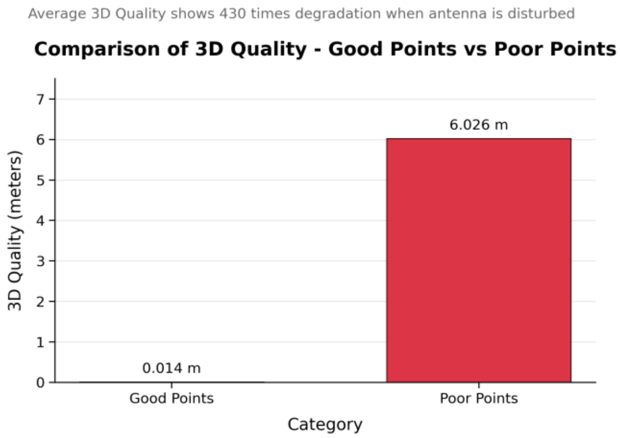

Figure 1: Comparison of 3D Quality - Good Points vs Poor Points

The key statistical findings are:
• Good Points: Average quality = 0.014 m, Best = 0.006 m, Worst = 0.040 m
• Poor Points: Average quality = 6.026 m, Best = 5.625 m, Worst = 6.687 m
• Degradation Factor: Approximately 430 times worse when antenna is disturbed

The most revealing analysis comes from comparing observations taken at the same physical location under different antenna conditions. At five different locations, I took both good and bad readings at exactly the same spot.

The results showed:
• Average horizontal position shift: 1.98 meters (ranging from 1.08 to 2.67 m)
• Average vertical position shift: 0.68 meters (ranging from 0.28 to 1.21 m)
• Maximum horizontal shift: 2.67 meters at location PN00019/PN00019R
• Maximum vertical shift: 1.21 meters at location PN0004/PN0004RR

One particularly interesting example is the PN00019 series. Here I reversed the sequence - PN00019 was taken first with disturbed antenna and showed 5.854 m quality (BAD). Then PN00019R was properly set up and showed 0.013 m quality (GOOD). The difference between these two observations at the exact same spot was 2.67 meters horizontally and 1.17 meters vertically. This clearly shows what happens when surveyor doesn't realize antenna is loose.

The survey points covered a large area and I noticed that quality problems were not location-dependent but purely antenna-condition dependent. Good points achieved excellent quality at both early morning and late morning. The only factor that mattered was antenna condition at that specific moment.

IV. CONCLUSION

Based on this controlled field experiment with 34 RTK-GPS observations, I can draw several important conclusions.

First, antenna condition is the most critical factor for RTK accuracy. Antenna problems cause meter-level errors - typically 2-3 meters - which is approximately 430 times worse than normal operation. This is far more serious than other error sources.

Second, accuracy degradation is severe and sudden. It jumps from centimeters to meters almost instantly. Once antenna is disturbed and phase lock is lost, the receiver can continue operating with wrong values, producing systematically wrong coordinates.

Third, the 3D Quality indicator is reliable and should be trusted. When quality was less than 0.02 m, positions were consistently accurate. When quality exceeded 1.0 m, position was wrong by meters.

Based on these findings, I recommend that field surveyors should check antenna connection thoroughly before starting, verify both base and rover SIM cards have good network signal, monitor 3D Quality for every observation, set automatic rejection thresholds, and stop immediately if quality suddenly increases. For boundary surveys, reject any point with quality above 0.025 m. For topographic surveys, reject above 0.050 m.

This study has limitations including testing only one receiver model and working in one geographic region only. Despite these limitations, the core conclusion is clear - antenna problems cause catastrophic accuracy degradation in RTK systems and field surveyors must pay careful attention to antenna setup and signal quality.

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