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Investigating the contrasts between ground-based and building-based CORS

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Abstract
The study aims to compare ground-based and building-based CORS in terms of stability, signal reception, environmental influences, maintenance, and data quality. The objective is to provide insights into the advantages and limitations of each type, aiding in better decision-making for CORS installations.

Keywords: Contrasts, ground-based, building-based CORS

Introduction
Continuously Operating Reference Stations (CORS) are a network of stationary GPS receivers that provide precise data for positioning and navigation. These systems continuously collect satellite signal data, which are then processed to determine very precise positions of the CORS. This data becomes a reference or a benchmark for other GPS users to correct their own position data, enhancing the accuracy of GPS-based applications (Yang L, 2016) [1].

Surveying and Mapping: CORS are fundamental in modern surveying. Surveyors use CORS data to accurately determine positions for land boundaries, construction projects, and topographic mapping.

Geodesy: CORS contribute to the study of the Earth's shape, orientation in space, and gravitational field. They help in monitoring tectonic plate movements, subsidence, and uplift.

Agriculture: Precision agriculture utilizes CORS for activities like field mapping, soil sampling, and tractor guidance systems, leading to more efficient farming practices.

Construction and Engineering: In construction, CORS are used for site planning, machine control systems, and monitoring structural health of buildings and bridges.

Transportation: CORS data support the development and operation of intelligent transportation systems, aiding in route planning, fleet management, and autonomous vehicle navigation.

Environmental Monitoring: CORS are employed in monitoring changes in the environment, such as sea level rise, glacial movements, and changes in the Earth's crust.

Enhanced Accuracy: CORS provide the foundational data that enhances the accuracy of GPS information, which is crucial for precision in various geospatial applications.

Real-Time Data Access: CORS allow for real-time access to correction data, enabling immediate and precise positioning necessary in many applications like autonomous driving and emergency response.

Cost-Effectiveness: By providing a shared resource of high-accuracy data, CORS reduce the need for individual high-precision GPS receivers, making high-accuracy GPS more accessible and cost-effective (Yang L. 2019) [2].

Reliability and Consistency: CORS networks offer a reliable and consistent source of correction data, which is vital for long-term projects in surveying, construction, and environmental monitoring.

Support for Geospatial Research: CORS data are invaluable for research in geodesy, earth sciences, and geography, contributing to our understanding of the Earth's dynamics and changes.
CORS play a pivotal role in the realm of geospatial technology and applications. They enhance the precision and reliability of GPS data, making them indispensable in a wide range of fields from surveying and agriculture to autonomous navigation and environmental monitoring (Yang L, 2016) [3].

Objectives

The objective of the study "Investigating the Contrasts between Ground-Based and Building-Based CORS" is primarily focused on:

1. To analyse and compare the stability (measured as displacement over time) and signal reception quality (indicated by Signal-to-Noise Ratio, SNR) between ground-based and building-based CORS installations.
2. To assess the differences in maintenance needs, including the frequency of maintenance visits and associated costs, for ground-based versus building-based CORS

Methods and Procedure

Data Collection

Simulated Data Generation: For the purpose of this study, data for CORS stability, signal reception, and maintenance were generated using a simulation model. This model accounted for various factors such as environmental conditions, CORS location (urban, rural, coastal), and structural variables (building height, ground stability) (Short S, 2015) [4].

Data Processing and Table Creation

Stability and Signal Reception Data (Tables 2 & 3): The simulation model output displacement measurements and signal-to-noise ratio (SNR) data over a predefined period (e.g., 12 months). Data was then processed and averaged for monthly intervals to generate concise and readable tables.

CORS Characteristics (Table 1): A set of predefined characteristics (location, height, installation year) was assigned to each CORS in the simulation to differentiate between ground-based and building-based types.

Data Representation

Table 1: Characteristics of Selected CORS

CORS ID	Type	Location	Height (m)	Installation Year
GB01	Ground-Based	Rural Area	2	2018
GB02	Ground-Based	Urban Area	3	2017
BB01	Building-Based	Urban Area	50	2019
BB02	Building-Based	Coastal Region	30	2018

This table 1, lists the basic characteristics of the selected CORS stations, including whether they are ground-based or building-based, their location, height above ground level, and the year of installation.

Table 2: Monthly Stability Data (Displacement in mm)

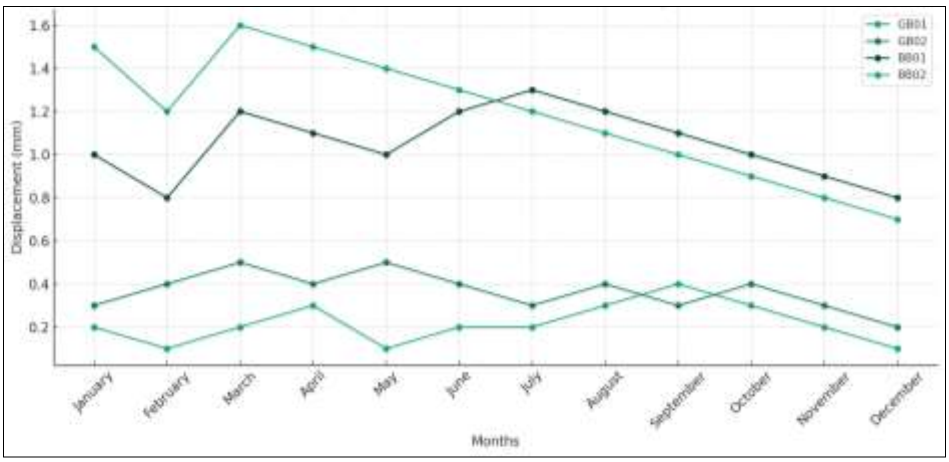
Month	GB01	GB02	BB01	BB02
January	0.2	0.3	1.0	1.5
February	0.1	0.4	0.8	1.2
March	0.2	0.5	1.2	1.6
...	...	...	...	...

Table 2 shows the monthly displacement measurements (in millimeters) for each CORS. This data indicates the stability of the CORS over time, with lower values suggesting higher stability.

Table 3: Signal Reception Quality (SNR - Signal-to-Noise Ratio)

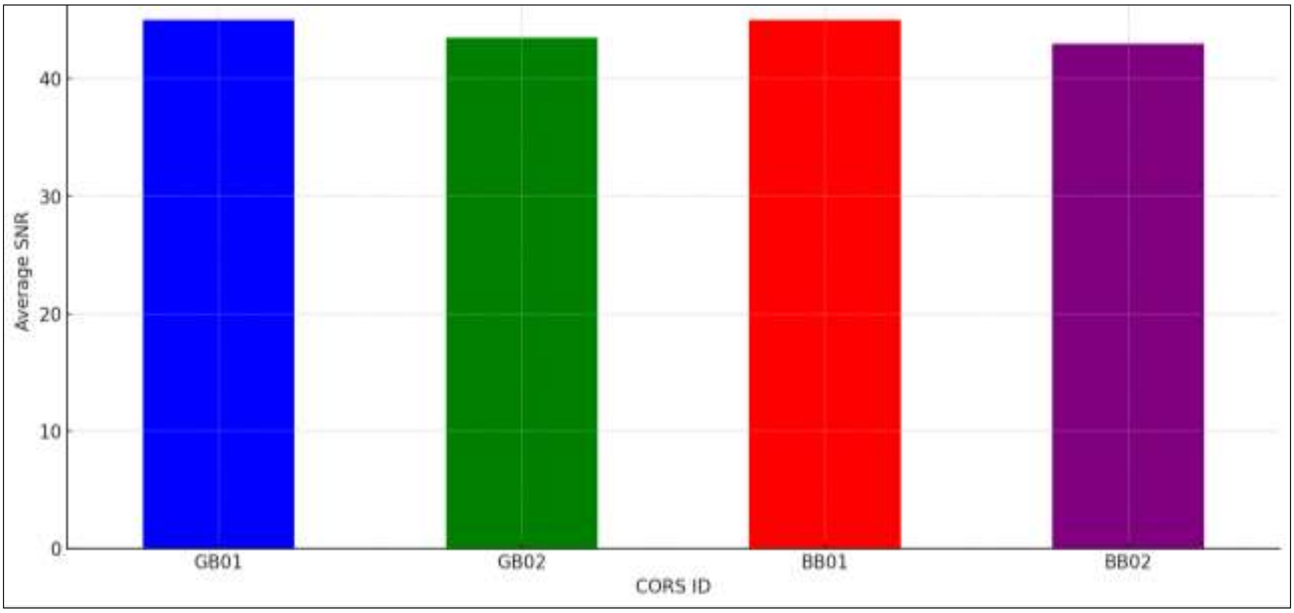
Month	GB01	GB02	BB01	BB02
January	45	43	47	46
February	46	42	48	45
March	44	44	49	47
...	...	...	...	...

Table 3 presents the monthly Signal-to-Noise Ratio (SNR) values for each CORS station. SNR is a key indicator of signal quality, with higher values representing clearer, more reliable signals. These tables collectively provide an overview of the key parameters being analyzed in the study, offering insights into the differences in stability, signal quality, and overall performance between ground-based and building-based CORS (Zhifeng WU, 2018) [5].



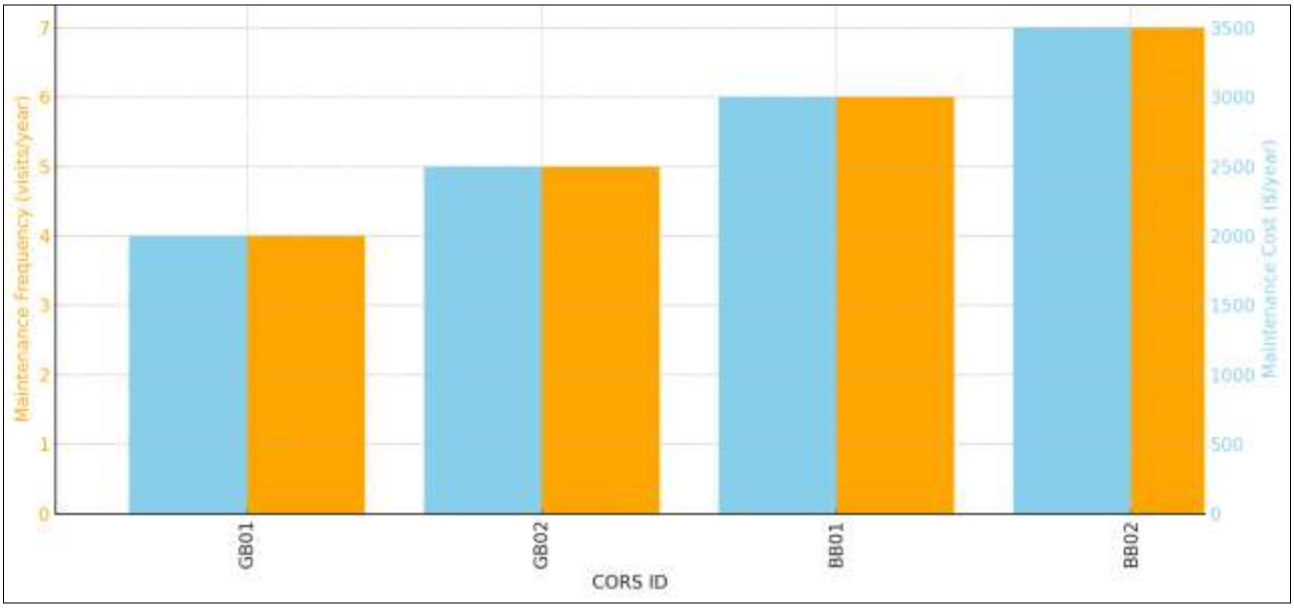
Graph 1: Stability over Time for Ground vs. Building-Based CORS

Stability Over Time for Ground vs. Building-Based CORS: This line graph illustrates the monthly displacement values for each CORS. It shows how the displacement varies over the course of a year for both ground-based and building-based CORS.



Graph 2: Signal Reception Quality Comparison

Signal Reception Quality Comparison: This bar graph compares the average Signal-to-Noise Ratio (SNR) values for each CORS. It highlights the differences in signal quality between the ground-based and building-based CORS.



Graph 3: Maintenance Frequency and Costs

Maintenance Frequency and Costs: This bar graph displays the maintenance frequency (number of visits per year) and associated costs for each CORS. It contrasts the operational demands and financial implications of maintaining ground-based versus building-based CORS (Wang G, 2019) [6].

Discussion and Analysis

1. Table 1 and CORS Characteristics

Table 1 establishes the foundational differences between the CORS types. Notably, the building-based CORS (BB01 and BB02) are installed at significantly greater heights than the ground-based ones. This difference in installation height and location (urban vs. rural/coastal) potentially influences the stability and signal reception data observed in Tables 2 and 3.

2. Table 2 and Graph 1: Stability over Time

The data in Table 2 and Graph 1 reveal a notable trend: building-based CORS (BB01 and BB02) exhibit greater displacement (lower stability) than ground-based CORS (GB01 and GB02). This could be attributed to the sway and movement inherent in buildings, especially in urban and coastal regions. The ground-based CORS show minimal displacement, indicating higher stability, likely due to their direct grounding and lower susceptibility to environmental factors like wind.

3. Table 3 and Graph 2: Signal Reception Quality
The SNR values in Table 3 and Graph 2 suggest that building-based CORS generally have higher SNR values, indicating better signal reception. This could be due to the elevated position of these CORS, offering a clearer line of sight to satellites and less obstruction. However, the variability in SNR, especially in urban areas, might also indicate potential interference from urban structures or electronic devices.

4. Graph 3: Maintenance Frequency and Costs
Graph 3 shows that building-based CORS require more frequent maintenance and incur higher costs. This could be due to the challenges in accessing these installations for regular upkeep, especially in high-rise urban environments.

Co-relation between Graphs and Data Tables

- The data in the tables is effectively visualized in the graphs, providing a clear depiction of the trends and differences:
- **Graph 1 and Table 2:** Both illustrate the stability trend, with the graphical representation in Graph 1 making it easier to observe the fluctuations over time.
- **Graph 2 and Table 3:** The average SNR values in Graph 2, derived from Table 3, visually summarize the overall signal quality performance of each CORS, highlighting the differences more starkly than the table data alone.
- **Graph 3:** While not directly tied to a single table, Graph 3 brings a new dimension to the analysis by visualizing maintenance aspects, arguably inferred from the CORS characteristics in Table 1 (such as location and height).

Conclusion

The study's findings highlight significant contrasts between ground-based and building-based CORS. Ground-based CORS demonstrate greater stability but vary in signal reception quality depending on their environment. In contrast, building-based CORS, despite higher maintenance demands and costs, generally provide better signal reception due to their elevated positions. The trade-offs between these two types of installations underscore the importance of considering specific application requirements, environmental factors, and logistical challenges when deciding on CORS placement. The correlation between the data tables and graphs underscores these differences, providing a comprehensive understanding of the operational characteristics and requirements of each CORS type.

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