Status Report on the Tsukuba VLBI Station

– Damage to the Substructure of the Antenna and Its Repair –

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Abstract The Geospatial Information Authority of Japan (GSI) has carried out a lot of VLBI experiments with the Tsukuba VLBI Station since 1998. On the other hand, repeating loads of the antenna has weakened the substructure gradually, and we had to suspend all sessions from May 2013 due to the damage. Investigations revealed the distortion of the rail track and the gaps under the sole plate, which caused the antenna to subside 6 mm at maximum. We repaired the damage and confirmed that the subsidence of the antenna was improved significantly. Finally, we resumed observations from November 2013.

Keywords Repair, wheel and track structure, damage

1 Introduction

The Tsukuba VLBI Station, which is one of the leading VLBI stations in Eastern Asia, was installed at the site of Geospatial Information Authority of Japan (GSI) in 1998. Recently we carried out more or less 200 sessions per year (Figure 1). On the other hand, a lot of loads were applied to the substructure of the antenna. Some phenomena concerning the damage to the substructure occurred from a few years ago. For example, outflow of the farinaceous grout occurred around the substructure, and vertical movement of the rail track was found when the wheel passed through. The pointing offset in April 2013 revealed that the offset was so large that it would affect observations. In response to this, we decided to suspend all observations from early May 2013. We investigated the substructure in order to know the damage in detail. In this article, we report the analysis result of the investigation and the repair work.

Geospatial Information Authority of Japan

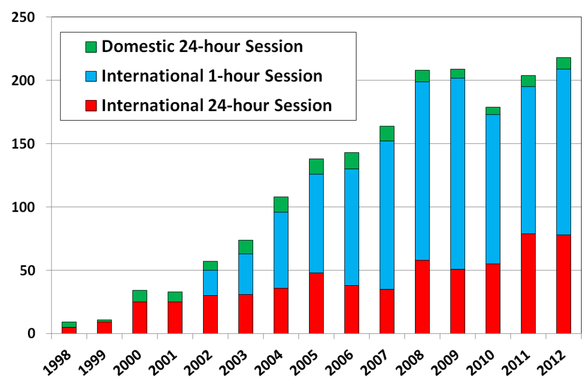

Fig. 1 The number of sessions carried out by using the Tsukuba VLBI Station.

2 Investigations

2.1 Pointing Offset

Figure 2 shows the result of the pointing offset in April. Large offsets occurred at specific azimuths in both the azimuth and the elevation plots. The maximum elevation offset was 170 arcseconds at the azimuth angle of 115 degrees, which was large enough to disturb observations because the beam half-value width of the Tsukuba antenna for X-band was about 250 arcseconds.

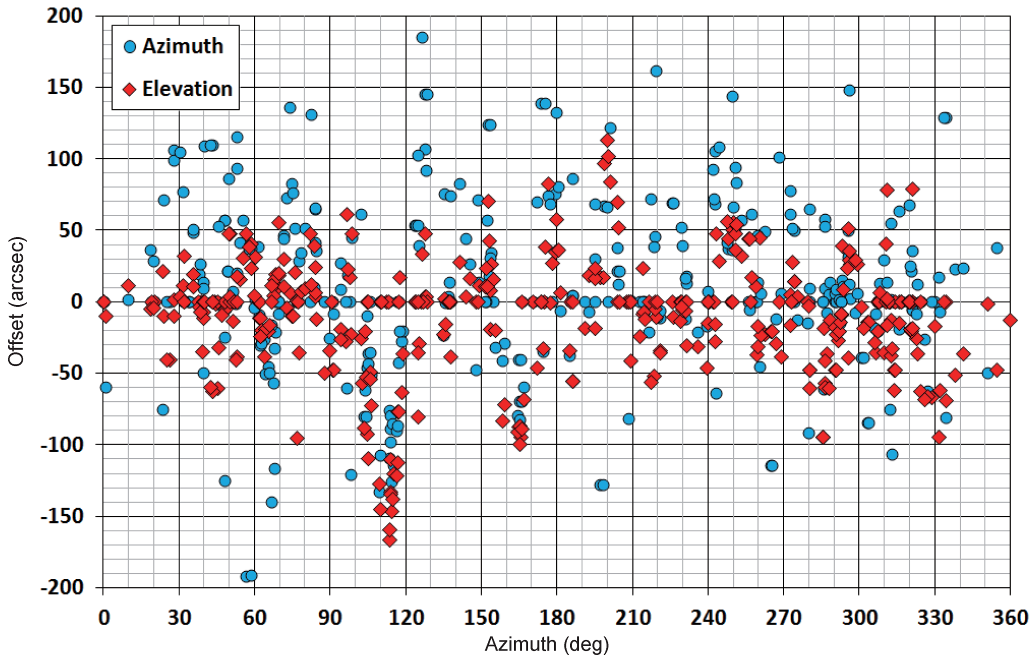

Fig. 2 The pointing offset of azimuth and elevation in April 2013 plotted as a function of the azimuth direction.

2.2 Investigations

Figure 3 is the schematic cross section of the substructure of the antenna. The rail track is mounted on the sole plate, and the sole plate is locked to the basement concrete by some anchor bolts. The space between the rail track and the sole plate is filled with cementitious grout. Additionally, the rail track and the sole plate are divided into several pieces, and those boundaries are arranged alternately.

In order to know the damage in detail, we conducted two kinds of investigations. One was leveling on the rail tracks under a no load condition. The other was the measurement of the vertical movements of the sole plates to the grout when the wheel passed through. Adding these results, we can understand the subsidence amount of the antenna from the reference level.

Figure 4 shows the results of the leveling and the vertical movement. It turned out from the leveling that almost all the rail tracks were distorted in a convex shape while only one rail track at the azimuth angle of 250 degrees was deformed concavely. The range of the level reached to 4 mm. The second investigation revealed the vertical movements of almost all the sole plates at their boundaries. The maximum amount of the vertical movement was up to 3.5 mm. The estimated

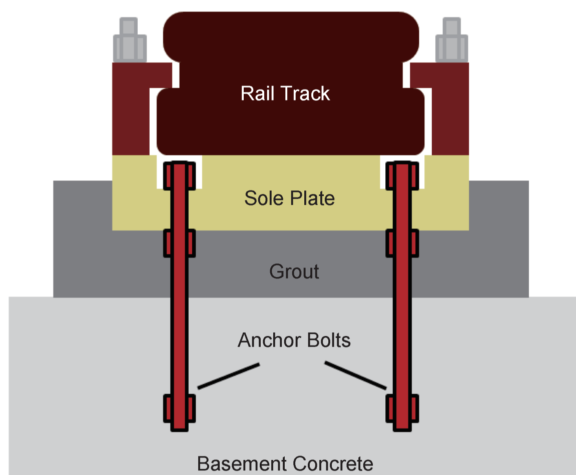

Fig. 3 A schematic cross section of the substructure of the antenna.

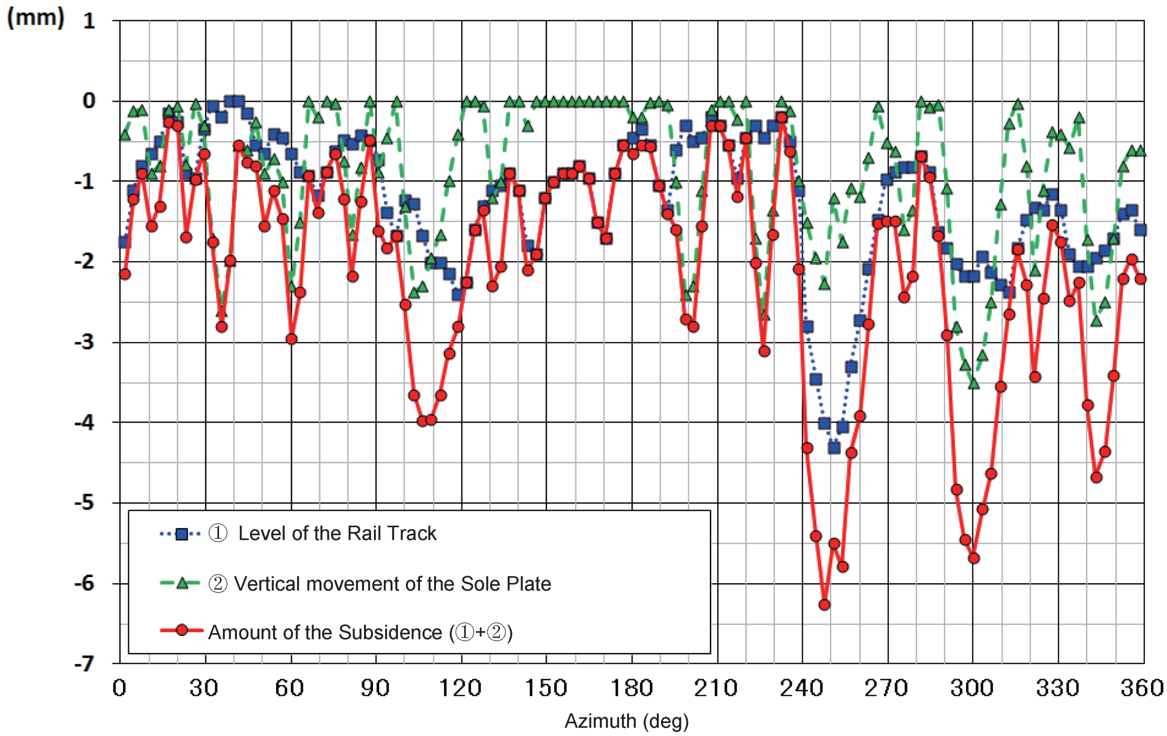

Fig. 4 The results of the leveling, the vertical movements, and the estimated subsidence amounts of the antenna. The blue squares, the green triangles, and the red circles show the level of the rail tracks, the vertical movements of the sole plates, and the estimated subsidence of the antenna respectively.

subsidence amount of the antenna was also plotted in Figure 4. The maximum subsidence came to 6 mm.

2.3 The Relationships Between the Elevation Offsets and the Subsidences

Assuming that the superstructure of the antenna is a rigid body, the antenna will miss the target when the wheels are located on subsidence spots (Figure 5). For example, we consider the case that one of the wheels is located on the maximum subsidence spot. In this case, both of the front wheels subside about 5 mm while both of the rear wheels scarcely subside (Figure 6). Five millimeters of the subsidence of the front wheels causes 52 arcseconds of the offset. The actually measured elevation pointing offset in such an arrangement of the wheels was 51 arcseconds (see Figure 2). That is, the subsidence of the antenna is able to cause the measured offset.

We reviewed the relationships between the measured elevation offsets and the estimates of the offsets caused by the subsidences. In almost all the cases, the positive/negative sign coincided with each other between both the measured and the estimated offsets. However, the estimated offset was insufficient to produce the whole amount of the measured offset in many cases. Considering these relationships, the fundamental cause of the measured offset was the subsidence of the antenna.

3 Repair

In order to prevent the antenna from subsiding and to reduce the offset, we conducted two kinds of repairs. One repair was the lifting up of the concavely deformed rail track. The other repair was the filling up of the gaps under the sole plates with new firm grout. It was con-

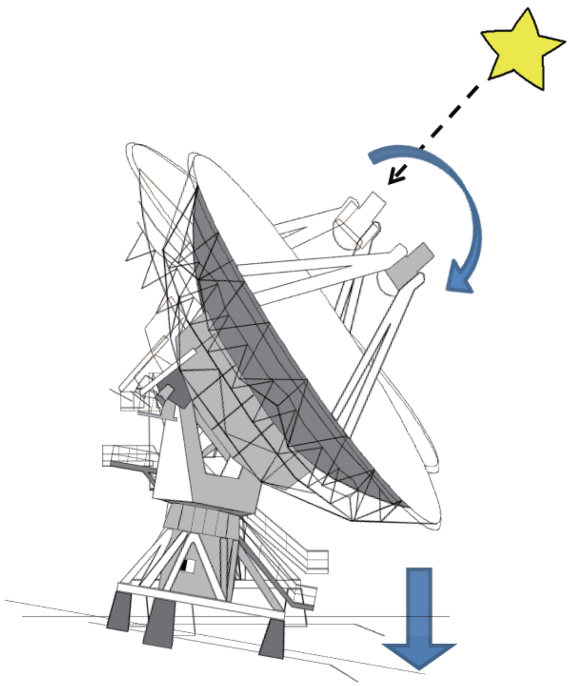

Fig. 5 Missing the target if some wheels subside.

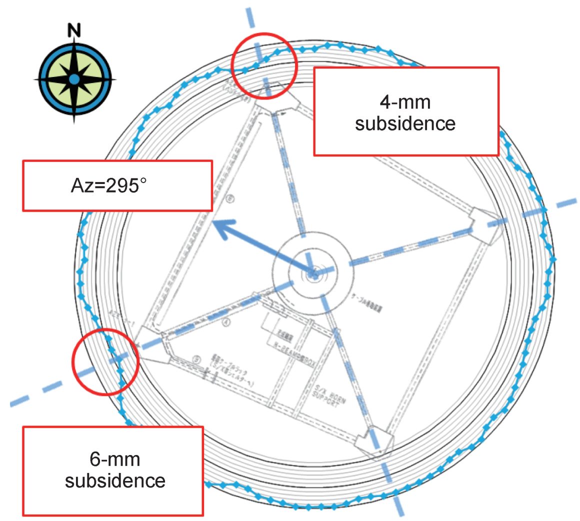

Fig. 6 The configuration of the antenna when one of the wheels is located on the maximum subsidence spot.

ducted under high pressure in order to fill every corner of the gaps.

After the repair, we measured the level and the vertical movements again. As a result, the concavely deformed rail track was raised by 1.5 mm, and almost all the vertical movements of the sole plates no longer existed. Eventually, the range of the subsidence was reduced to 2.5 mm (Figure 7).

We checked the pointing accuracy of the antenna after those measurements. Although some of the offsets remained, most of the offsets were improved. The maximum offset was reduced to 100 arcseconds, which did not have harmful influence on observations (Figure 8). At last, we resumed observations from the end of November.

4 Conclusions

All observations at the Tsukuba VLBI station were interrupted by the damage to the substructure of the antenna. Investigations revealed the deformations of the rail tracks and the vertical movements of the sole plates. By checking the relationship between the measured elevation offsets and the estimates of the offsets caused by the subsidence of the antenna, it turned out that the subsidence was the fundamental cause of the measured offset. Most of the subsidences were cleared, and the pointing offset was improved substantially by the repair. Finally, the Tsukuba VLBI station returned to sessions from November 2013.

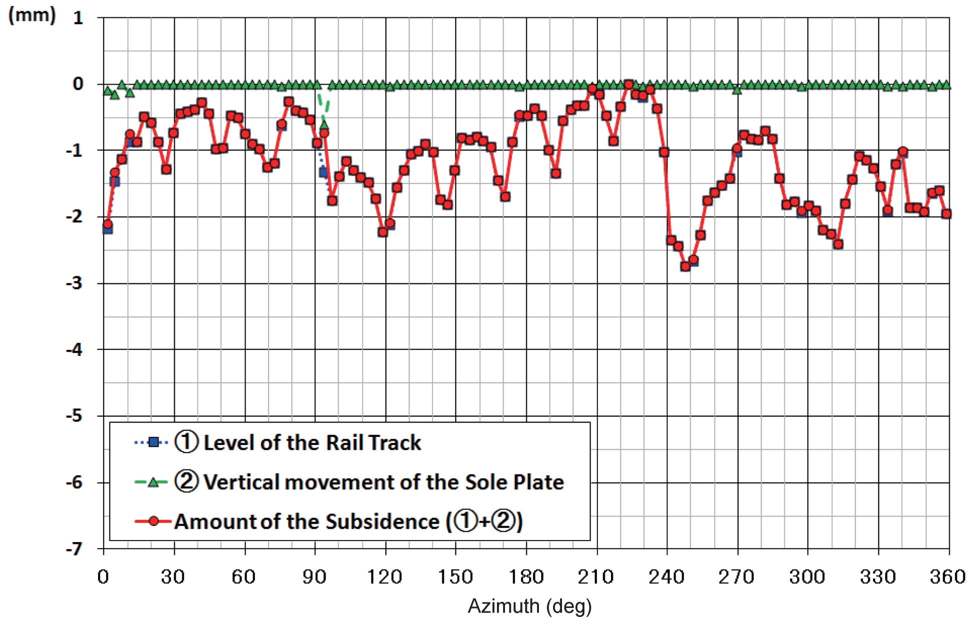

Fig. 7 The results of the investigations after the repair. The blue squares, the green triangles, and the red circles show the level of the rail tracks, and the vertical movements of the sole plates and the estimated subsidence, respectively.

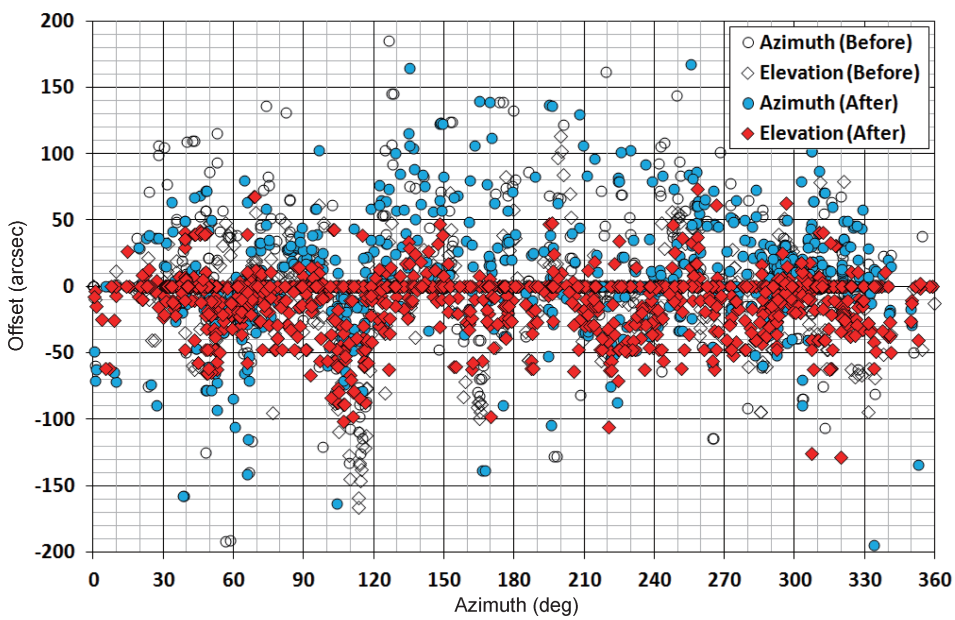

Fig. 8 The azimuth and elevation pointing offsets after the repair plotted as a function of the azimuth direction. The offsets before the repair are also plotted by open circles and rhombuses.