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Agenda Item 5: Radio Altimeter Issues

Preliminary measurement of base station signal characteristics of Sub-6 band 5G mobile communication systems around and above an airport

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SUMMARY

The base station signal characteristics of Sub-6 band 5G mobile communications system around and above Sendai International Airport and Sendai City is measured using a 5G NR signal analyzer. The measurement includes the frequency band between 3.6 and 4.1 GHz and that between 4.5 and 4.6 GHz, which covers all Sub-6 band 5G communication systems currently operated in Japan. Although the results are obtained with a receiving antenna inside the cabin and the obtained signal power may be lower than the actual power received with radio altimeter antenna, it still exceeds the interference tolerance mask value obtained under Japanese frequency conditions. Conversely, signals with 100 MHz guard band frequencies, which cause the greatest interference, are only observed in a few locations. These electromagnetic environments need to be measured and evaluated continuously in the future.

1. INTRODUCTION

This paper discusses the measurements of the base station signal characteristics of Sub-6 band 5G mobile communication systems around and above Sendai International Airport, located in northeast Japan. The results of flight experiments evaluating radio altimeter interference due to Sub-6 band 5G mobile communications have been reported previously [1], [2]. However, evaluation results for the actual base station signal characteristics around and above an actual airport are limited. First, the measurement setup employed to evaluate the base station signal characteristics is discussed. The measurement scenario, which includes the ILS approach scenario, and urban area flight scenarios, is then explained. Finally, the altitude characteristics of the base station signal in different flight areas are evaluated based on the obtained results.

2. DISCUSSION

2.1 Measurement setup

Table I summarizes the parameters used to measure the base-station signal characteristics. The measured frequency ranges are 3.6–4.1 GHz and 4.5–4.6 GHz, which cover all Sub-6 band 5G communication systems currently operated in Japan. Figure 1 shows a block diagram of the measurement setup. A receiving omnidirectional antenna, connected to a four-way splitter, provides the signal to a 5G NR signal analyzer (VIAVI OneAdvisor800) and a real-time spectrum analyzer (Keysight Technologies N9918B). A 5G NR signal analyzer captures the signal strength of each carrier channel at intervals of 1 s. In addition, a real-time spectrum analyzer is used to monitor the spectrum.

Table I. Measurement parameters

Frequency band	Sub-6 band 5G communication system currently operated in Japan: 3.6–4.1 GHz, 4.5–4.6 GHz
Receiving antenna	Omnidirectional antenna inside the cabin
Measurement instruments	5G NR signal analyzer
Measurement scenario	ILS approach scenario Urban area scenario at 2000 ft, 3000 ft (Flight above Sendai central business district and density area)

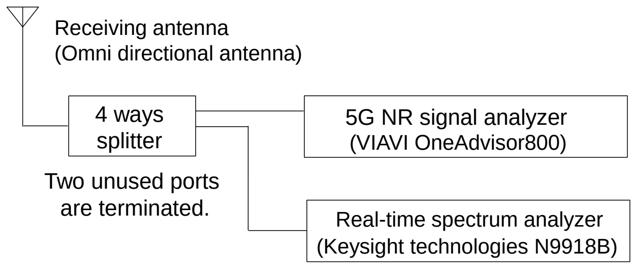


Figure 1. Block diagram for the measurement of the base station signal characteristics of a Sub-6 band 5G mobile communication system.

Figure 2. Beechcraft B300 aircraft (used for flight experiments) and location of the receiving antenna.

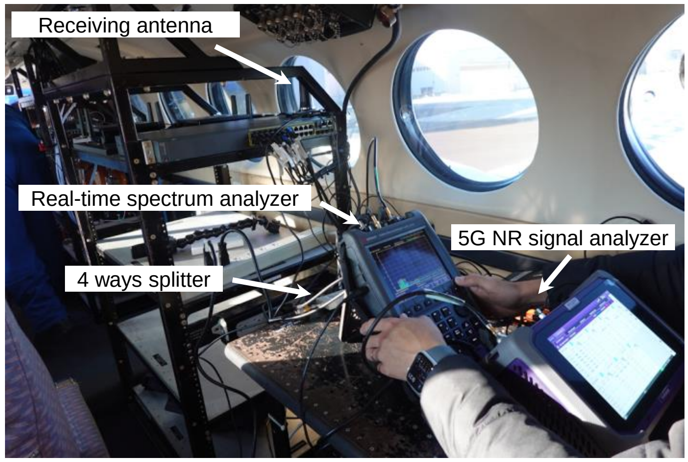


Figure 3. Overview of the measurement setup inside the cabin of the Beechcraft B300. The receiving antenna is located on the side of the right window.

2.2 Measurement scenario and typical results

A limitation of this test is that the receiving antenna is installed inside the aircraft to avoid modifying the aircraft. Therefore, owing to window and fuselage losses, measurement results may be more than 20 dB lower than the power received by the actual antenna of the radio altimeter. Figure 2 shows an overview of the Beechcraft B300 aircraft (KingAir B350) used for flight experiments and the location of the receiving antenna. Figure 3 shows the measurement setup inside the cabin. The receiving antenna is located on the side of the right window. The flight test comprises two parts. One is an ILS approach scenario, and the other is a flight scenario over an urban area. After performing multiple ILS approach scenarios in one flight, the aircraft flies over the city. Over the city, the aircraft will fly a raster scan path with an interval of 2 NM at an altitude of 2000 or 3000 ft. Three flight tests are conducted over three days. Figure 4 shows the measured signal strength (indicated as received signal strength indicator (RSSI)) against time and altitude of flight on 18th December 2024. The figure shows that the signal strength varies depending on the frequency band. It can also be seen that the signal strength is the strongest when moving over the ground, and the signal strength tends to increase as the altitude decreases during the ILS approach. Furthermore, the signal strength varies significantly depending on the location and time in the urban areas.

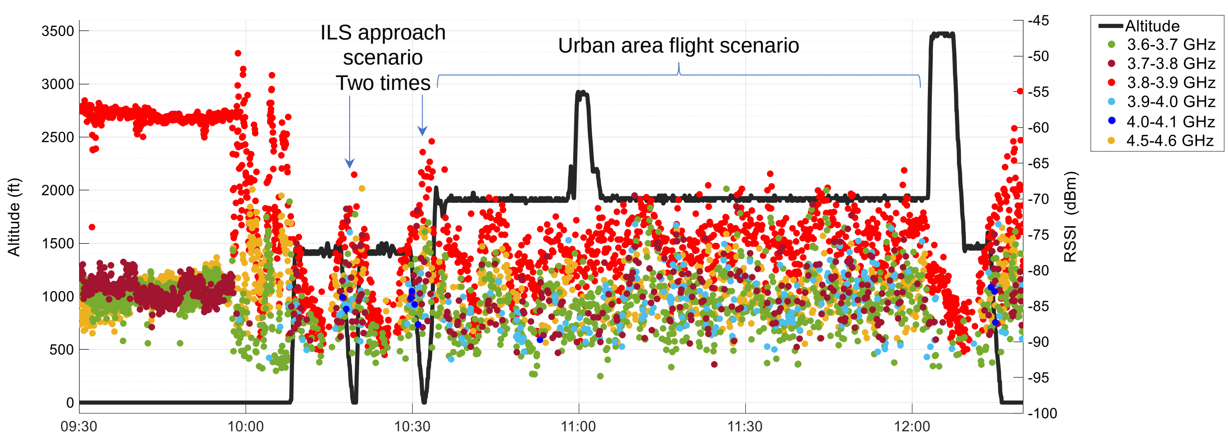
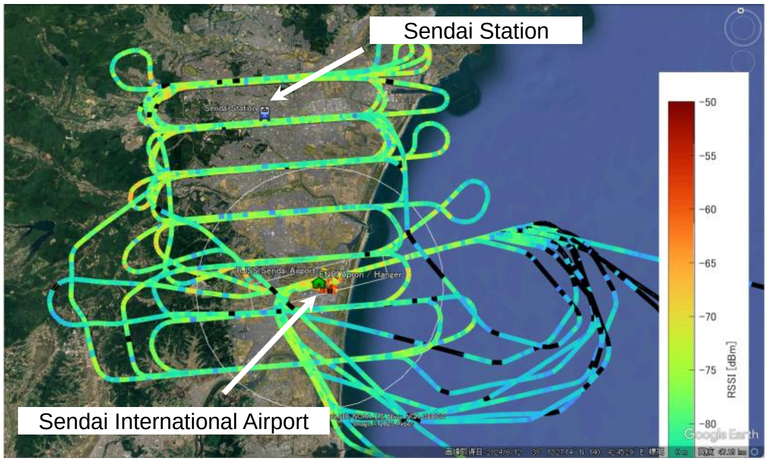
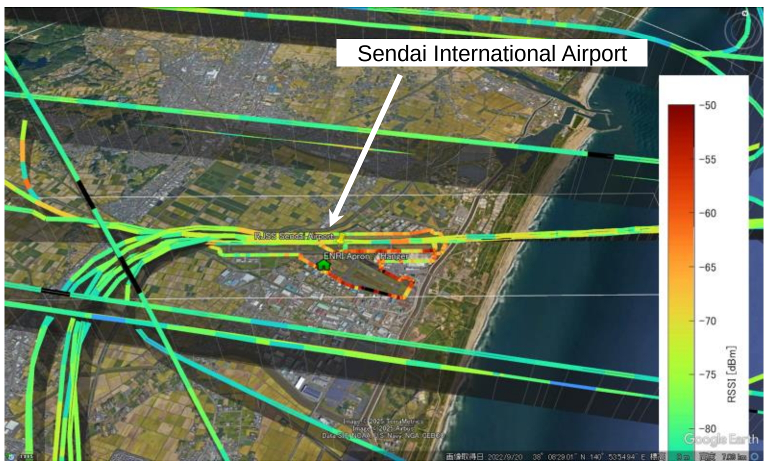


Figure 4. Measured signal strength against time and altitude of flight on 18th December 2024.



(a) All areas



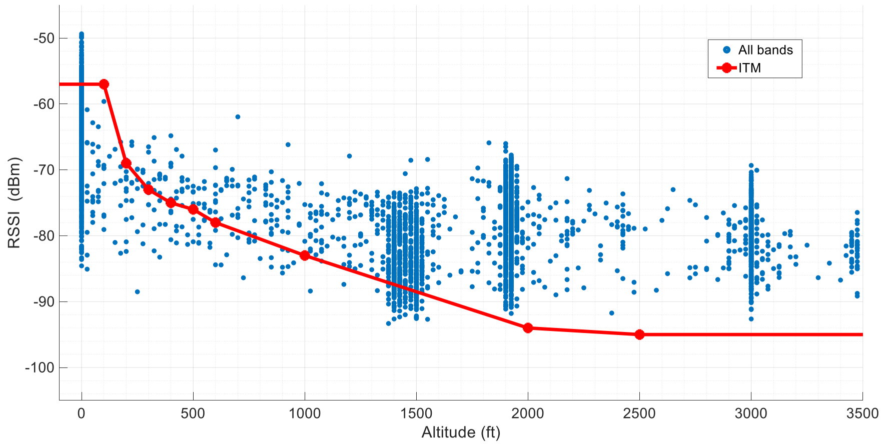
(b) Around the airport

Figure 5. Measured base station signal characteristics for all flight scenarios and ground measurements. The signal characteristics of (a) all areas and (b) areas around the airport are plotted on the flight path.

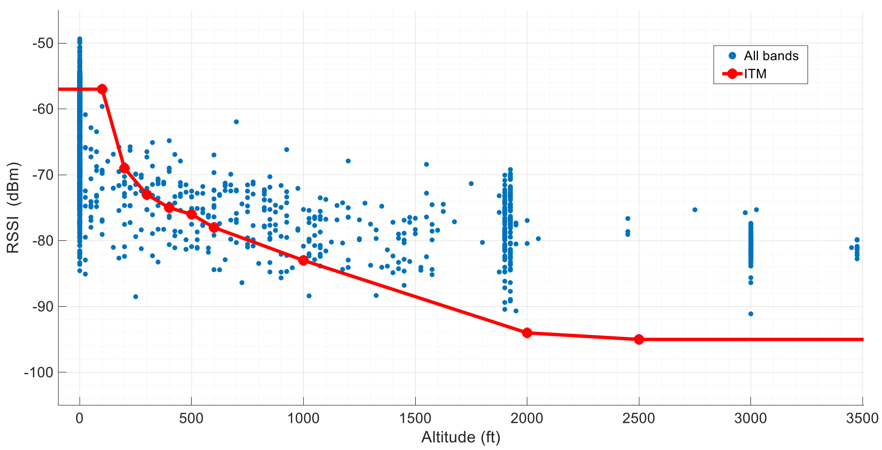
2.3 Altitude characteristics of measured base station signal

Figure 5 shows the measured base station signals along the flight path. In addition, the results of the ground measurements taken using the airport's perimeter roads are also included. Gradations indicate the signal strength, and black lines indicate that no signal is received. This figure shows the signal strength over a two-dimensional location, clearly illustrating that the base station signal levels are particularly high in the low-altitude areas near the airport and in the western area where the ground level is high.

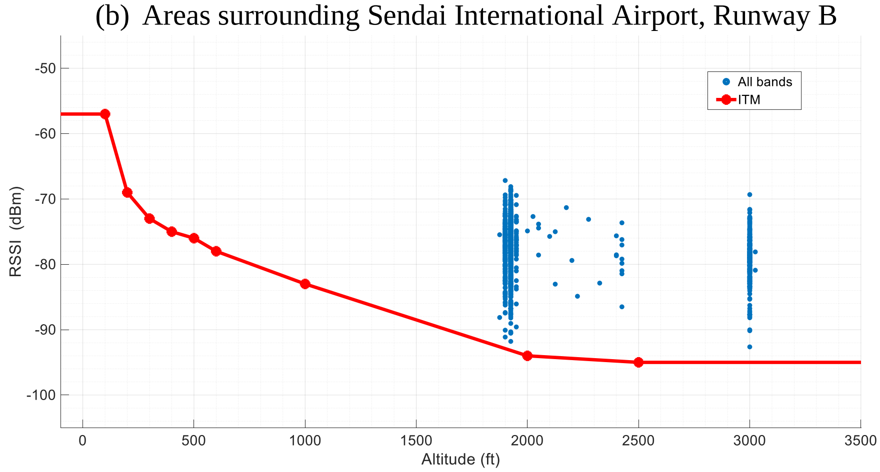
The altitude characteristics of the measured base station signals for all the flights are shown in Figure 6. The results of (a) all areas, (b) the surrounding area of Sendai International Airport Runway B, and (c) the central business district and populated area of Sendai city are shown. The surrounding area of Sendai International Airport Runway B stands inside a rectangular area with a long side of 3 NM from both ends of the runway and a short side of 1.6 NM from the center of the runway. In addition, the central business district and populated area of Sendai city represent the inside of a 9-km-radius circle area centered on the Sendai Station.



(a) All areas



(b) Areas surrounding Sendai International Airport, Runway B



(c) Central business district and populated area of Sendai City

Figure 6. Altitude characteristics of the measured Sub-6 band 5G communications system base station signal strength for all flights: (a) all areas, (b) the surrounding area of Sendai International Airport Runway B, and (c) the central business district and populated area of Sendai city.

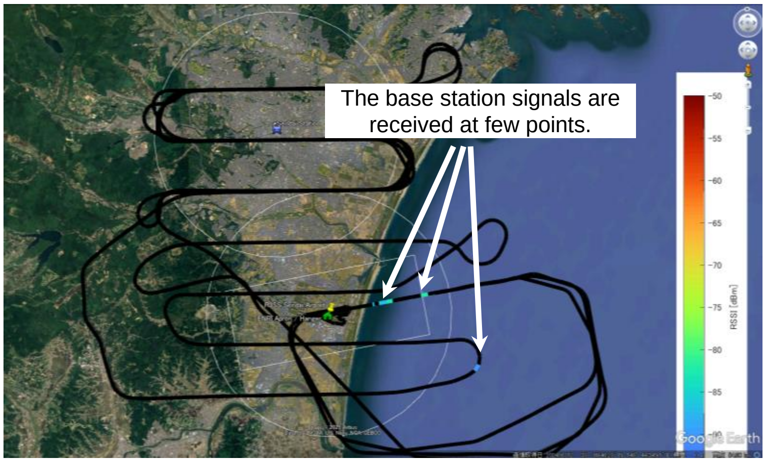


Figure 7. Measured 4.0–4.1 GHz band base station signal characteristics for all flight and ground evaluations.

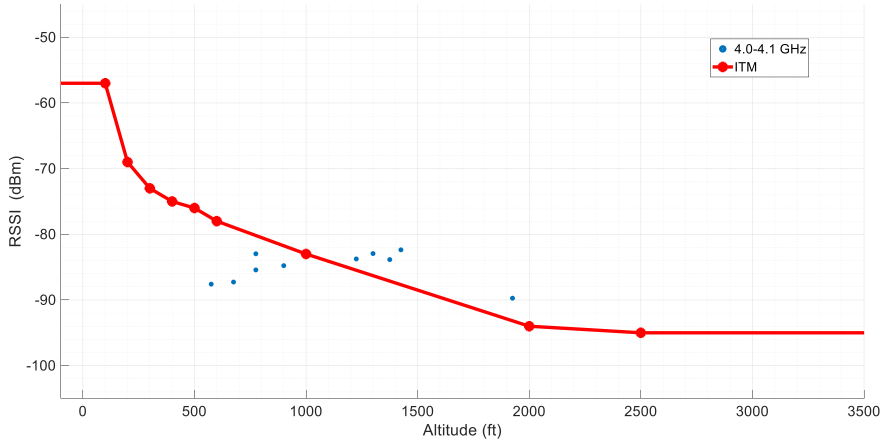


Figure 8. Altitude characteristics of the measured 4.0–4.1 GHz band base station signal strength for all flight scenarios and ground evaluations.

These figures combine the base station data for all frequencies. They also show the interference tolerance mask (ITM) values, which includes a 6 dB ICAO safety margin, obtained under previously reported Japanese frequency conditions [3] and additional measurements. The ITM values are lower than those listed in the RTCA report [4] because of Japan's narrow guard band of 100 MHz. The figures confirm that the base station signal strength exceeds the ITM values for all evaluation areas. As mentioned in the previous section, these measurements are performed using the receiving antenna inside the cabin. It is important to note that the actual power received by the radio altimeter antenna may be higher.

The ITM value presented in this study is the minimum value for all Sub-6 frequencies. However, the minimum ITM value is obtained in the 100-MHz guard band, i.e., 4.0–4.1 GHz. Therefore, Figures 7 and 8 show the measurement results for the 4.0–4.1-GHz frequency band in all flight tests and the altitude characteristics of the base station signal characteristics, respectively. These results confirm that the coverage of the base stations for the 4.0–4.1-GHz frequency band is limited to the Sendai airport and Sendai city. If the number of base stations in these frequency bands increases in the future, there is a concern that the signal power of the base station will exceed the ITM value of the radio altimeter.

3. CONCLUSION

The base station signal characteristics of a Sub-6 band 5G mobile communication system around and above Sendai International Airport and Sendai City were measured and evaluated. These results represent the first preliminary evaluation of the Sub-6 band 5G signal strength in the sky over Japan and will provide fundamental data for future evaluations of potential interference with aircraft radio altimeters. Although this result was obtained with a receiving antenna inside the cabin and the obtained signal power may be lower than the actual power received by the radio altimeter antenna, it still exceeded the ITM value obtained under Japanese frequency conditions. Furthermore, as this measurement clarified, the installation of Sub-6 band 5G base stations in Japan is still in the process of expansion, and nationwide deployment has not yet been completed. Consequently, there are concerns that the ITM value of radio altimeters may exceed those around airports and above urban areas, as base station installations will expand in the future. We will continue to conduct periodic measurements to assess the electromagnetic environment surrounding the radio altimeter frequency bands.

REFERENCES

[1] France, “Outcome from preliminary trial on one type of radio altimeter fitted on helicopter,” ECC PT1 document, ECC PT1(21)192, Sep. 2021.
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[3] S. Futatsumori, "Radio altimeter interference susceptibility test results under Japanese sub-6 5G mobile communications system frequency conditions," ICAO Frequency Spectrum Management Panel, WG/15/IP03, Aug. 2022.
[4] Radio Technical Commission for Aeronautics (RTCA), “RTCA SC-239: Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations,” RTCA Paper No. 274-20/PMC-2073, Oct. 2020.

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