Start of Transmission from Tokyo Skytree

—Part 1: History of the Relocation Project—

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Efforts to switch over to digital broadcasting began to gather momentum from around 1997, when NHK (Japan Broadcasting Corporation) and five commercial broadcasters based in Tokyo entered into discussions regarding a suitable transmission site.

Although the idea of attaching transmitters to the Tokyo Tower was investigated, its operator (Nippon Television City Corporation) was initially of the opinion that the tower had neither enough space for the attachment of digital broadcast antennas, nor enough strength to support their weight.

There was also insufficient space to house the transmitter equipment, so if the Tokyo Tower were to be used for broadcasting, a new building would have to have been built nearby to house the transmitter equipment.

Besides, there are many more high-rise buildings in central Tokyo today compared with when the Tokyo Tower was built, so the interference of radio waves from the Tokyo Tower has increased significantly. The construction of tall buildings is likely to continue into the future.

Therefore, in 1998, a transmission-related project was set up by NHK and five commercial broadcasters, who began discussing the idea of building a new broadcasting tower.

1. Initial studies of the new tower

At this stage, the investigations initially focused on three candidate sites — the Tokyo Tower, Saitama Tower and Tama Tower. Plans had been made to use UHF signals for digital broadcasting, but these were said to have a shorter propagation distance than VHF signals. It was also necessary to consider the cliff effect (cut-off characteristic) that is inherent to digital broadcasting. It was therefore concluded that a taller tower was needed to allow signals to propagate further, and that the tower should be roughly 500 m tall. We investigated the total cost of each approach, including not only the master station but

also the number of relay stations required, and summarized these results in an interim report.

As a result, we found that a tower at least 500 m tall could also reduce the number of relay stations required. (However, since there was not enough time for relocation to take place before the end of analog transmissions, it was ultimately not possible to reduce the number of relay stations.)

After that, a new tower study project and a current tower project were set up in conjunction with a further six companies based in Tokyo. These projects published two reports in June 1999.

Due to the time taken to conduct these studies, it was by this stage starting to seem unlikely that a new tower could be constructed in time for the start of digital broadcasting.

Therefore, to make the September 1999 plan more realistic, scenarios were prepared for the introduction of terrestrial digital broadcasting.

2. Proposal of a stepped transition to transmissions from a new tower

This proposed scenario corresponds to the case where high-power broadcasting is performed from another transmission point after broadcasting at low power from the existing tower.

Before starting digital broadcasting, it was necessary to change the frequencies used for analog broadcasting.

Since full-power transmissions were to start after changing the analog frequencies in regions with large numbers of residential households, such as the service areas of the Tama and Utsunomiya relay stations, it was decided that low-power transmissions would be made from the Tokyo Tower during the initial stage of digital broadcasting. Therefore, a plan was drawn up whereby the existing Tokyo Tower would initially be used only for low-power transmissions for a few years, and then a single-frequency network (SFN) would be configured using high-power transmissions from a new transmitter tower, together with low-power transmissions from the Tokyo Tower, before completing the transition to the new transmitter tower.

An issue to be resolved in this case was the degree to which SFN interference would result in households being unable to receive a signal. It was found that the number of affected households was very large, so a stepped transition would be difficult to achieve in an SFN configuration. This meant that a single overnight switchover was the only viable option.

Thereafter, from 2000, Nippon Television City Corporation proposed the construction of a new tower situated 130 m away from the existing Tokyo Tower. This proposal was also considered by the transmission-related project.

Although technically sound, this proposal was severely hampered because the vicinity of the existing tower is designated as an existing non-compliant structure according to Japanese aviation law, which would mean having to obtain a special dispensation from the Ministry of Transport to build a new tower in this location.

3. Expanding the One-Seg area, and increasing the field strength

There were some broadcasting companies that questioned the need for this, and in 2002 a private research establishment was commissioned to examine the feasibility of a new tower. The report on this study was submitted in 2003.

This resulted in a significant expansion of the area in which One-Seg can be viewed, and also increased the field strength. This makes it possible to ensure that critical infrastructure remains available in the event of a natural disaster, and from a business perspective it also had advantages such as support for advertising in the mobile communication era.

Initially, it was decided that digital transmissions would start at the Tokyo Tower, and would then be transferred to the new tower. The structure of the Tokyo Tower was partially reinforced, and a new transmitter room was installed below the tower's observation deck. A multi-faceted antenna for digital transmissions was installed in the lower part of the gain tower for the existing analog antenna.

From December 2003, terrestrial digital television was first started in Japan's major cities — Tokyo, Osaka and Nagoya. In Tokyo, the signals were initially transmitted at low power from the Tokyo Tower

4. Establishment of a new Tokyo Tower expert committee in 2004

Considering the growing rivalry between potential locations for the new tower, the six companies established an expert committee on candidate sites for the new tower. The members of this committee were chosen from among university professors and other specialists in fields such as urban landscaping, seismology, city planning, electromagnetic wave propagation, civil engineering and tourism.

Four candidate sites were shortlisted from a total of fifteen candidates, and finally in March 2005 the findings of this study were released. Sumida ward was recommended because it is close to the city center and would allow viewers in most places to continue receiving signals without having to adjust the direction of their antennas.

Based on this report, the six companies finally announced at the end of March that Sumida ward had been chosen as the prime contender.

This was followed by a series of discussions with the site's owner (the Tobu railway company) regarding the building specifications and other matters, and the formal decision to go ahead with construction was made in March 2006. The Tobu railway company held a groundbreaking ceremony in 2008, and it was decided that the new tower would be called the Tokyo Skytree.

After resolving many issues relating to the tower's design and construction (bearing in mind the prevalence of earthquakes in Tokyo), the construction was completed in May 2011. The Tokyo Skytree is 634 m tall, making it the highest free-standing broadcasting tower in the world and a center of tourism in Tokyo.

5. Advance investigation of reception hindrances caused by relocating the transmitter station to the Tokyo Skytree

NHK and the five commercial broadcasting companies formed an investigative working group, and convened 83 times on a once-per-week basis. The working group conducted wide-ranging field studies as described below. The procedure for the simulation of reception difficulties was more or less the same as the procedure used by the joint council for the promotion of terrestrial digital broadcasting (an organization formed by the Ministry of Internal Affairs and Communication) when studying the change of analog frequencies and the start of terrestrial digital television broadcasting (master stations and relay stations). Studies were conducted on the following topics:

- Interference countermeasures in the Kanto region: Interference between relay stations constituting the single frequency network (SFN)
- Interference countermeasures for neighboring prefectures: Interference of broadcasting in neighboring prefectures using the same channels as Tokyo (e.g., Fukushima master station, Kofu master station, Mishima relay station)
- Reception measures for the local vicinity of the tower: Reception difficulties arising from the fact that the electric field strength from the Tokyo Skytree is greatly reduced compared with the Tokyo Tower
- Countermeasures for reception difficulties caused by buildings: Countermeasures to new incidences of signal blocking by buildings
- Booster interference countermeasures: Countermeasures for excessive input to the boosters used in ordinary receiver equipment
- Countermeasures to interference in channel 28 (the Open University of Japan): Countermeasures for reception difficulties arising due to the lack of an adequate adjacent channel protection ratio for channel 27 (used by the Skytree) and channel 28 (which continues to broadcast from the Tokyo Tower)
- Reception countermeasures for communal reception facilities in outlying areas and for communal reception facilities with interference countermeasures: Countermeasures for reduced/increased electric field strength or interference occurring due to changes in the reception environment at the point of reception
- Interference countermeasures for reception at relay stations: Countermeasures for reduced/increased electric field strength or interference occurring due to changes in the reception environment at the point of reception
- Reception surveys and countermeasures for relay stations receiving signals from the tower, methods for the utilization of test signals

6. Basic concepts of simulation

The area being studied was subdivided by a fine grid drawn onto a map, and at a representative point in each grid cell, a table (called an electric field list) was produced from data including the electric field strengths of the Tokyo Skytree signal, the Tokyo Tower signal, and other signals that use the same frequency and arrive from relay stations necessary for studies and the like. This data was then subjected to probabilistic analysis according to statistical methods by using the macro function of a spreadsheet application. As a result of this analysis, decisions were made such as whether or not it was possible to set up a SFN and whether or not there would be interference between different programs. The possibility of successful reception in each area was also calculated and used to derive a figure for the number of affected households, which was plotted on the map in order to visualize the data.

Furthermore, to predict the occurrence of booster interference, the performance of a commercial booster was modeled, and was used to quantitatively evaluate the reception interference resulting from the intermodulation components of the harmonics such as the third and fifth harmonics generated by non-linear input/output characteristics.

Based on the number of affected households, the scale of countermeasures was calculated by considering a menu of countermeasures suited to each form of interference.