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Agenda item n.n

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Result of a Field Trial on VHF Digital Voice Communication

# Summary

Japan Coast Guard (JCG), Japan Aids to Navigation Association (JANA), Japan Radio Co., Ltd. (JRC), and Tokyo University of Marine Science and Technology (TUMSAT) conducted a field trial on VHF digital voice communication.

Digital communication performs better than analogue communication within the range of 30 kilo metres. However, sudden degradation of voice communication was observed in certain condition and/or at longer distance.

In general, transmission distance of digital voice communication was longer than analogue one, and digital voice was evaluated as clearer than analogue voice. In addition, it was assessed that the head loss in the digital voice was not a practical problem.

## Purpose of the document

This document provides the result of a field trial on VHF digital voice communication in order to facilitate the discussion in the IALA committees.

## Related documents

1. NCSR12/20 Report to the Maritime Safety Committee
2. DTEC2-5.2.2.2 Demonstration paper for VHF digital communications
3. VTS55-5.2.1 Inf paper VHF digital demo Japan

# Background of the digitalisation of VHF voice communications

VHF voice communication is an essential and widely used means of communication to ensure the safety of navigation, and the efficient use of VHF frequency spectrum is being considered due to growing need for introduction of VHF Data Exchange System (VDES).

The VHF digital voice communication will contribute to a more efficient use of spectrum, as it uses only half of the bandwidth of existing VHF analogue communication. In addition, the clear voice provided by the digital modulation could improve the Vessel Traffic Service (VTS) operations. On the other hand, however, there are concerns that VHF digital communication may introduce another risk due to the reduced background noise, which is sometimes useful for the VTS operators.

The World Radiocommunication Conference 2023 (WRC-23) resolved that the consideration of improving the utilization of VHF marine radiocommunication should be included in the preliminary agenda of WRC-31(Preliminary Agenda Item 2.7). The digitalization of VHF voice communications could be considered in the scope of the preliminary agenda item.

In addition, to guide regulatory developments of the International Telecommunication Union (ITU), the International Maritime Organization (IMO) resolves that the development of a transition scheme for the introduction of digital technology for VHF voice communication is included in the biennial agenda of the Sub-Committee on Navigation, Communication and Search and Rescue (NCSR) for the 2026-2027 biennium as an urgent matter. And the provisional agenda for NCSR 13 an output on "Development of a transition scheme for the introduction of digital technology for very high frequency (VHF) voice communications", with a target completion year of 2027.

Similarly, at IALA, discussions on VHF digital voice communication are just now accelerating, as demonstrated by Japan in DTEC 2 and VTS 55.

In order to facilitate the discussion on the digitalisation of VHF voice communication in the IALA, it would be useful for the members have a better understanding of the technology and how it is heard for considering future usage. JCG, JANA, JRC and TUMSAT conducted a field trial for comparing the analogue and digital voice communication.

# Discussion

## GENERAL INFORMATION

This field trial consisted of two trials. One was a land and sea trial, and the other was a short-range trial. The main purpose of the land and sea trial was to compare analogue and digital VHF voice communications by communicating at sea at line-of-sight distance or further. On the other hand, the main purpose of the short-range trial was to compare analogue and digital VHF voice communications at the same frequency. The land and sea trial was conducted in Tokyo Bay on 17 December 2024, and short-range trial was conducted in TUMSAT on 15 January 2025.

In these trial, two types of radio equipment were used. The one is the IC-F5400DP (vehicle-mounted radio equipment), and the other is the IC-F3400DPS (mobile radio equipment).



IC-F5400DP

IC-F3400DPS

1. radio equipment used in field trial

## EXECUTIVE SUMMARY

In the land and sea trial, digital voice communication was evaluated as clearer than analogue voice communication, and - Transmission distance of digital voice communication was longer than analogue one, generally up to about 30 kilometres without noise. In addition, transmission distance of digital voice communication was longer than analogue one, generally up to about 30 kilometres without noise.

In short-range trial, it was assessed that the head loss in the digital voice communication was not a practical problem.

## RESULTS OF TRIAL

### Land and sea trial

In this trial, participants were divided into two groups (land and ship) and listened to analogue and digital voice. Then, they evaluated two voices according to the evaluation criteria described below in this section. Each group has nine people as evaluators.

#### Equipment and conditions

In this trial, two radio stations placed on land and ship were used to communicate over the actual maritime line-of-sight distance or further, to evaluate analogue and digital voice communication in comparison near the limits of the transmit range. Each following table shows each radio station and ship which was used in this trial.

1. equipment of the radio station on ship (Yayoi)

| Place | Yayoi (Survey and research ship of TUMSAT) |
| --- | --- |
| Height of Antenna | 5.6m (from port to point B, C and D)  4.8m (from point D to port via point A) |
| Radio Equipment | IC-F5400DP |
| Frequency | 157.150MHz (both analogue and digital) |
| Radio Wave Format | 16K0 F3E (analogue)  5K80 F1E (digital) |
| Antenna Power | 25W (from port to point B, C and D)  6W (from point D to port via point A) |
| Antenna | 7ABJD0004 (half-wave vertical dipole antenna) |
| Coaxial Cable | 8D-2V, 12m |

1. equipment of the radio station on land (Futtsu)

| Place | Futtsu, Chiba  (3518'47.12N, 13947'08.23E) |
| --- | --- |
| Height of Antenna | 4.0m |
| Radio Equipment | IC-F5400DP |
| Frequency | 157.150MHz (both analogue and digital) |
| Radio Wave Format | 16K0 F3E (analogue)  5K80 F1E (digital) |
| Antenna Power | 25W (from port to point B, C and D)  6W (from point D to port via point A) |
| Antenna | 7ABJD0004 (half-wave vertical dipole antenna) |
| Coaxial Cable | 8D-2V, 12m |

1. particulars of YAYOI

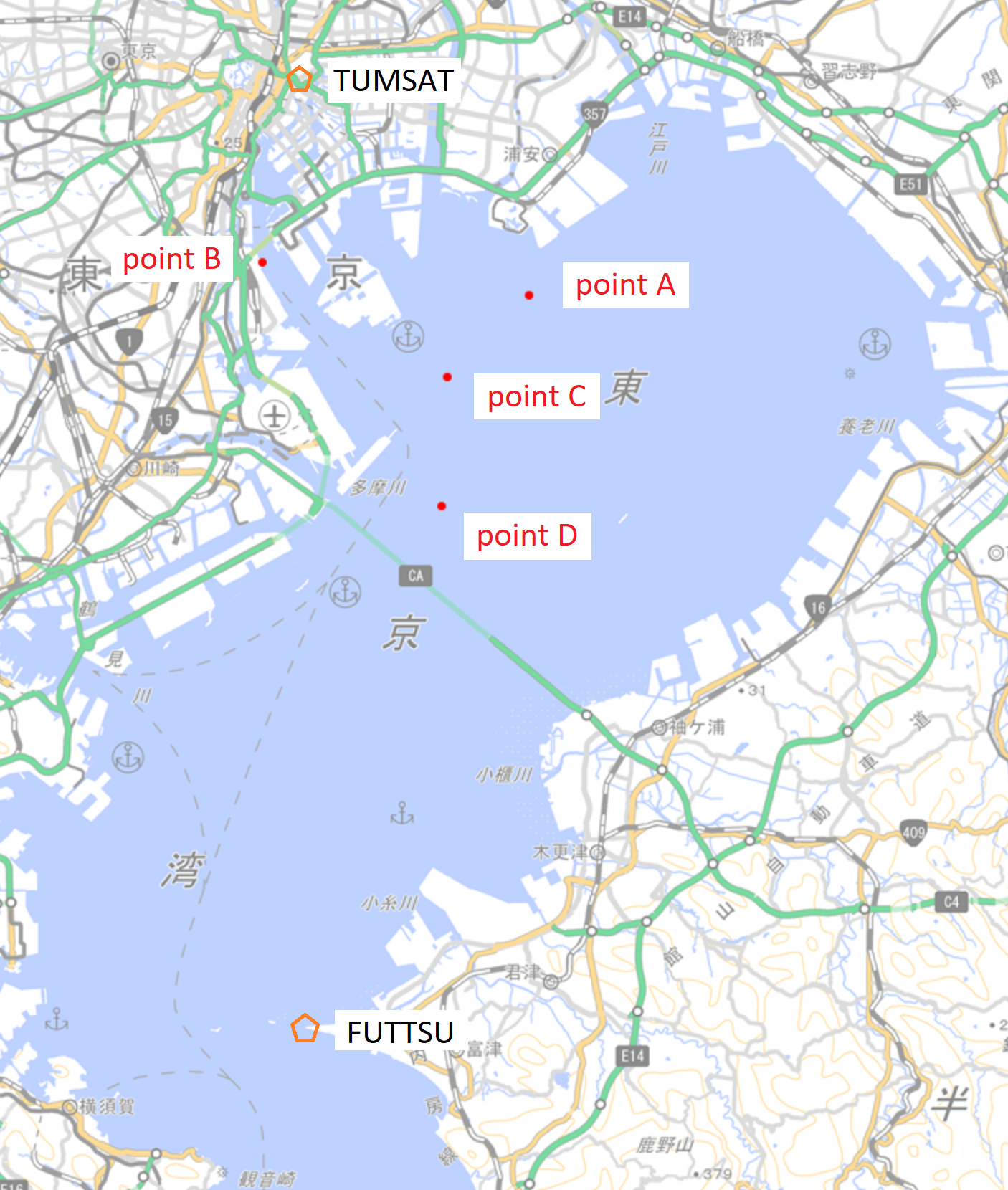
| Length | 17.80m |
| --- | --- |
| Breadth | 4.28m |
| Depth | 1.49m |
| Gross Tonnage | 19 tons |
| Maximum Number of Persons Allowed on Board | 57 persons  (55 persons as passenger and two persons as crews) |
| Material of Ship | Aluminium alloy |

This trial was conducted under following conditions.

1. metrological and hydrographic conditions

| Time | Weather | Temperature (Celsius Degree) | Precipitation (mm) | Wind Direction | Wind Speed (m/s) | Wave (Direction/Height) | Height of Tide (cm) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 09:00 | clear | 8.4 | 0.0 | ESE | 1.4 | calm | 154 |
| 10:00 | 9.9 | 0.0 | ENE | 0.8 | calm | 133 |
| 11:00 | 11.3 | 0.0 | ENE | 1.4 | calm | 121 |
| 12:00 | 11.6 | 0.0 | SE | 2.8 | calm | 114 |
| 13:00 | 12.0 | 0.0 | SE | 1.4 | calm | 121 |
| 14:00 | 12.2 | 0.0 | ENE | 2.2 | calm | 135 |
| 15:00 | 11.9 | 0.0 | ENE | 2.0 | calm | 155 |

This trial was conducted in areas that following figure is showing.



1. places where land and sea trial was conducted

Each point in the previous figure indicates following places.

* point A: 3535.884'N, 13953.548'E (app. 17.9NM from Futtsu).
* point B: 3536.649'N, 13945.899'E (app. 17.9NM from Futtsu).
* point C: 3533.970'N, 13951.214'E (app. 15.5NM from Futtsu).
* point D: 3530.964'N, 13951.043'E (app. 12.6NM from Futtsu).

#### Methods and evaluation items

In this trial, three test was conducted.

* Sensitivity and clarity.
* Unpredictable.
* Comparison of transmission distances.

Yayoi departed TUMSAT and went in order B, C, D and A. Each test was conducted at each point.

In the sensitivity and clarity test, receivers compared analogue and digital voice, used same text, and evaluated ease of hearing (sensitivity and clarity) in five degrees as below.

1. evaluation criteria of sensitivity and clarity test

|  |  |  |
| --- | --- | --- |
| Degree | | Evaluation Criteria |
| 5 | Extremely good | Stable and good reception without noise |
| 4 | Good | There is a little noise, but it does not interfere with the call |
| 3 | Middle | Weak signal, lots of noise, but content can all be understood at once |
| 2 | Poor | Choppy but understandable if you listen again |
| 1 | Bad | It can be seen that signals are transmitted, but it cannot be understood the contents. |
| - | No signal | No signal (in case of digital, it is not demodulated at all) |

Unpredictable test was conducted at point C and D, then receivers evaluated in five degrees as below.

1. evaluation criteria of unpredictable test

|  |  |  |
| --- | --- | --- |
| Degree | | Evaluation Criteria |
| 5 | Extremely good | Completely clear and there is no room for misunderstanding |
| 4 | Good | Mostly clear, but with slight possibility of misunderstanding |
| 3 | Middle | Understandable, but some words are unclear |
| 2 | Poor | Difficult to understand what is said and many words are unclear |
| 1 | Bad | Hardly understand |

Furthermore, the sent sentences were compared with the texts written down by the evaluators and three figures were obtained as shown in the table below.

1. definitions of figures obtained in unpredictable test

|  |  |
| --- | --- |
| Percentage Correct | Percentage of texts with content understood and fully written down |
| Percentage Incorrect | Percentage of texts containing some of the content listened and also incorrectly listened |
| Percentage Not Understood | Percentage of the whole or part of the texts that were not listened |

However, in the calculation of these figures, the correctness of the written text and transmitted sentences is subjective to the enumerator, and some of the figures are accounted for in both the percentage incorrect and not understood.

In the comparison of transmission distance, both modulation systems were compared by alternating between analogue and digital while gradually increasing the distance between the station on ship and the land station. This test was conducted using the same radio equipment, with the same frequency, antenna hight and antenna power, but switching only the modulation system.

It was conducted from the point D to the point A. Transmitter continuously transmitted the same sentence, switching between analogue and digital, and the point at which sensitivity and clarity changed was recorded. Sensitivity and clarity were also evaluated the same criteria as given in table five.

In this test, as it was anticipated that the test would not be completed within the scheduled area due to excessive radio reception if the test was conducted under the same conditions as the sensitivity and clarity test, the antenna power of both station and the antenna hight of the ship station were changed as following table.

1. changes of power and hight of antenna in the comparison of transmission distance

|  |  |  |  |
| --- | --- | --- | --- |
| Station | Item | Before Change | After Change |
| Ship | Antenna power | 25W | 6W |
| Antenna hight | 5.6m | 4.8m |
| Land | Antenna power | 25W | 6W |
| Antenna hight | 4.0m | 4.0m |

#### Results

The following table summarizes the results of both analogue and digital voice at points A to D in the sensitivity and clarity test.

1. results of the sensitivity and clarity test

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Points | A | | B | | C | | D | |
| Antenna Power | 6 W | | 25 W | | 25 W | | 25 W | |
| Distances from Futtsu | 17.9 NM | | 17.9 NM | | 15.5 NM | | 12.6 NM | |
| Modulation | Analogue | Digital | Analogue | Digital | Analogue | Digital | Analogue | Digital |
| Ship | 1.21 | 2.25 | 2.88 | 4.39 | 3.76 | 5.0 | 4.53 | 4.94 |
| Land | 2.35 | 3.13 | 4.00 | 4.11 | 4.50 | 5.0 | 5.00 | 5.00 |

From the above table, it can be read that receiver evaluated digital voice as clearer than analogue voice at all points. On ship in particular, clarity of the digital voice was clearly higher in an environment with a lot of ambient noise, such as engine noise.

In the unpredictable test, receivers evaluated as following two tables. These tables also indicate each percentages obtained according to Table 7.

1. result of the unpredictable test at point C

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Modulation | Evaluator | Degree | Percentage | | |
| Correct | Incorrect | Not Understood |
| Analogue | Ship | 3.7 | 58.8% | 17.6% | 29.4% |
| Land | 4.5 | 56.3% | 37.5% | 6.3% |
| Digital | Ship | 2.1 | 0.0% | 13.3% | 86.7% |
| Land | 3.9 | 56.3% | 18.8% | 25.0% |

1. result of the unpredictable test at point D

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Modulation | Evaluator | Degree | Percentage | | |
| Correct | Incorrect | Not Understood |
| Analogue | Ship | 4.6 | 82.4% | 5.9% | 11.8% |
| Land | 4.8 | 94.1% | 5.9% | 0.0% |
| Digital | Ship | 4.9 | 88.2% | 11.8% | 0.0% |
| Land | 4.9 | 94.1% | 5.9% | 0.0% |

Above tables show that analogue voice communication tends to maintain a constant level under various conditions, with communication quality varying in steps according to the radio propagation environment. This characteristic ensures relatively stable communication.

In addition, it is observed that digital voice communication exhibited the same or better quality as analogue under normal conditions, but under certain conditions, there was a significant drop in quality.

Furthermore, as a matter of special note, cases were observed, in digital voice communication, a lack caused by a communication failure was mistakenly recognized as a mistake by the transmitter. In analogue voice, voice and noise are heard during communication and the start or continuation of communication can be easily recognized, but in digital voice, the start of communication cannot be clearly identified by speech, and the receiver has difficulty in determining the state of communication because the call starts suddenly. This characteristic may increase the risk of miscommunication and misunderstanding of information between transmitter and receiver.

In the comparison of transmission distances, the distances where sensitivity and clarity were greater than three were approximately 28.6 kilometres in analogue voice communication, and 29.7 kilometres in digital voice communication. The table below shows the distances between land station and points at which the degree had changed.

1. result of the comparison of transmission distance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Change of Degree | 5 became 4 | 4 became 3 | 3 became 2 | 2 became 1 | 1 became 0 |
| Analogue | 23.3 km  (12.6 NM) | 26.7 km  (14.4 NM) | 28.6 km  (15.5 NM) | 30.3 km  (16.4 NM) | 33.7 km  (18.2 NM) |
| Digital | 29.0 km  (15.7 NM) | - | 29.7 km  (16.1 NM) | - | 32.3 km  (17.4 NM) |

The result indicates that digital voice reached slightly further.

About analogue voice, the received sound gradually became noisy when the distance exceeded 23.3 kilometres, the call started to break up when the distance exceeded 28.6 kilometres, and the received signal could not be confirmed when the distance exceeded 33.7 kilometres.

On the other hand, in the case of digital voice, the voice was clear and did not have noise up to a distance of over 29.0 kilometres, and the call was interrupted at a distance of around 29.7 kilometres, shortly after the noise started to mix. For this reason, it was not possible to determine the point at which the sensitivity and clarity went from 4 to 3. When the distance exceeded 29.7 kilometres, the received sound was sometimes demodulated intermittently, but the call content could hardly be determined, and the received sound was not demodulated at all when the distance exceeded 32.3 kilometres.

### Short-range trial

In this trial, the following tests were conducted using mobile and vehicle-mounted radio equipment.

* Test for head loss and connection delays in digital voice communication.
* Comparison of sound quality of speaker in analogue and digital voice communication.
* Comparison of sound quality in analogue and digital voice communication.

Eighteen people attended to this trial as evaluators.

#### Equipment and conditions

Three radio equipment were used, two mobile radio equipment (IC-F3400DPS) and one vehicle-mounted radio equipment (IC-F5400DP)

#### Methods and evaluation items

In the test for head loss and connection delays, evaluators used two mobile radio equipment and experienced head loss and connection delays in digital voice communication by the following procedure.

* evaluator transmitted signal from one side to the other one, and the time to capture the signal was checked. In other words, evaluators experienced the connection delays.
* evaluators spoke by one side and listen on the other one, and they checked whether there is a head loss or not.

The meaning of the two mentioned phrases in this test are as follow.

* *head loss* means to delay in capturing the signal.
* *connection delays* mean lack of speech beginnings in transmitting.

In the comparison of sound quality of speaker, same sentence was transmitted by both modulation systems and received by mobile and vehicle-mounted radio equipment. evaluators then evaluated the audibility of each speaker in five degrees as below.

1. evaluation criteria of the comparison of sound quality of speaker

|  |  |
| --- | --- |
| Degree | Evaluation Criteria |
| 5 | Mobile is better |
| 4 | Mobile is slightly better |
| 3 | Both are the same |
| 2 | Vehicle-mounted is slightly better |
| 1 | Vehicle-mounted is better |

In the comparison of sound quality in analogue and digital voice communications, two mobile radio equipment were used and speakers transmitted same sentence in both modulation systems. evaluators compared sound quality and evaluated in five degrees as below.

1. evaluation criteria of the comparison of sound quality

|  |  |
| --- | --- |
| Degree | Evaluation Criteria |
| 5 | Analogue is better |
| 4 | Analogue is slightly better |
| 3 | Both are the same |
| 2 | Digital is slightly better |
| 1 | Digital is better |

#### Results

The result of the test for head loss and connection delays is as follows.

* In digital voice communication, head loss and connection delays are observed, but many evaluators assessed that these were not a practical problem.
* In analogue voice communication, connection delays were hardly perceptible, but noise made it difficult to hear the voice immediately after the start of reception.

This result shows that although head loss in digital voice communication occurred, head loss also occurred in analogue voice communication, not due to connection delays, and it cannot be said that the lack of beginning of the transmitted content is a disadvantage specific to digital voice communication.

In the comparison of sound quality of speaker, evaluators compared both sound quality of two speakers in analogue and digital voice communication. The sound quality of both speakers was assessed as not being noticeably different. Following table summarizes the result of this test.

1. result of the comparison of sound quality of speaker

|  |  |
| --- | --- |
| Modulation System | Average of Degree |
| Analogue | 2.85 |
| Digital | 2.93 |

In addition, some evaluator pointed out as follows.

* The voice from vehicle-mounted sounded stable, and phrases from it sounded connected.
* The voice from mobile radio equipment was clear.

In comparison of sound quality in analogue and digital voice communications, the average of degree was 3.88, which indicates that digital voice communication was preferred due to its lower noise and clearer sound quality. On the other hand, analogue voice communication was also preferred for its natural sound quality, but it was pointed out that background noise remained as issue. Degree varies from evaluator to evaluator, some evaluator preferring analogue voice.

## CONCLUSIONS

Each trial shows that following points

* Land and sea trial
* In general, digital voice communication was evaluated as clearer than analogue voice communication.
* Analogue voice communication maintains constant quality under various conditions, as the quality of sound varies step by step according to propagation condition of radio waves, whereas digital voice communication degrades significantly in quality under certain conditions.
* Transmission distance of digital voice communication was longer than analogue one, generally up to about 30 kilometres without noise.
* Short-range trial
* Many evaluators assessed that the head loss in the digital voice communication was not a practical problem.
* Although head loss in digital voice communication occurred, head loss also occurred in analogue voice communication, it is not due to connection delays, and it cannot be said that the lack of beginning of the transmitted content is a disadvantage specific to digital voice.
* Many evaluators preferred digital voice due to its lower noise and clearer sound quality, but the other preferred analogue one.

# References

N/A

# Action requested of the Committees

The Committees are requested to note the information in this paper.