International Civil Aviation Organization

NINTH MEETING OF SPECTRUM REVIEW WORKING GROUP (SRWG/9)

Bangkok, Thailand, 07 – 09 May 2025

Agenda Item 10: States and Regional updates

THE USE OF FREQUENCY COUPLING FOR DIRECT CONTROLLER-PILOT COMMUNICATIONS IN HONG KONG, CHINA

(Presented by Hong Kong, China)

SUMMARY

This paper examines the use of frequency coupling in Direct Controller-Pilot Communication (DCPC) and its role in enhancing efficiency, situational awareness, and communication reliability under Hong Kong's air traffic control (ATC) operations. While frequency coupling provides significant benefits, it also induces technical and operational challenges, including undetected simultaneous transmissions, system calibration complexities, intermodulation interference, and difficulties in fault finding. A balanced evaluation of its advantages and limitations is necessary to ensure effective implementation in ATC operations.

1. INTRODUCTION

1.1 What is Frequency Coupling

Frequency coupling is a method of air-ground voice communication that enables an air traffic controller to utilize multiple frequencies simultaneously. Transmission on one frequency is automatically rebroadcasted on other coupled frequencies by the Voice Communication System (VCS). This ensures seamless information exchange among pilots and air traffic controllers operating on these coupled frequencies, enhancing flexibility in air traffic control sectorization and frequency management.

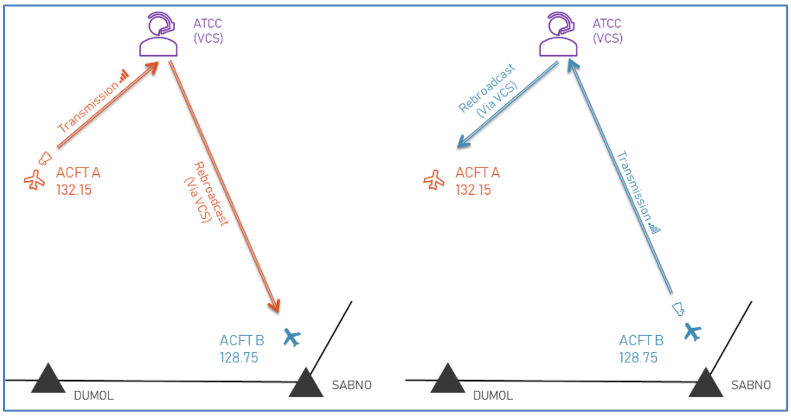

Fig 1 - Transmission rebroadcasted by the VCS

1.2 Considerations for using Frequency Coupling

1.2.1 In Hong Kong, frequency coupling is primarily used for ATC sectors consolidation during low-traffic periods. Frequencies allocated to each sector are coupled, enabling a single air traffic controller to operate multiple frequencies concurrently. This approach maintains ATC operational efficiency without requiring pilots to switch frequencies, while ensuring all pilots on the coupled frequencies retain full situational awareness and maintain good radio discipline.

Fig 2 – An air traffic controller operates multiple frequencies concurrently with frequency coupling

1.2.2 Other regions may utilize frequency coupling for additional operational needs, including:

a) Operational Adjustments – Temporarily merging tower and approach control services during low-traffic periods to streamline workflow.

b) Managing Diverse Aircraft Communication Capabilities – Supporting aircraft using different channel spacings, such as 25 kHz versus 8.33 kHz, enabling seamless DCPC without requiring manual transitions.

2. DISCUSSION

2.1 Technical and Operational Limitations

2.1.1 Undetected Simultaneous Transmissions

While frequency coupling improves DCPC continuity, it introduces challenges related to simultaneous pilot transmissions:

a) When pilots transmit on the same frequency simultaneously, air traffic controllers could often observe overlapping voice transmissions and take actions for clarification. However, when pilots transmit on different coupled frequencies simultaneously, voice transmissions may be completely blocked due to rebroadcasting mechanics of the VCS, preventing air traffic controllers from identifying the issue.

b) This increases the likelihood of missed voice transmissions.

(Mitigation strategies referred to Paragraphs 2.2.3 (a, b, c & e))

2.1.2 Syllable Loss and Coupling Loops

Non-optimized system tuning (e.g., debouncing delays and attack/decay time) could lead to:

a) Syllable loss, if the system settings are too conservative, affecting message clarity.

b) Coupling loops, if the system settings are too aggressive, causing repetitive transmissions that may disrupt critical DCPC.

(Mitigation strategy referred to Paragraph 2.2.1 (a))

2.1.3 Intermodulation Interference

The more frequencies are coupled, the more ground transmitters will be on-air simultaneously, increasing the likelihood of intermodulation interference affecting DCPC clarity.

a) Such interference may lead to degraded voice quality.

b) Interference caused by intermodulation effects, usually in the form of speech breakthroughs, raises greater concerns compared to intermittent noise.

(Mitigation strategies referred to Paragraphs 2.2.1 (b), 2.2.2 (a & b), and 2.2.3 (a, c, d & e))

2.1.4 Difficulties in Fault Finding

Identifying transmission failures in coupled frequencies is challenging, as rebroadcasting mechanics may mask underlying issues.

a) Investigators may find it difficult to determine on which frequency a specific aircraft was operating.

b) Investigating external interference is complex, as interference in one channel may spread to all coupled frequencies, making detection and resolution more difficult.

(Mitigation strategies referred to Paragraphs 2.2.1 (c) and 2.2.3 (d))

2.2 Mitigation Strategies

To optimize frequency coupling in DCPC, the following strategies are recommended:

2.2.1 VCS

a) Conduct commissioning calibration to fine-tune system setting (e.g. debouncing delays and attack/decay time), ensuring proper frequency coupling function.

b) Indicate recommended transmitters (located in different radio stations) to air traffic controllers on the VCS interface to minimize intermodulation interference.

c) Equip recorder systems with separate transmit and receive recordings (i.e., distinguishing source frequency vs. re-broadcast frequency), and timing analyzers.

2.2.2 Radio Equipment

a) Carefully plan transmitter and receiver locations, studying intermodulation effects.

b) Avoid locating transmitters of frequencies in the same coupling group too close to each other.

2.2.3 ATC Coordination and Procedural Adjustments

a) Limit the number of coupled frequencies.

b) Ensure air traffic controllers are aware of undetected simultaneous transmission and apply mitigation strategies.

c) Enable frequency coupling only when on-air utilization is low.

d) Establish procedures to decouple frequencies to facilitate investigations when performance issues arise.

e) Use a single frequency whenever practicable, preventing unnecessary complications.

2.3 Effective Implementation

With a prudent assessment of the limitations under frequency coupling and the effective implementation of corresponding mitigation strategies, the use of frequency coupling in DCPC could achieve the following:

a) Enhance situational awareness and maintains radio discipline by ensuring consistent DCPC across coupled frequencies.

b) Reduce communication gaps for maintaining uninterrupted information flow.

c) Reduce air traffic controller and pilot workload by minimizing frequency change instructions and preventing unnecessary transitions.

d) Expand coverage by coupling frequencies with different coverage areas.

e) Enhance service efficiency, particularly during temporary sector consolidation.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the technical and operational limitations of frequency coupling and corresponding mitigation strategies; and

b) discuss any relevant matter as appropriate

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