

**ICAO***International Civil Aviation Organization***THE ELEVENTH MEETING OF SYSTEM WIDE  
INFORMATION MANAGEMENT TASK FORCE  
(SWIM TF/11)***Bangkok, Thailand, 25 – 29 May 2026*

- Agenda Item 3: Outcomes of relevant meetings on SWIM-related matters
- SWIM Implementation Pioneer Ad-hoc Group

## **WORK PROGRESS OF SIPG TASK 2: REFINE THE REVISED HIERARCHICAL ARCHITECTURE**

(Presented by China on behalf of the SWIM Implementation Pioneer Ad-Hoc Group)

### **SUMMARY**

This paper presents the progress of SIPG Task 2 Refine the revised hierarchical architecture. Based on the revised APAC SWIM hierarchical architecture, SIPG Task 2 focuses on routing mechanism, multi-queue configuration and other core researches and clarifies technical principles. A multi-level test plan is formulated, the tests are being carried out, participants have completed basic tests, and remaining tests are underway.

## **1. INTRODUCTION**

1.1 At the Second Working Session of the SWIM Implementation Pioneer Ad-Hoc Group (SIPG WS/2), building on the outcomes of the 10th SWIM Task Force (SWIM TF/10) meeting held on 20 – 23 May 2025, a revised APAC SWIM hierarchical architecture was proposed. SIPG Task 2 Refine the revised hierarchical architecture has been set as a priority task, aiming to refine the architectural design and validate key technical solutions, provide core technical support for integrating the APAC SWIM Technical Infrastructure (TI), and address issues such as inconsistent routing mechanisms, unclear multi-queue configurations, and missing logic for message priority handling in the original architecture.

1.2 SIPG Task 2 is led by China, with participants including Australia, Hong Kong, China, India, Japan, Fiji, Singapore, Thailand, Malaysia, USA, Republic of Korea, New Zealand, and CANSO. A hierarchical architecture scheme has been proposed, with participants currently conducting joint testing and verification on the basis of consensus. SIPG Task 2 collaborates with Tasks 1 and 3 to establish a unified test environment, so as to provide stable and interoperable architectural support for the implementation of APAC SWIM.

## **2. DISCUSSION**

### **SIPG Task 2 Current Research Content**

2.1 According to the meeting report of SIPG WS/2, the work items under SIPG Task 2 are listed below:

- Use SWIM TF/10 WP/17 as inputs;
- Routing via topics and comparing between message properties and message topics for routing purposes;
- Explore the use of multiple queues and their configuration methods;
- Message priority implementation and transmission retry mechanisms.

2.2 SIPG Task 2 conducts technical solution and test plan in compliance with the work items listed above. The research currently focuses on routing mechanisms under different business scenarios, naming and configuration specifications of multiple queues, and the specification of message priority, data model and other features through message metadata. The test plan adopts a layered approach that progresses from simple to complex and supports continuous expansion, so as to ensure effective support for the research work. The detailed task technical solutions and test plan are listed below:

2.2.1 **SWIM TI Interoperability Routing Mechanism.** This mechanism integrates on-demand routing strategies, relying on message brokers and routing services to meet the Message Exchange Patterns (MEPs) and Quality of Service (QoS) requirements of SWIM information services.

- **Business Scenario Routing:** The routing mechanism adapts to the evolution of MEPs during the migration from AFTN/AMHS to SWIM, covering two core modes. The mode with explicit recipient IDs enables precise delivery, while the recipient-free mode fully decouples senders and receivers through subscription-based filtering.
- **Transmission Path Routing:** Static routing predetermines transmission paths with low computational overhead and high controllability, while dynamic routing adjusts paths in real time based on network status to support load balancing.
- **Granularity-Adapted Routing:** Coarse-grained routing uses hierarchical topics to achieve efficient bulk transmission between backbone nodes by classifying information by domains and scenarios. Fine-grained routing performs accurate filtering based on standardized metadata fields, satisfying customized information access demands of SWIM information consumers.

2.2.2 **APAC SWIM Address Naming Pattern.** A standardized address naming scheme is under study to enable consistent message routing and interoperability across the APAC SWIM TI

- **Scope and Environment Identification:** This section distinguishes regional and runtime environments.
- **Routing-Oriented Address Architecture:** Hierarchical identifiers are adopted to enable hop-by-hop forwarding across EMS nodes. Adjacent nodes perform path lookup by parsing these identifiers, ensuring standardized forwarding and consistent end-to-end services.

- Information Domain Classification: Categorizes information domains and additional supplementary details to realize standardized identification and processing of aviation information.

2.2.3 SWIM Message Metadata Specifications. SWIM message metadata provides the contextual information necessary to identify, route, secure, and trace information exchanges across EMSs. SWIM message metadata consists of technical and business features. The technical attributes include essential sender/receiver information, routing details, priority levels and other relevant fields, which are uniformly defined by SIPG, while the business metadata can be flexibly extended based on different information domains. In SIPG Task 2, metadata is implemented using standard and custom properties of AMQP 1.0.

### **APAC SWIM Hierarchical Architecture Test Plan and Test Status**

2.3 Based on the APAC SWIM hierarchical architecture, SIPG Task 2 has formulated a seven-level test plan for heterogeneous EMSs interconnected over the CRV network. The test plan follows the principles of progressive correlation and full-scenario coverage (See Appendix A for the detailed test plan):

- a) Level 1 and Level 2 focus on basic connectivity to verify inter-node reachability;
- b) The middle three levels (Level 3 - 5) focus on message transmission and routing to ensure reliable and accurate message delivery;
- c) The upper two levels (Level 6 and Level 7) focus on stability and adaptability to guarantee service availability under anomalies and adaptation to topology adjustments.

2.4 To date, some participants of SIPG Task 2 have constructed their physical SWIM TIs based on the hierarchical architecture and participants can conduct the tests on the TI. 6 participants have indicated their intention to deploy EMS nodes and join the testing. Some EMS participants have already launched their testing work, and the current test progress is set out below:

2.4.1 Completed Phases: 5 participants have successfully passed the Level 1 (Basic Network Connectivity) and Level 2 (Direct EMS Interconnection) tests, with all inter-node communication links verified as fully qualified, as shown in Figure 1.

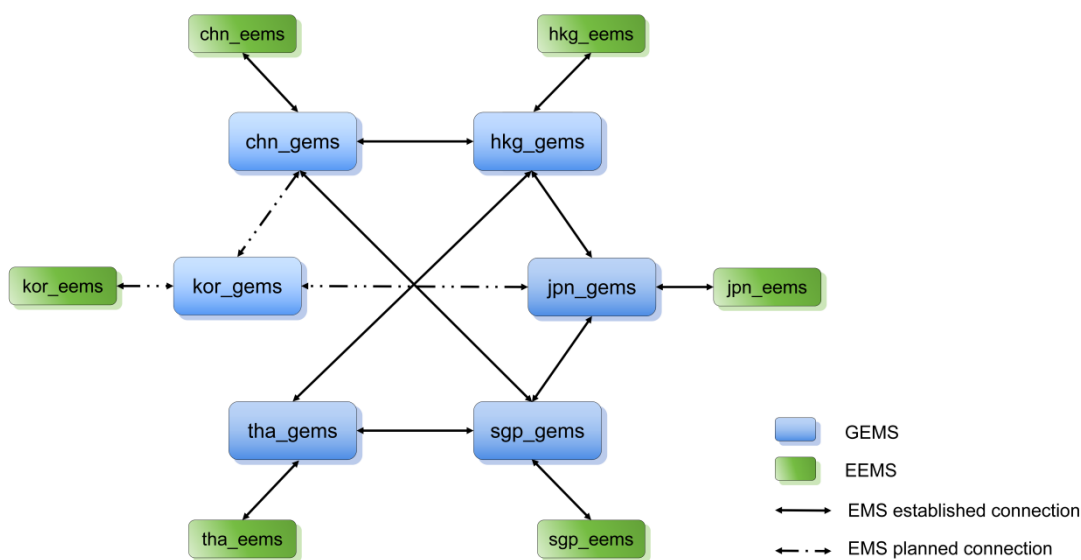


Figure 1: Participants connection status

2.4.2 Current Phase: The Level 3 (Basic Message Transmission) testing is progressing as scheduled, laying a solid foundation for subsequent advanced testing phases, including multi-node routing and exception fault tolerance.

2.5 In the future, it is planned to complete the verification in 2026. As the testing activities move forward, test levels and EMS participants will be expanded as required by actual operational and testing needs.

### 3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information contained in this paper;
- b) discuss any relevant matter as appropriate; and
- c) encourage more states to participate in SIPG Task 2 and provide feedback on test plan in Appendix A.

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## APPENDIX A

### APAC SWIM Hierarchical Architecture Test Plan

#### 1. Test Objectives

This test for the CRV network environment verifies the connectivity between APAC SWIM EMS nodes (EEMS/GEMS) and adjacent nodes, along with the compliance, reliability and routing correctness of their message transmission. It is required to ensure successful full-process message delivery under the two core message interaction modes: asynchronous request-response and publish-subscribe. All test results shall comply with the APAC SWIM TI specifications, AMQP 1.0 protocol and relevant message format requirements.

#### 2. Test Premises and Environment Preparation

The CRV network is activated; IP connectivity is available between adjacent EMS nodes involved in the test, meeting the cross-border connectivity configuration requirements.

All EMS nodes (EEMS/GEMS) are deployed; the AMQP 1.0 broker is running normally; the username, password and URI configurations comply with specifications; and the user's read/write access permissions for AMQP addresses are correctly configured.

EMS node information has been entered into the routing table, supporting static/dynamic routing; the binding relationship configuration between EEMSS and their corresponding superior GEMS is completed.

Test data is prepared, covering data formats such as FIXM, AIXM, IWXXM and ASTERIX that conform to the APAC\_CATEGORY enumeration.

#### 3. Multi-level Test Design

##### Level 1: Basic Network Connectivity Test for Adjacent EMS Nodes (Verify "Network Link Reachability Between Adjacent Nodes")

###### Test Content

Only verify the IP connectivity and port reachability of adjacent EMS nodes in the CRV network, and ensure no network-layer blockage between adjacent nodes (tests for non-adjacent nodes across regions are not involved).

###### Test Steps

1. Confirm adjacent node combinations: all EEMS bound superior GEMS connections and GEMS-to-GEMS connections (classified based on the actual deployed adjacent relationships).

2. For each group of adjacent nodes, execute the ping command from the initiating node and ping continuously for 100 times (e.g., EEMS → superior GEMS, GEMS → adjacent GEMS).

3. On the EEMS nodes, execute the telnet command to test the AMQP port of the connected GEMS and verify the establishment of TCP connections; similarly, on the GEMS nodes, test the AMQP port of adjacent EEMS/GEMS.

4. Use the route-trace tool to track the link of each group of adjacent nodes, confirm no routing interruption, and ensure the smoothness of the direct link between adjacent nodes.

### **Expected Results**

The ping test success rate of all adjacent nodes is 100%, with average latency  $\leq 50$  ms and no packet loss.

Telnet connection to the AMQP port between adjacent nodes is successful, returning an AMQP protocol handshake response.

Adjacent nodes are directly connected, with no loops or interrupted nodes.

### **Test Focus**

Focus on the effectiveness of network paths between adjacent nodes, laying a foundation for subsequent EMS layer connections and message transmission.

## **Level 2: Direct connectivity test between EMS (Verify "EMS layer reachability")**

### **Test Content**

Verify the effectiveness of AMQP connections between adjacent EEMS and GEMS, as well as between GEMS and GEMS, to ensure normal communication at the EMS layer.

### **Test Steps**

1. Configure the superior GEMS for a specific EEMS and enter the AMQP URI (IP: Port) of the corresponding GEMS.

2. Initiate an AMQP connection request from this EEMS to connect to the superior GEMS and record the connection status.

3. Repeat Steps 1-2 to complete the following connection tests: connections between all EEMS and their corresponding superior GEMS, as well as between adjacent GEMS.

4. After the connection is established, maintain it for 30 minutes and monitor connection stability (no disconnection or reconnection).

### **Expected Results**

The success rate of AMQP connection establishment between all adjacent EMS nodes is 100%, with no abnormal disconnection during the connection maintenance period.

There are no errors such as authentication failure or protocol incompatibility in the AMQP connection logs.

### **Test Focus**

Verify the configuration effectiveness of the binding relationship between EEMS and their superior GEMS, as well as the direct connectivity between GEMS.

### **Level 3: Single Transmission Mode Message Sending Test (Verify "Basic Message Transmission")**

#### **Test Content**

Verify the message sending compliance and success rate between adjacent nodes under the two transmission modes (Point to Point and Broadcast) respectively.

#### **(1) Point to Point Mode Test**

##### **Test Steps**

This test case addresses scenarios that require an explicit recipient ID, such as the submission of a filed flight plan.

1. SWIM message sender delivers SWIM message with an explicit recipient ID in the message metadata to connected EEMS;
2. EEMS delivers SWIM message with the destination EEMS to connected GEMS;
3. GEMS routes messages to the appropriate next-hop GEMS node;
4. The next-hop GEMS routes SWIM message to the destination EEMS;
5. The destination EEMS routes the message to the SWIM message receiver according to the recipient ID contained in the message metadata.

##### **Expected Results**

The message sending success rate reaches 99.9%.

Message format verification passed: addresses comply with lowercase requirements, message metadata are complete, and application attributes conform to APAC enumeration specifications.

#### **(2) Broadcast Mode (Pub/Sub) Test**

##### **Test Steps**

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This test case address recipient-free scenarios such as meteorological information publication.

1. SWIM message sender publishes SWIM message with the recipient-free in the metadata;
2. EEMS publishes SWIM message to connected GEMS;
3. The GEMS publishes SWIM messages, and adjacent GEMSs subscribe to the Topic address to receive the messages;
4. The EEMS subscribes to the Topic address of the superior GEMS to receive SWIM messages and replicate messages to EEMS's own topic;
5. SWIM message receivers subscribe to the Topic address of the EEMS and consume SWIM messages.

### **Expected Results**

The message reception success rate of all subscribers reaches 99.9%; the message content received by each node is consistent without loss or tampering.

Message format verification passed: addresses comply with lowercase requirements, message metadata are complete, and application attributes conform to APAC enumeration specifications.

### **Level 4: Mixed Multi-transmission Mode Test (Verify "Mode Compatibility")**

#### **Test Content**

Run Point to Point and Broadcast (Pub/Sub) mode messages simultaneously to verify that there are no conflicts between the two modes and no confusion in message routing.

#### **Test Steps**

1. Execute all test steps of the Point to Point mode test specified in Level 3.
2. Execute all test steps of the Broadcast (Pub/Sub) mode test specified in Level 3 simultaneously.
3. Monitor the message sending, receiving, routing and system logs of both transmission modes in real time.

### **Expected Results**

The message sending success rate is  $\geq 99.9\%$  in concurrent scenarios, with no message loss or misdelivery.

There are no conflicts between the address formats and routing logic of the two modes' messages, and no routing exception alarms in logs.

### **Level 5: Multi-node Collaborative Message Routing Test (Verify "Cross-node Routing")**

**Test Content**

Simulate the real hierarchical architecture to verify multi-GEMS hop routing and end-to-end message transmission of EEMS - GEMS - GEMS - GEMS - EEMS (across non-adjacent nodes).

**Test Steps**

1. Ensure that messages traverse multiple GEMS nodes between the sender and the recipient.
2. Perform Level 4 testing.

**Expected Results**

The message sending success rate is  $\geq 99.9\%$  in concurrent scenarios, with no message loss or misdelivery.

There are no conflicts between the address formats and routing logic of the two modes' messages, and no routing exception alarms in logs.

**Level 6: Exception Scenario Fault Tolerance Test (Verify “Stability and Fault Tolerance”)**

**Test Content**

Simulate scenarios such as network interruption, node failure and message abnormality to verify the fault tolerance capability of EMS message transmission.

**Test Cases**

Exception Scenario	Test Steps	Expected Results
Adjacent node network temporary interruption (10s)	During multi-node routing test, interrupt the CRV connection between transit GEMS and target GEMS (adjacent relationship) for 10 seconds and then restore it.	After network recovery, messages are automatically re-transmitted without loss (success rate: 100%)
Message Timeout	When sending Point to Point messages, set TTL = 1000ms and deliberately block the receiver port	Timed out messages are automatically discarded without duplicate delivery; timeout alarms are recorded in logs
Duplicate Messages	Manually send 2 messages with the same MESSAGE_ID	The receiver performs deduplication and retains only 1 valid message
Non-Compliant Message Format	Send broadcast messages missing the APAC_CATEGORY field	The receiver rejects the messages, returns a format error response, and clearly marks the missing field in logs

## **Level 7: Topology Structure and Message Routing Adjustment Test (Verify "Adaptability to Topology/Routing Changes")**

### **Test Content**

In the CRV network environment, verify the normalcy of adjacent node connectivity, message transmission reliability and routing correctness after EMS node topology adjustments (node addition/decommissioning, adjacent node relationship modification) and message routing strategy adjustments (static routing update, dynamic routing switch, backup routing change). Ensure no connectivity interruption, message loss or routing disorder occur after topology and routing changes, so as to support the system's adaptability to topology iteration requirements in actual deployment.

### **Test Steps**

1. EMS node topology adjustment: Add, decommission EMS nodes and modify adjacent node relation, and verify adjacent node connectivity.
2. Routing info update: modify routing dynamically or statically.

### **Expected Results**

Node adjacent connectivity is normal and routing is correct. No interruption, message loss or routing disorder occurs.

## **4. Test Entry and Exit Criteria**

### **(1) Test Entry Criteria**

The CRV network has completed adjacent node deployment with correct node IP/port configurations, meeting bandwidth and latency requirements.

The AMQP broker of EMS nodes starts normally; routing tables and binding relationships between EEMS and GEMS have been configured completely.

Test data (message templates, node association information) is ready and complies with APAC SWIM specifications.

### **(2) Test Exit Criteria**

The pass rate of all Levels' test cases is  $\geq 99.9\%$ , with no critical defects (e.g., connectivity failure, message loss, routing errors).

The compliance verification rate of message format reaches 100% (no violations in addresses, message headers, and application attributes).

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The routing latency of cross-region multi-node meets expectations, with no performance bottlenecks in concurrent message processing.

In exception scenarios, EMS nodes have fault tolerance capability without system avalanche, data tampering or similar issues.