# International Civil Aviation Organization
## Aeronautical Telecommunication Network Panel (ATNP)
## Working Group Meetings
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**Agenda Item 6.4**

## Availability and Continuity of Service for Mobile ATN Users

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### Summary

The ICAO ADS Panel developed the operational requirements for the ATS data link applications concurrent with the ATNP WG2 development of the ICS SARPs (i.e., Sub-Volume V of Doc 9705). The ADSP has defined very stringent requirements for service availability and continuity of service that probably cannot be satisfied by early (i.e., Package 1) implementations as a consequence of the combined mobile subnetwork and routing characteristics. This working paper provides an overview of certain of the issues related to providing an ICS capable of satisfying the availability and continuity of service requirements and serves as an introduction to WP484, WP485 and WP486.

References:

1. ICAO Doc 9705, First Edition, Sub-Volume V, 1998
2. WG2/WP484, Mobile Subnetwork Connectivity Reporting Requirements for ICS Package-2," January 1999
3. WG2/WP485, "Mobile Subnetwork Connectivity Reporting Under r.f. Channel Fading Conditions," January 1999
4. WG2/WP486, "Transport Protocol Requirements for Package-2 ICS," January 1999

## 1. BACKGROUND

The ICAO ADS Panel developed the operational requirements for the ATS data link applications concurrent with the ATNP WG2 development of the ICS SARPs (i.e., Sub-Volume V of Doc 9705). The ADSP has defined very stringent requirements for service availability and continuity of service. Ongoing work of the ADSP to define Required Communications Performance (RCP) may further refine the operational requirements that must be satisfied by the communication services. Early evaluations of the ATN ICS where multiple mobile subnetworks have been considered and/or employed have shown the potential inability of the ICS to provide a high continuity of service under the conditions where one or more of the mobile subnetworks provides less than optimum reporting of subnetwork connection status.

## 2.    DISCUSSION

2.1    The ICAO ADS Panel has produced an ICAO Manual of ATS Data Link Applications. In this document the operational requirements for the ATS data link applications are defined. The following table and text are excerpted from this document.

| Application | Availability | Integrity | Reliability | Continuity |
|---|---|---|---|---|
| DLIC | 99.9% | $10^{-6}$ | 99.9% | 99.9% |
| ADS | 99.996% | $10^{-7}$ | 99.996% | 99.996% |
| CPDLC | 99.99% | $10^{-7}$ | 99.99% | 99.99% |
| FIS | 99.9% | $10^{-6}$ | 99.9% | 99.9% |
| AIDC | 99.996% | $10^{-7}$ | 99.9% | 99.9% |
| ADS-B | 99.996% | $10^{-7}$ | 99.996% | 99.996% |

*Table 3A-2:  Application Specific Performance Requirements*

"Except in catastrophic situations, no single end-to-end outage should exceed 30 seconds (end-to-End availability may be achieved through provision of alternate communications routings where feasible)."

It is important to note the very demanding requirements for continuity of service and service availability for the CPDLC and ADS (contract) applications. As noted in the accompanying text (above) the availability may be achieved through provision of alternate communications routing. Although not explicitly stated, this comment could also be applicable to the requirement for continuity of service.

2.2    The scenarios described below can lead to a serious degradation of availability and/or continuity of the ICS. All of these scenarios are for the case where two or more mobile subnets are available and the connectivity provided by the primary mobile subnet (i.e., the forwarding path indicated in the router's FIB) is in a state of change.

2.2.1    The primary mobile subnet will continue to accept packets from the BIS after that mobile subnet loses r.f. connectivity, such as due to the aircraft flying out of the

coverage area of the subnet. Issues arise when this condition has not existed long enough for the subnet to have cleared the connection or issued a Leave Event to the connected BISs. In this scenario there will be an interruption of overall internet service to the given aircraft, for all traffic classes were the given mobile subnet is selected by the BIS as the being the preferred path even if an alternative path, via another mobile subnet, is available. This condition will persist until either the primary mobile subnet:

a)   restores connectivity; or

b)   detects the loss of connectivity, is unable to restore connectivity and the connection to the BIS is cleared or a Leave Event is issued.

Currently Sub-Volume V places no required or recommended limit on how much time a mobile subnet has from the actual loss of connectivity until the subnet informs the BIS. The lack of such a requirement clearly has the potential of compromising the ability of internet service to satisfy the overall operational requirements for service availability and continuity.

The intent of the following ADSP requirement appears ambiguous:

> *"Except in catastrophic situations, no single end-to-end outage should exceed 30 seconds (end-to-End availability may be achieved through provision of alternate communications routings where feasible)."*

If the above operational requirement were to be applied to each application connection (i.e., dialog) then only mobile subnetworks with very low transit delays could be used for ATSC. This could inherently rule out such mobile subnetworks as AMSS and HFDL from being used as the primary communications path. However, if the above operational requirement is intended to apply to the overall service from a given ATS facility, rather than on a connection-by-connection basis, then it may be achievable but may require an increased role for systems management to support service restoration.

2.2.2 The aircraft may be in a physical location where temporary fading is occurring on the r.f. channel of the primary mobile subnetwork. Under such conditions the mobile subnet may after some delay clear the connection and/or issue a Leave Event then rapidly re-establish connectivity and issue a Join Event. Under extreme, but not unrealistic conditions where the aircraft is operating near the edge of r.f. coverage, some mobile subnetworks may issue a rapid sequence of Joint Events follow by Leave Events followed by Joint Events, etc. In the event where an alternative path exists via another mobile subnetwork, such a situation on the primary mobile subnet could result in substantial additional BIS-BIS traffic being routed over the alternative subnetwork and additional delays on packet delivery, due to the situation described in para. 2.2.1 above as well as increased loading on the alternative path.

2.2.3    There is a normal condition where there will be a delay between the actual loss of mobile subnetwork connectivity and the detection and reporting to the attached airborne and air-ground BISs that the connection is lost.  When this occurs on the primary mobile subnet the BIS will continue to forward packets to the effected mobile subnet until informed by that subnet that connectivity can no longer be provided.  ATN end systems implementing the Connection Oriented Transport Protocol (COTP), as per Sub-Volume V, would eventually attempt to retransmit the TPDU(s) based on the lack of receiving a transport ACK.  Because Sub-Volume V recommends TP4 timer settings that are intended to accommodate the lowest performance mobile subnetworks, the retransmission of effected TPDU(s) may not occur for several minutes.  By this time the BIS may have received the Leave Event from the effected mobile subnet and is now forwarding packets via an alternative path.  During the interval where the BIS has already begun to forward packets via the alternative path and before TP4 retransmits the original TPDU(s), additional TPDU(s) may be successfully delivered via the alternative path.  The receiving TP4 will buffer these out of sequence TPDUs until the delayed TPDUs are received.  This would result in an interruption of service of up to several minutes even thought a viable air-ground path has existed during the entire interval.  This situation could negatively impact the ability of the ICS to satisfy the operational requirements for availability and continuity of service.

## 3.    RECOMMENDATIONS

It is recommended that WG2 develop changes to the Doc 9705 Sub-Volume V to improve the overall ability of the ICS to recover from loss of connectivity via the primary mobile path.  The three specific scenarios of concern are described in para. 2.2 above and the working group is invited to review and accept the recommendations of WP484, WP485 and WP486 that propose the development of enhancements to the Doc 9705 Sub-Volume V (ICS) to address the concerns described herein.