**INTERNATIONAL CIVIL AVIATION ORGANIZATION**
**SOUTH AMERICAN REGIONAL OFFICE**

**FOURTH INFORMAL MEETING ON THE PLANNING AND IMPLEMENTATION OF THE SAM DIGITAL NETWORK**

**(REDDIG/4)**

(Lima, 4 to 8 September 2000)

**Agenda Item 2: Technical aspects for the implementation of the REDDIG Domestic speech circuits**

(Presented by the Secretariat)

**Summary**

**This working paper presents for the meetings consideration, matters regarding the transmission, synchronization and numbering plans related with the domestic speech circuits and the REDDIG, as well as the backup network which are necessary to consider in order to maintain the quality of the communications and the harmonization of the function between them. This working paper also presents information of the principal causes that produces the transmission impairments and suggests a series of solutions aimed at solving and avoiding these problems.**

## 1. Introduction

1.1 This working paper is aimed at presenting to the meeting the considerations taken during the REDDIG design, as well as those which should be bearing in mind by the States according with their domestic networks. Inside this category, the ATS domestic circuits are included as well as the administrative circuits. In paragraph 3.1.4 of the REDDIG Technical specifications document, are described the services that will be provided by the network, as well as the voice and data communications related aspects.

1.2 During the network design, the States were required to provide information regarding their communication systems in order to incorporate it to the Technical specifications document, however most of the information received has been partial.

1.3 Based on the information presented in this working paper, and due to the project implementation terms, it is intended that the States can complete during the meeting, the particular technical data that is necessary to incorporate in the Technical specification document.

1.4 The following are the technical items mentioned in this working papers summary.

## 2. Technical aspects

2.1 In this section the following technical aspects are described:

a) The transmission plan.
b) The effects of the echo and the transmission time.
c) The quantification noise effect and the compression/decompression of the signal.
d) The synchronization network plan.
e) The technical aspects regarding the network signalization.
f) The back up network.
g) The numbering plan.

### 2.2 The transmission plan

2.2.1 The transmission plan constitutes a fundamental part of a network planning. The ITU-T has developed the G.101 and G.171 recommendations regarding the transmission plan.

2.2.2 The transmission plan considers the aspects related to the transmission and reception levels, the stability of the circuits through the addition of losses (signal attenuation) in order to avoid oscillations, the echo control, the transmission time considerations, the codification of the signal processing in a digital route, the compression and the evaluation of the signal degradations.

2.2.3 Those aspects must be considered not only in the REDDIG but also in the domestic network, so the usage of terrestrial digital circuits (for example the E1/T1) in the domestic branch, could simplify notoriously, the plan design, the tune up and the network maintenance as well as its growing and will allow to assure the delay times required according with ITU/T G.114 recommendation.

2.2.4 The States should take the necessary measures in order that the circuits that will be connected to the REDDIG were available and operative before the beginning of the node installation.

2.2.5 The ICAO during the planning time of the current ATS speech circuits, studied the echo problems that would be presented in it, as a result of the use of two wire terminals. The ICAO recommended to the States for the ATS speech circuits implementation, to consider the use of four wire terminals only, as with them no echo problems could exist in the network, it would not be necessary the use of echo suppressors, devices that while perform the control of the echo also produces the degradation of the signal (signal mutilation), not only in terminal calls, but also in the transit ones, being the last indicated, the more seriously affected due to the fact that switches do not have mechanisms to disable the echo suppressors in transit calls. The States in its majority, incorporated to the ATS network four wires terminals for the local subscribers as well as for international ones associated to the switching center.

## 2.3 **Echo and transmission time effects**

2.3.1 The transmission times for the switching with digital segments comprises the delays introduced by the equipments and systems (principally those caused by the multiplex process, voice compression, switching and for the echo cancel devises) and the propagation time of the transmission way (microwaves, optic fiber, satellite, etc.).

2.3.2 So due to the delay, the talker echo and the difficulties in an interactive conversation produce the effects that limit the maximum transmission time.

2.3.3 H. Decker studied the aspects related with the conversation difficulties over circuits with high delay, initially in 1931. The study was made through conversation subjective tests over circuits of four wires. In these tests echo problems were not found. The results of these tests shown that from 400 ms of delay extreme-to-extreme in only one way, the 60% of participants had conversation difficulties. Latter examinations made with the implementation of the first satellite communications using echo suppressors, shown similar results as found by Decker.

2.3.4 Since 1987 there were presented to the ITU, as a contribution of some telephone administrators and manufactures, test results considering the use of echo cancellers and the delay effects in the dynamic of a conversation.

2.3.5 The test results of the first group shown that there were no considerable differences of “difficulty average” for delays between 45 and 300 ms, and that from the 500 ms the “difficulty average” was duplicated. Even though, this value of 16% is lower than the 60% obtained with the echo suppressors.

2.3.6 Through the second group of tests, there were evaluated the dynamic effect of the conversation considering the interruption and the quality through the conversations ways that involves the reception of numbers, the verification of random numbers, the completion of missing letters in words, the verification of city names, the determination of figures based on the conversation, and the conversation of free topic. The results of this test shown that the subjective quality, in accordance with the delay, varies depending on the way of conversation and on the human group tested.

2.3.7 With respect to the tests, the ITU concludes that when using echo cancellers in the connections by satellite, they provide identical quality and operation as to the terrestrial telephone communications, and that the unfavorable effects are caused purely by the delay.

2.3.8 The ITU in its recommendation G.114 (1996) take into consideration the above described tests and establishes that the one way transmission time extreme-to-extreme lower than 400 ms, for connections with echo properly controlled, are acceptable, and are unacceptable those communications that get higher than 400 ms for the network planning aspects.

2.3.9 In its circular 183-AN on planning of ATC speech circuits, the ICAO establishes that the mentioned time can be higher than 400 ms.

2.3.10 The REDDIG design is compliant with the ICAO circular 183-AN and the ITU-T G.114 recommendation in order to guarantee the communications quality. In view of that, it is required the use of echo cancellers and the establishment of extreme-to-extreme communications through only one satellite jump.

2.3.11 The Civil Aviation Administrations (CAAs) should take into account the requirements mentioned in the above paragraph, with respect to the circuits that shall be connected through domestic networks. The path of these circuits must be done only over terrestrial networks (microwaves, fiber optic, etc.). Another limiting feature in the transmission time associated with the domestic circuit is the delay in the echo canceller path, which must be minimized.

2.3.12 The States while planning its local network, must take into consideration that the prolongation of a two wires circuits over another local transmission means, introduces multiple echo points (more than one hybrid in the circuit route) and probably, the addition of another echo cancellers in the circuit route, that produce the degradation of the signal.

2.3.13 The States should consider the advantage that offer the usage of a pure digital solution with digital terminals (TE1), which allows, based in its full on wire design, the simplification of the implementation of the transmission plan and the echo control, and the accomplishment of reducing the transmission problems to a “pure delay” problem, with the correspondent benefits indicated by the ITU-T. Even though it must be taking

into account that the implementation through terminals (TE-2) that requires of an adapter does not provide the same benefits.

## 2.4 Noise and quantification effects and the delay times associated with the A/D conversations and the signal compression/decompression

2.4.1 The conversion from an analog signal to a PCM signal, as well as the compression/decompression of the voice signal, introduces noise and delay in the communications.

2.4.2 The noise is introduced in the A/D conversation by the effect of the quantification of the signal in a determined number of discrete values, which represents the continuous signal. Likewise, the noise is introduced in the signal in the numeric algorithms of compression and decompression of the signal. This process is additive and appears in each stage where he A/D conversion or compression/decompression of the signal is performed.

2.4.3 Another important feature to be considered is the delay introduced in the communications in each A/D conversion an in the compression/decompression of the signal.

2.4.4 The A/D communication introduces a delay of approximately 0.125 ms. The ITU-T in its G.711 recommendation, includes the codification schemes corresponding to the A Law (European standard) and to the μ Law (American standard). Likewise, the ITU establishes that in those connections that do not used the same codification scheme (A Law and μ Law) it must be done a translation in the extreme of the network that uses the μ Law.

2.4.5 The ITU-T has recommendations regarding the voice compression. Among the available voice codifications are the ADCPM at 32 kbps, the LD CELP at 16 kbps, the CS-ACELP at 8 kbps and the MPLQ/ACELP at 6.3 Kbps. There are another codifications schemes available; even so they are proprietary type. Taking into account that the new network environment with which the REDDIG must interact are digital, it is convenient to choose a standardized codification scheme which allows the codification and decodification to be performed in the circuit extremes.

2.4.6 The signal compression/decompression, depending on the type and level of compression as well as the grade of algorithmic complexity, introduces algorithmic delays of 2ms for the compression LD CELP G.728 at 16 kbps, 15 ms for the compression CS ACELP G.729 at 8 kbps and 35 ms for the compression MPLQ/ACELP G.723.1 at 6.3/5.3 kbps respectively. Due to the limitations in the digital processing units, which perform the signal compression and decompression, the total delay times can be higher, but frequently they are inferior to the double of the algorithmic time.

2.4.7 The delay times mentioned, together with the times introduced in the switches, must be considered in the networks design in its backup network. The delay time introduced by the ISDN switch is 1 ms and approximately 5 ms in a Frame Relay commuter.

2.4.8 In view of the degradation suffered by the signal in each A/D conversation and in each compression/decompression of the signal, as well as the delays produced in each operation, it is required that them will be done only in the circuits extremes, so, under transit operation conditions, the switches must be able to switch the signals directly, without conversion and/or compression/decompression of the signals. This switch characteristic will be initially used in the REDDIG backup network, and also later, when the nodes were integrated through the fiber optic links.

2.4.9 The REDDIG has considered the use of the A codification law, and the standardized compression algorithms of the ITU-G G.723.1, G.728 and G.729 with the purpose of facilitating the interconnection with another networks.

## 2.5 **The network synchronization**

2.5.1 The synchronization of a digital network represents one of the more critique features in the implementation of an international private network with connection with the public networks, due to possible errors that can be produced in the signals as a result of the differences between its transmission and reception speeds.

2.5.2 Regarding this matter, the ITU-T in its recommendation G.826 and the ISO/IEC in its regulation 11573 are facing the network synchronizations.

2.5.3 The REDDIG has adopted a scheme based on GPS clocks, due that in some points of the network the digital links with the suitable accuracy are not available yet, from where the local signal can be transferred. Likewise the mechanisms to keep the networks synchronization in case of primary signal failure have been considered.

## 2.6 **Signaling**

2.6.1 The ICAO recommended to the States, the adoption of the CCITT-No 5 signalization protocol between the switching centers for the current ATS speech circuits network, due to its common usage between the international commutation centers. This recommendation in its opportunity took into account the development of the network and system in the region, which for having been based on the analogical networks and for having been using the satellite as principal way of transmission, did not had the facilities to provide out of band signaling (E and M), and that not allowed the use of compelled

signaling protocols (R2) due to the transmission times around 260 ms, which in case to be used shall produced a delay of 0.5s in the transmission of each number dialed.

2.6.2 The States implemented the CCITT No 5 signalization through supplementary equipment (signaling converts) due to that the available switches did not include the protocol. These converts were almost local developments that incorporate deviations with respect to the ITU-T recommendations, producing operational problems in the network.

2.6.3 The REDDIG has foreseen the provision of the switching function and the use of different interfaces and signaling protocols, (analog and digital) in order to facilitate the integration of the network with the CAAs switches.

2.6.4 Since the REDDIG provides the necessary resources to establish different types of signaling, it will not be necessary to keep the current CCITT No. 5 signaling between the switching centers, because it will be possible to replace this protocol with one which is implemented in the switch as for example, the Wink and the DTMF. This will carry on the elimination of the network protocols standardization problem, as well as the problems associated with the logistic of the signaling converters.

2.6.5 While discussing this matter, the States should consider the convenience of use protocols based on PSS1/QSIG signaling in those cases where the CAAs switches have implemented this type of signaling. This decision would facilitate the future networks migration toward this new signaling protocol, as well as the early implementation of some supplementary services.

## 2.7 **Backup network**

2.7.1 The REDDIG has foreseen a backup network to guarantee the service continuity in case of failure in the principal internodes links. This backup network has been foreseen through switched access through the ISDN public network.

2.7.2 In some States it is possible that the access to the ISDN network will not be available during the time of the REDDIG implementation. With regard to this matter, the States should consider the alternative of using dedicated links or using another ways in case of a contingency.

2.7.3 With regard to this matter, the States should take the necessary measures in order that the backup circuits will be operative at the beginning of the node installation.

## 2.8 Numbering plan

2.8.1 The numbering plan for the ATS speech circuits network, included in the REDDIG technical specifications document, corresponds to a closed numbering plan which is easy to implement and that requires a few digits to perform the routing of the communication. The plan proposed comprises five digits, where one corresponds to the zonal code (7) for South America; two digits for the node and finally two digits to identify the line of the subscriber in the node. Likewise, the REDDIG specifications have included the sub addressing ability, which would allow the development of interworking with LAN networks.

2.8.2 With regard to the numbering plan of the data network, the plan indicated in the X.121 ITU recommendation has been selected.

2.8.3 Even the proposed numbering plan for the ATS speech circuits is simple, the States should consider the possibility of implement a plan according with the I.330 and ITU E.164 recommendations, which requiring more digits and handling of an open numbering plan, but it would allow the administrations to harmonize the numbering plan in its networks and switches, even in those used for the satellite mobile service (INMERSAT), as well as the alternate routing through the public and data networks (x.25, Frame Relay) as established by the E.166 ITU recommendation. While studying this possibility, the States should take into account the facilities that incorporates its switches as well as those provided by the REDDIG for the abbreviate dialing and routing.

## 3. Suggested actions

3.1 The meeting is invited to consider:

a) The necessity of expands the transmission plan to the local network, according with the ITU recommendations.

b) The convenience of: the usage of only digital interfaces in the interconnection between the REDDIG and the local network; the discard of the use of two wires analog terminals which are supported over local transmission ways, and the use of digital terminals (TE1) instead of analogical terminal connected with the REDDIG and/or with its switching systems.

c) The necessity of providing local circuits under delays implanted only over terrestrial fiber optic or microwaves in order to keep the delay time under the value indicated by the ITU, as well as to use only echo cancellers correspondents to the G.165 ITU-T recommendation in the network extremes.

d) The convenience of: to use algorithms of voice compression, standardized by the ITU with the intention of facilitate the interconnection with the CAAs systems, avoiding the possibility of adding noise and delay in the network switches, as a result of the effects of the compression and decompressions of the signal in each point of transit.

e) The advantages of the network synchronization based on a GPS clock, and the use o the PSS1/QSIG signaling and the Wink/DTMF as replacement of the current CCIT No 5 signaling protocol.

f) The possibility of implementing a numbering plan according with the E.164, E.166 and ITU I.330 recommendations and the use of the network sub addressing.

g) The urgent need of completing the implementation details of each administration, in order to incorporate them in the tables of the Technical specifications document, as well as the services tune up requirements for the local and backup circuits.

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