International Civil Aviation Organization

AN-Conf/12-WP/32
5/10/12

WORKING PAPER

TWELFTH AIR NAVIGATION CONFERENCE

Montréal, 19 to 30 November 2012

Agenda Item 1: Strategic issues that address the challenge of integration, interoperability and harmonization of systems in support of the concept of "One Sky" for international civil aviation
1.1: Global Air Navigation Plan (GANP) – framework for global planning

TIME REFERENCE

(Presented by the Presidency of the European Union on behalf of the European Union and its Member States[1]; by the other Member States of the European Civil Aviation Conference[2]; and by the Member States of EUROCONTROL)

SUMMARY

This paper identifies the need to review the requirements concerning the accuracy with which the clocks used for air traffic management systems are synchronised to UTC. In moving towards the Global ATM Operational concept and in particular 4D trajectory management and intensive exchanges of information through SWIM, some of the current provisions might not be sufficient and could become a barrier to the transition following the Aviation System Block Upgrades of the GANP. While a technical solution might well be at hand with the increasing use of GNSS, it is nevertheless essential to quantify future requirements and ensure that possibly new suitable standards and procedures are available in good time.

Action: The Conference is invited to agree to the recommendation in paragraph 4.

1. INTRODUCTION

1.1 ATM systems and ATM actors need time information to perform their operations. The time reference for aviation is defined to be the Coordinated Universal Time (UTC). The requirements with regard to the accuracy of the time information depend on the kind of "ATM application" where it is used. For each ATM application, all contributing systems and all contributing users must be synchronised to a time reference that satisfies this accuracy requirement.

[1] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom. All these 27 States are also Members of ECAC.

[2] Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Georgia, Iceland, Moldova, Monaco, Montenegro, Norway, San Marino, Serbia, Switzerland, The former Yugoslav Republic of Macedonia, Turkey and Ukraine.

1.2 UTC is the common time reference, but the present requirements for the accuracy with which aviation clocks are synchronised to UTC may be insufficient to cover future needs coming from the longer-term Aviation System Block Upgrades, such as integrity and timeliness of information or the use of dependent surveillance for close separations, as well as more generally the 4D trajectory operations. System requirements for synchronisation using an external reference must also be considered.

1.3 The requirements and possible solutions need to be identified, including fall-back considerations.

2. BACKGROUND

2.1 Coordinated Universal Time is based on International Atomic Time (TAI) with leap seconds added from time to time as needed to compensate for the Earth's slowing rotation. UTC is also used for many Internet and World Wide Web standards. Accuracies well below the second can be achieved with widely available industrial products such as Precision Time Protocol (IEEE 1588). At the World Radiocommunication Conference in February 2012 (WRC 12), ITU adopted a recommendation to "*invite WRC 15 to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of UTC or some other method*".

2.2 The time reference for aviation is addressed in ICAO Annexes 2, 10, 11 and 15 (more specifically Annex 11, section 2.25 and 2.28; Annex 2, section 3.5; Annex 10 Vol.III, part 1, section 3.4.14, and Volume IV, section 5.2.3.5; Annex 15, section 3.7.3). The provisions can be summarised as follows:

2.2.1 SARPS require that aircraft and ATC units achieve a local time reference accuracy of within 30 seconds of UTC. Wherever data link communications are utilized by an air traffic services unit, clocks and other time-recording devices shall be checked as necessary to ensure correct time to within 1 second of UTC. The correct time shall be obtained from a standard time station or, if this is not possible, from another unit which has obtained the correct time from such a station. Aerodrome control towers shall, prior to an aircraft taxiing for take-off, provide the pilot with the correct time, unless arrangements have been made for the pilot to obtain it from other sources. Air traffic services units shall, in addition, provide aircraft with the correct time on request. Time checks shall be given to the nearest half minute.

2.2.2 The above last statement may be open to interpretation. Annex 11 section 2.25.5. does not say whether this means that time is given to plus-minus 15 seconds (i.e. either full or half minutes are expressed) or whether it means plus-minus 30 seconds (i.e. only full minutes are expressed).

2.2.3 Where the absolute time of day is used within the ATN, it shall be accurate to within 1 second of coordinated universal time (UTC) (Note: The time accuracy value results in synchronization errors of up to two seconds). Systems which generate ADS-B and/or TIS-B reports based on the reception of surface position messages, airborne position messages, and/or TIS-B messages shall use GNSS UTC measured time for the purpose of generating the report time applicability.

2.3 In addition, Annex 10 Volume I addresses the time of the GNSS constellations.

3. ISSUES

3.1 In terms of time reference there is already is a well specified reference scheme – UTC. However, the issue is not one of defining a reference standard but rather the performance requirement for accuracy with respect to UTC for each system in the ATM architecture that relies on a coordinated time

requirement. Different elements require different accuracy and precision requirements for specific applications. The need for the reference relates to the notion of "Time stamping" for automated systems that are in communication with each other.

3.2 The timing requirements of a system depend not only on the clocks used but also on how they are used. Current systems are predominately organised as relative and self-contained, e.g. each radar system often each uses its own internal time for operations. The distribution of data with one internal time scale to another system requires that the relationship between the clocks is determined. "Timing" should be rather defined as the ability of information or data to move through the systems. This will become more important with the progressive migration of systems to SWIM environment.

3.3 The issue has the following two main aspects:

a) level of required accuracy at which a specific application or system's internal time reference needs to meet UTC (e.g. UTC ± 30 s, UTC ± 1 s, UTC ± 10 µs). This would be expressed in terms of the specific functional location or system clock (e.g. aircraft, ATC unit, or aircraft/ATC system time [FMS]) and may only need an update and minor expansion of existing SARPs; and

b) time stability: the long term timing accuracy will be dependent on the short term stability of the timing signal (usually frequency dependent) expressed as unit time (e.g. 1 s) ± tolerance. The drift experienced over a given period would be corrected by an update from a master "system time".

3.4 The current 1-second accuracy specified for data link communications will probably not be sufficient for a number of applications where time data are critical or where close separations are involved, making use of data on relative configurations (typically Mach 1 at standard sea level means 340 m per second).

3.5 However, it does not seem feasible or necessary to say simply that the need is for all elements to achieve UTC ± a tolerance which would be many orders of magnitude below one second. Indeed, the new requirements are related to a combination of factors, e.g. movement of aircraft Vs separation minima. Moreover it should be noted that, for the purposes of separation provision where GNSS is the primary positioning/surveillance origin, the synchronization of time may not be the major error issue but rather the positioning Datum.

3.6 Recommending a 10-2 (or 10-3?) second for the most stringent stamping requirements could look like a significant leap. However, this value could also probably be well sufficient for the anticipated separation minima and for resolving the data update ambiguities in the system, while remaining well within the performance of the many time reference sources or of GNSS. This would therefore mean that the goal could be met without new technological developments or costly investments.

3.7 In order to define the system time synchronization performance requirements in a distributed architecture like ATM, a number of considerations have to be taken into account and analysed, such as: reference sources of common time and frequency with defined accuracy and using various signals and coding formats. One should also make optimum use of the already existing timing resources and cater for prolonged absence of updates from time dissemination links.

3.8 When analysing the way to meet the requirements, it is suggested to that consideration be given, amongst others, to the following aspects which, while making for a long list and requiring careful attention, do not mean that the solution is complex or difficult to reach:

a) accuracy of clocks in ATC facilities;

b) networked computers on the ground: they are probably not a technical issue but one needs to review what tolerance they use and whether it is good enough for SWIM;

c) aircraft time via the systems: for aircraft equipped with GNSS, use time provided by airborne equipment.

d) for the timing of ADS-B messages, need to review how the clocks are synchronised and the care to be taken in order to secure reliability in the use of aircraft data in close proximity configurations;

e) if/when Wimax (AEROMACS) is available; consider how to use industrial protocols to achieve the required synchronisation (new data link application?). Check possible use of other means such as radio clocks;

f) discuss the GNSS jamming/outage/back up issues;

g) discuss the impact on ATM applications of aircraft not meeting the synchronisation requirements, for example. when one or several actors are subject to a loss of synchronisation with the UTC time (e.g. as consequence of GNSS unavailability, reset of the on board time source, etc.), leading to a possibly disruptive situation especially for time sensitive operations; and

h) clarify the legal aspects associated with the use of the time sources.

3.9 This work should be done by taking into account the redefinition of UTC which is being investigated under the auspices of ITU to eliminate the leap seconds.

3.10 Finally, one should avoid having to repeat the exercise and to amend standards and regulations several times. It should, therefore, be done for the changes planned in Block 1, 2 and 3.

4. CONCLUSION

4.1 The Conference is invited to:

a) recognise the existence of the time reference accuracy issue for the new advanced ATM applications implied by the realisation of the Global ATM Operational Concept and the system changes foreseen in the longer term aviation system block upgrades; and

b) request ICAO to work on defining the accuracy requirements for the future use of time reference, to communicate them timely to ITU and to prepare the necessary amendments to SARPS.

— END —