



Agenda Item 3 CNS Developments
3.4 GNSS Implementation

**ICAO GUIDELINES ON THE POLITICS OF COST ALLOCATION FOR THE GNSS AND
PROPOSAL FOR AMENDMENT OF THE SARPS RELATED TO THE IMPLEMENTATION
AND EVOLUTION OF THE GNSS**

(Presented by the Secretariat)

SUMMARY
This paper provides information on the Conclusions of the ICAO study related to the GNSS cost allocation, as well as the proposal for amendment to the SARPs related to the implementation and evolution of the GNSS.
References: • ICAO Electronic Bulletin, Ref.: EC 2/84-EB/07/14 • State Letter Ref.: AN 7/1.3.91-07/31 and AN 2/2-07/31

1. Introduction

1.1 The conclusions of the Secretariat's study on Global Navigation Satellite System (GNSS) cost allocation, which were reviewed by the Council during its 180th Session in February 2007. The results of this review were informed by the Secretary General as "provisional policy guidance on the allocation of costs of GNSS services," through the Electronic Bulletin, Ref. EC 2/84-EB/07/14, dated 11 May 2007. The Bulletin is published in the ICAO-NET Website, under the link "Electronic Bulletin." For ease of reference, this bulletin is presented in **Appendix A** to this paper.

1.2 Furthermore, ICAO sent the State Letter 2007/31, dated 11 May 2007, related to the proposals for amendment to the standards and recommended practices (SARPs) of Annex 10, Volume I, as well as issues in Annexes 11 and 15 that are related to the evolution of existing GNSS systems and equipment for the achievement of the associated safety and efficiency benefits; and they also provide resolutions of implementation issues that have arisen so far. The mentioned letter is published in the ICAO-NET Website, under the link "State Letters" and is presented in **Appendix B** to this paper. ICAO has requested to receive comments on the proposal for amendment before 24 August 2007.



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Ref.: EC 2/84-EB/07/14

11 May 2007

Subject: Conclusions of the study on Global Navigation
Satellite System (GNSS) cost allocation

Action required: Note and consider the provisional
policy guidance on GNSS cost allocation

Sir/Madam,

I have the honour to invite your attention to the conclusions of the Secretariat's study on Global Navigation Satellite System (GNSS) cost allocation. The request for the study originates from the World-wide CNS/ATM Systems Implementation Conference (held in Rio de Janeiro in May 1998), which called on ICAO to address the issue of cost allocation amongst all users of GNSS, including allocation between civil aviation and other user categories. The study has since been considered by several fora, including the Conference on the Economics of Airports and Air Navigation Services (ANSConf 2000, June 2000), the Eleventh Air Navigation Conference (AN-Conf/11, September 2003) and three meetings of the Air Navigation Services Economics Panel (ANSEP).

The Council reviewed the study during its 180th Session in February 2007. The following five conclusions of the study were accepted by the Council as "provisional" policy guidance on the allocation of the incremental costs of more advanced GNSS services:

- a) basic GNSS services will be provided free of charge as a common good to a multiple number of user categories, while more advanced GNSS services (including augmentation services) requiring a higher quality of service and hence higher costs will have to be paid for by all their users in most cases;
- b) the incremental costs for more advanced GNSS services should be allocated amongst all the users who can actually derive benefits from them. Such cost allocation should take place at the regional level and take into account the requirements of different user categories, where the service level can be adjusted to satisfy different requirements;

- c) before any costs are recovered from civil aviation, cost allocation amongst all users should be discussed and agreed upon through transparent negotiations and consultations between a GNSS service provider and representatives of civil aviation as well as other user categories;
- d) any cost allocation and resultant cost recovery should be consistent with ICAO's policies on air navigation services charges in order to ensure that civil aviation is requested to pay only its fair share of the relevant costs according to sound accounting principles and that international civil aviation is not discriminated against other modes of international transport and other user groups; and
- e) once the civil aviation's share has been determined, the allocation among participating States (or air navigation services providers (ANSPs)) and on the different phases of flights should be performed according to existing ICAO policy and guidance. ANSPs could then recover the costs from the users within their existing charging systems.

I would like you to consider the use, as far as possible, of this provisional policy guidance in your discussions and negotiations with GNSS service providers, responsible authorities and other interested parties. This provisional guidance could serve as a tool for the civil aviation community to ensure an equitable treatment of all users.

In view of the important subject addressed by the study, the Council requested me to continue to monitor developments, and collect relevant information to make an inventory of GNSS applications, and to further coordinate technical, legal and economic aspects associated with GNSS cost allocation. Once consensus has been built on the definition of basic services and liabilities of GNSS service providers, this provisional guidance is to be redrafted with appropriate wording for inclusion in *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082).

Accept, Sir/Madam, the assurances of my highest consideration.

Taïeb Chérif
Secretary General



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11 May 2007

Ref.: AN 7/1.3.91 } -07/31
AN 2/2

Subject: Proposals for the amendment of Annex 10,
Volume I, addressing navigation systems
implementation issues and reflecting GNSS evolution
for consequential amendments to Annex 11 and
Annex 15

Action required: Comments to reach Montreal by
24 August 2007

Sir/Madam,

1. I have the honour to inform you that the Air Navigation Commission, at the second and third meetings of its 175th Session on 19 and 26 April 2007, considered proposals developed by the Navigation Systems Panel (NSP) to resolve certain navigation systems implementation issues and to reflect the evolution of existing GNSS systems and equipment by amending Annex 10 — *Aeronautical Telecommunications*, Volume I — *Radio Navigation Aids*, and by making consequential amendments to Annex 11 — *Air Traffic Services* and Annex 15 — *Aeronautical Information Services*, and authorized their transmission to Contracting States and appropriate international organizations for comments.
2. The purpose of the proposed amendments is to facilitate the wider implementation of the existing GNSS Standards and Recommended Practices (SARPs) and the achievement of the associated safety and efficiency benefits. They provide resolutions of implementation issues that have arisen so far and reflect the evolution of existing GNSS systems and equipment.
3. In examining the proposed amendments, you should not feel obliged to comment on editorial aspects as such matters will be addressed by the Air Navigation Commission during its final review of the draft amendment.

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4. May I request that any comments you may wish to make on the amendment proposals be dispatched to reach me not later than 24 August 2007. The Air Navigation Commission has asked me to specifically indicate that comments received after the due date may not be considered by the Commission and the Council. In this connection, should you anticipate a delay in the receipt of your reply, please let me know in advance of the due date.

5. For your information, the proposed amendment to Annex 10, Volume I, is envisaged for applicability on 20 November 2008. The proposed amendment to Annex 11 is envisaged for applicability on 19 November 2009, while the proposed amendment to Annex 15 is envisaged for applicability on 18 November 2010. Any comments you may have thereon would be appreciated.

6. The subsequent work of the Air Navigation Commission and the Council would be greatly facilitated by specific statements on the acceptability or otherwise of the proposals. Please note that, for the review of your comments by the Air Navigation Commission and the Council, replies are normally classified as "agreement with or without comments", "disagreement with or without comments" or "no indication of position". If in your reply the expressions "no objections" or "no comments" are used, they will be taken to mean "agreement without comment" and "no indication of position", respectively. In order to facilitate proper classification of your response, a form has been included in Attachment D which may be completed and returned together with your comments, if any, on the proposals in Attachments A, B and C.

Accept, Sir/Madam, the assurances of my highest consideration.



Tajeb Chérif
Secretary General

Enclosures:

- A — Proposed amendment to Annex 10, Volume I
- B — Proposed amendment to Annex 11
- C — Proposed amendment to Annex 15
- D — Response form

ATTACHMENT A to State letter AN 7/1.3.91, AN 2/2-07/31

PROPOSED AMENDMENT TO ANNEX 10, VOLUME I

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1. ~~Text to be deleted is shown with a line through it.~~ text to be deleted
2. New text to be inserted is highlighted with grey shading. new text to be inserted
3. ~~Text to be deleted is shown with a line through it~~
followed by the replacement text which is highlighted
with grey shading. new text to replace existing text

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**PROPOSED AMENDMENT TO
INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES**

AERONAUTICAL TELECOMMUNICATIONS

**ANNEX 10
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION**

**VOLUME I
(RADIO NAVIGATION AIDS)**

CHAPTER 1. DEFINITIONS

...

Essential radio navigation service. A radio navigation service whose disruption has a significant impact on operations in the affected airspace or aerodrome.

Radio navigation service. A service providing guidance information or position data for the efficient and safe operation of aircraft supported by one or more radio navigation aids.

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**CHAPTER 2. GENERAL PROVISIONS FOR
RADIO NAVIGATION AIDS**

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**2.8 Provision of information on
the operational status of radio navigation aids services**

2.8.1 Aerodrome control towers and units providing approach control service shall be provided ~~without delay~~ with information on the operational status of radio navigation aids services essential for approach, landing and take-off at the aerodrome(s) with which they are concerned, on a timely basis consistent with the use of the service(s) involved.

...

CHAPTER 3. SPECIFICATIONS FOR RADIO NAVIGATION AIDS

3.1 Specification for ILS

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3.1.2.1.1 Facility Performance Categories I, II and III — ILS shall provide indications at designated remote control points of the operational status of all ILS ground system components, as follows:-

a) ~~Note 1.— It is intended that~~ for all Category II and Category III ILS, the air traffic services unit involved in the control of aircraft on the final approach shall be one of the designated remote control points and shall receive, ~~receiving, without delay~~ information on the operational status of the ILS, with a delay commensurate with the requirements of the operational environment, ~~as derived from the monitors;.~~

b) for a Category I ILS, if that ILS provides an essential radio navigation service, the air traffic services unit shall be one of the designated remote control points and shall receive information on the operational status of the ILS, with a delay commensurate with the requirements of the operational environment.

Note 1.— The indications required by this Standard are intended as a tool to support air traffic management functions, and the applicable timeliness requirements are sized accordingly (consistently with 2.8.1). Timeliness requirements applicable to the ILS integrity monitoring functions that protect aircraft from ILS malfunctions are specified in 3.1.3.11.3.1 and 3.1.5.7.3.1.

Note 2.— It is intended that the air traffic system is likely to call for additional provisions which may be found essential for the attainment of full operational Category III capability, e.g. to provide additional lateral and longitudinal guidance during the landing roll-out, and taxiing, and to ensure enhancement of the integrity and reliability of the system.

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3.7 Requirements for the Global Navigation Satellite System (GNSS)

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3.7.3 GNSS elements specifications

3.7.3.1 GPS Standard Positioning Service (SPS) (L1)

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3.7.3.1.5.4 *Signal power level.* Each GPS satellite shall broadcast SPS navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the output of a 3 dBi linearly-polarized antenna is within the range of ~~-160~~ ~~158.5~~ dBW to -153 dBW for all antenna orientations orthogonal to the direction of propagation.

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3.7.3.2 GLONASS Channel of Standard Accuracy (CSA) (L1)

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3.7.3.2.1 Space and control segment accuracy Accuracy

Note.— The following accuracy standards do not include atmospheric or receiver errors as described in Attachment D, 4.2.2.

3.7.3.2.1.1 *Positioning accuracy.* The GLONASS CSA position errors shall not exceed the following limits:

	Global average 95% of the time	Worst site 99.9995% of the time
Horizontal position error	28-19 m (92-62 ft)	140-44 m (460-146 ft)
Vertical position error	60-29 m (196-96 ft)	585-93 m (1-920-308 ft)

3.7.3.2.1.2 *Time transfer accuracy.* The GLONASS CSA time transfer errors shall not exceed 700 nanoseconds 95 per cent of the time.

3.7.3.2.1.3 *Range domain accuracy.* The range domain error shall not exceed the following limits:

- range error of any satellite — 30 m (98.43 ft);
- range rate error of any satellite — 0.04 m (0.12 ft) per second;
- range acceleration error of any satellite — 0.013 m (0.039 ft) per second squared;
- root-mean-square range error over all satellites — 7 m (22.97 ft).

3.7.3.2.2 *Availability.* The GLONASS CSA availability shall be at least 99.64 per cent (global average) as follows:

≥99 per cent horizontal service availability, average location (44 m, 95 per cent threshold)

≥99 per cent vertical service availability, average location (93 m, 95 per cent threshold)

≥90 per cent horizontal service availability, worst-case location (44 m, 95 per cent threshold)

≥90 per cent vertical service availability, worst-case location (93 m, 95 per cent threshold)

3.7.3.2.3 *Reliability.* The GLONASS CSA reliability shall be at least 99.98 per cent (global average) within the following limits:

- frequency of a major service failure — not more than three per year for the constellation (global average); and

b) reliability — at least 99.7 per cent (global average).

3.7.3.2.4 *Coverage.* The GLONASS CSA coverage shall cover the surface of the earth up to an altitude of 2 000 km be at least 99.9 per cent (global average).

Note.— Guidance material on GLONASS accuracy, availability, reliability and coverage is given in Attachment D, 4.2.

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3.7.6—Status monitoring and NOTAM

3.7.6.1—Changes in the current and projected status of GNSS space and ground elements that may have an impact on user performance or operational approvals shall be reported to relevant air traffic service units.

Note 1.—Additional information is provided in Attachment D, 9.

Note 2.—To assess the operational impact of changes in status, a service prediction tool may be required.

Table 3.7.2.4-1 Signal-in-space performance requirements

Typical operation	Accuracy horizontal 95% (Notes 1 and 3)	Accuracy vertical 95% (Notes 1 and 3)	Integrity (Note 2)	Time-to-alert (Note 3)	Continuity (Note 4)	Availability (Note 5)
...						
Approach operations with vertical guidance (APV-I)	16.0 m (52 ft)	20 m (66 ft)	$1 - 2 \times 10^{-7}$ per in any approach	10 s	$1 - 8 \times 10^{-6}$ in any per 15 s	0.99 to 0.99999
Approach operations with vertical guidance (APV-II)	16.0 m (52 ft)	8.0 m (26 ft)	$1 - 2 \times 10^{-7}$ per in any approach	6 s	$1 - 8 \times 10^{-6}$ in any per 15 s	0.99 to 0.99999
Category I precision approach (Note 8)	16.0 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft) (Note 7)	$1 - 2 \times 10^{-7}$ per in any approach	6 s	$1 - 8 \times 10^{-6}$ in any per 15 s	0.99 to 0.99999

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4. Ranges of values are given for the continuity requirement for en-route, terminal, initial approach, NPA and departure operations, as this requirement is dependent upon several factors including the intended operation, traffic density, complexity of airspace and availability of alternative navigation aids. The lower value given is the minimum requirement for areas with low traffic density and airspace complexity. The higher value given is appropriate for areas with high traffic density and airspace complexity (see Attachment D, 3.4.2). Continuity requirements for APV and Category I operations apply to the average risk (over time) of loss of service, normalized to a 15 second exposure time (see Attachment D, 3.4.3).

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APPENDIX B. TECHNICAL SPECIFICATIONS FOR THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

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3. GNSS ELEMENTS

3.1 Global Positioning System (GPS) Standard Positioning Service (SPS) (L1)

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3.1.1.3.3.5 *Satellite configuration summary.* Page 25 of subframe 4 shall contain a 4-bit-long term for each of up to 32 satellites to indicate the configuration code of each satellite. These 4-bit terms shall occupy bits 9 through 24 of words 3, the 24 MSBs of words 4 through 7, and the 16 MSBs of word 8, all in page 25 of subframe 4. The MSB of each 4-bit term shall indicate whether anti-spoofing is activated (MSB=1) or not activated (MSB=0). ~~The first MSB of each field shall be reserved.~~ The 3 LSBs shall indicate the configuration of each satellite using the following code:

Code	Satellite configuration
001	Block II satellite
001	Block II/IIA/IIR satellite
010	Block IIR-M satellite
011	Block IIF satellite

...

3.2 Global navigation satellite system (GLONASS) channel of standard accuracy (CSA) (L1)

...

3.2.1.1 *RF CHARACTERISTICS*

3.2.1.1.1 *Carrier frequencies.* The nominal ~~value~~ ~~values~~ of L1 ~~and~~ carrier frequencies shall be as defined by the following expressions:

$$f_{k1} = f_{01} + k\Delta f_1$$

where

$k = -7, \dots, 0, 1, \dots, 13-6$ are carrier numbers (frequency channels) of the signals transmitted by GLONASS satellites in the L1 sub-band;

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...

Table B-16. L1 carrier frequencies

Carrier number	H_n^A (see 3.2.1.3.4)	Nominal value of frequency in L1 sub-band (MHz)
13 *	13	1 609.3125
12 **	12	1 608.7500
11 **	11	1 608.1875
10 **	10	1 607.6250
09 **	9	1 607.0625
08 **	8	1 606.5000
07 **	7	1 605.9375
06 ***	6	1 605.3750
05 ***	5	1 604.8125
4	4	1 604.2500

...

*—~~This frequency may be used for technical purposes over the Russian Federation before 2006 and is planned to be vacated after 2005.~~

**—~~These frequencies are planned to be vacated after 2005.~~

***—~~These frequencies may be used for technical purposes over the Russian Federation after 2005.~~

...

3.2.1.1.4 *Spurious emissions.* The power of the transmitted RF signal beyond the GLONASS allocated bandwidth shall not be more than –40 dB relative to the power of the unmodulated carrier.

Note 1.— GLONASS satellites that are launched during 1998 to 2005 and beyond will use filters limiting out-of-band emissions to the harmful interference limit contained in ~~CCIR~~ Recommendation ITU-R RA.769 for the 1 660 – 1 670 MHz band.

Note 2.— GLONASS satellites that are launched beyond 2005 will use filters limiting out-of-band emissions to the harmful interference limit contained in ~~CCIR~~ Recommendation ITU-R RA.769 for the 1 610.6 – 1 613.8 MHz and 1 660 – 1 670 MHz bands.

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3.5 Satellite-based augmentation system (SBAS)

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3.5.5 DEFINITIONS OF PROTOCOLS FOR DATA APPLICATION

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3.5.5.2.1.1 The ~~clock time error estimate~~ code phase offset correction ($\delta\Delta t_{SV,i}$) for a GPS or SBAS satellite i at any time of day t_k is:

$$\delta\Delta t_{SV,i} = \delta a_{i,f0} + \delta a_{i,f1} (t_k - t_{i,LT})$$

...

3.5.5.5.3.2 For IPPs north of N85° or south of S85°:

Replace:

$$y_{pp} = \frac{|\phi_{pp} - \phi_1|}{10^\circ}$$

with the following:

$$y_{pp} = \frac{|\phi_{pp}| - 85^\circ}{10^\circ}$$

...

3.5.5.6 *Protection levels.* The horizontal protection level (HPL) and the vertical protection level (VPL) are:

...

w_i = the inverse weight associated with satellite i $= \sigma_i^2$.

...

3.5.5.6.2 *Definition of fast and long-term correction error model.* If fast corrections and long-term correction/GEO ranging parameters are applied, and degradation parameters are applied:

...

If fast corrections and/or long-term corrections/GEO ranging parameters are not applied, and but degradation parameters are not applied:

$$\sigma_{i,flt}^2 = [(\sigma_{i,UDRE}) (\delta_{UDRE}) + 8m]^2$$

~~If fast corrections or long-term corrections/GEO ranging parameters are not applied to a satellite, or if an~~

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~~ephemeris covariance Type 28 message has not been received for the satellite but an active Type 28 message has been received for a different satellite:~~

$$\sigma_{i,\text{fit}}^2 = (60)^2 \text{m}^2$$

...

3.5.5.6.2.3 Long-term correction degradation

3.5.5.6.2.3.1 Core satellite constellation(s)

3.5.5.6.2.3.1.1 For velocity code = 1, the degradation parameter for long-term corrections of satellite i is:

Replace:

$$\varepsilon_{\text{ltc}} = C_{\text{ltc_lsb}} + C_{\text{ltc_v1}} \max(0, t_{i,\text{LT}} - t, t - t_{i,\text{LT}} - I_{\text{ltc_v1}})$$

with the following:

$$\varepsilon_{\text{ltc}} = \begin{cases} 0, & \text{if } t_{i,\text{LT}} < t < t_{i,\text{LT}} + I_{\text{ltc_v1}} \\ C_{\text{ltc_lsb}} + C_{\text{ltc_v1}} \max(0, t_{i,\text{LT}} - t, t - t_{i,\text{LT}} - I_{\text{ltc_v1}}), & \text{otherwise} \end{cases}$$

...

3.5.5.6.2.3.2 GEO satellites. The degradation parameter for long-term corrections is:

Replace:

$$\varepsilon_{\text{ltc}} = C_{\text{geo_lsb}} + C_{\text{geo_v}} \max(0, t_{0,\text{GEO}} - t, t - t_{0,\text{GEO}} - I_{\text{geo}})$$

with the following:

$$\varepsilon_{\text{ltc}} = \begin{cases} 0, & \text{if } t_{0,\text{GEO}} < t < t_{0,\text{GEO}} + I_{\text{GEO}} \\ C_{\text{geo_lsb}} + C_{\text{geo_v}} \max(0, t_{0,\text{GEO}} - t, t - t_{0,\text{GEO}} - I_{\text{geo}}), & \text{otherwise} \end{cases}$$

where t = the current time.

Note.— When long-term corrections are applied to a GEO satellite, the long-term correction degradation is applied and the GEO navigation message degradation is not applied.

3.5.5.6.2.4 Degradation for en-route through non-precision approach

$$\varepsilon_{\text{er}} = \begin{cases} 0, & \text{if neither fast nor long-term corrections have timed out for precision approach/approach with vertical guidance} \\ C_{\text{er}}, & \text{if fast or long-term corrections have timed out for precision approach/approach with vertical guidance} \end{cases}$$

...

3.5.6 MESSAGE TABLES

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Table B-42. Type 9 ranging function message

Data content	Bits used	Range of values	Resolution
Spare Reserved	8	—	—

...

...

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Table B-45. Type 17 GEO almanac message

Data content	Bits used	Range of values	Resolution
For each of 3 satellites			
Spare Reserved	2	— 0	—
...			
...			

Table B-54. Data broadcast intervals and supported functions

Data type	Maximum broadcast interval	Ranging	GNSS satellite status	Basic differential correction	Precise differential correction	Associated message types
		...				
Fast corrections	$I_{fc}/260\text{s}$		R*	R	R	2 to 5, 24
		...				

Notes.—

1. “R” indicates that the data must be broadcast to support the function.
2. “R*” indicates special coding as described in 3.5.7.3.3.
3. Type 12 messages are only required if data are provided for GLONASS satellites.
4. I_{fc} refers to the PA/APV time-out interval for fast corrections, as defined in Table B-57.

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3.5.7.5.4 *Ionospheric integrity data.* For each IGP for which corrections are provided, SBAS shall broadcast GIVEI data such that the integrity requirement in 3.5.7.5.1 is met. If the ionospheric correction or $\sigma^2_{i,GIVE}$ exceed their coding range, SBAS shall indicate the status that the IGP is unhealthy—“Do Not Use” (designated in the correction data, 3.5.4.6) for the IGP. If $\sigma^2_{i,GIVE}$ cannot be determined, SBAS shall indicate that the IGP is “Not Monitored” (designated in the GIVEI coding).

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3.5.8.1.1 *Conditions for use of data.* The receiver shall use data from an SBAS message only if the CRC of this message has been verified. Reception of a Type 0 message from an SBAS satellite shall result in deselection of that satellite and all data from that satellite shall be discarded for at least 1 minute. For GPS satellites, the receiver shall apply long-term corrections only if the IOD matches both the IODE

and 8 least significant bits of the IODC. For GLONASS satellites, the receiver shall apply long-term corrections only if the time of reception (t_r) of the GLONASS ephemeris is inside the following IOD validity interval, as defined in 3.5.4.4.1:

$$t_{LT} - L - V \leq t_r \leq t_{LT} - L$$

Note 1.— For SBAS satellites, there is no mechanism that links GEO ranging function data (Type 9 message) and long-term corrections.

Note 2.— This requirement does not imply that the receiver has to stop tracking the SBAS satellite.

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~~3.5.8.1.1.6 For GPS satellites, the receiver shall apply long-term corrections only if the IOD matches both the IODE and 8 LSBs of the IODC.~~

~~*Note.— For SBAS satellites, there is no mechanism that links GEO ranging function data (Type 9 message) and long-term corrections.*~~

3.5.8.1.1.67 In the event of a loss of four successive SBAS messages, the receiver shall no longer support SBAS-based precision approach or APV operations.

3.5.8.1.1.78 The receiver shall not use a broadcast data parameter after it has timed out as defined in Table B-56.

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Table B-57. Fast correction time-out interval evaluation

Fast correction degradation factor indicator (ai_i)	NPA time-out interval for fast corrections (I_{fc})	PA/APV time-out interval for fast corrections (I_{fc})
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Editorial Note.— The remaining paragraphs will be renumbered, as necessary, in the final edition.

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3.5.8.4.2 Precision approach and APV operations

3.5.8.4.2.1 The receiver shall compute and apply long-term corrections, fast corrections, range rate corrections and the broadcast ionospheric corrections. For GLONASS satellites, the ionospheric corrections received from the SBAS shall be multiplied by the square of the ratio of GLONASS to GPS frequencies ($f_{GLONASS}/f_{GPS}$)².

3.5.8.4.2.2 The receiver shall use a general weighted-least-squares position solution.

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3.7 Resistance to interference

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Table B-86. Interference thresholds for pulsed interference

	GPS and SBAS	GLONASS
Frequency range	1 575.42 MHz ± 10 MHz	1 592.9525 MHz to 1 609.36 MHz
Interference threshold (Pulse peak power)	-10-20 dBW	-10-20 dBW
Pulse width	≤125 µs, ≤1 ms*	≤1 ms≤250 µs
Pulse duty cycle	≤10%1%	≤10%1%

* Applies to GPS receivers without SBAS.

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**ATTACHMENT D. INFORMATION AND MATERIAL
FOR GUIDANCE IN THE APPLICATION OF THE
GNSS STANDARDS AND RECOMMENDED PRACTICES**

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2. General

Standards and Recommended Practices for GNSS contain provisions for the elements identified in Chapter 3, 3.7.2.2. Additional implementation guidance is provided in the *Global Navigation Satellite System (GNSS) Manual* (Doc 9849).

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3. Navigation system performance requirements

3.3 Integrity and time-to-alert

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3.3.5 For APV and precision approach operations, integrity requirements for GNSS signal-in-space requirements of Chapter 3, Table 3.7.2.4-1, were selected to be consistent with ILS requirements.

Insert new text as follows:

3.3.6 The approach integrity requirements apply in any one landing and require a fail-safe design. If the specific risk on a given approach is known to exceed this requirement, the operation should not be conducted. One of the objectives of the design process is to identify specific risks that could cause misleading information and to mitigate those risks through redundancy or monitoring to achieve a fail-safe design. For example, the ground system may need redundant correction processors and shut down automatically if that redundancy is not available due to a processor fault.

3.3.7 A unique aspect of GNSS is the time-varying performance caused by changes in the core satellite geometry. A means to account for this variation is included in the SBAS and GBAS protocols through the protection level equations, which provide a means to inhibit use of the system if the specific integrity risk is too high.

3.3.8 GNSS performance can also vary across the service volume as a result of the geometry of visible core constellation satellites. Spatial variations in system performance can further be accentuated when the ground system operates in a degraded mode following the failure of system components such as monitoring stations or communication links. The risk due to spatial variations in system performance should also be reflected in the protection level equations, i.e. the broadcast corrections.

3.3.9 GNSS augmentations are also subject to several atmospheric effects, particularly due to the ionosphere. Spatial and temporal variations in the ionosphere can cause local or regional ionospheric delay errors that cannot be corrected within the SBAS or GBAS architectures due to the definition of the message protocols. Such events are rare and their likelihood varies by region, but they are not expected to be negligible. The resulting errors can be of sufficient magnitude to cause misleading information and should be mitigated in the system design through accounting for their effects in the broadcast parameters

(e.g. σ_{iono_vert} in GBAS), and monitoring for excessive conditions where the broadcast parameters are not adequate. The likelihood of encountering such events should be considered when developing any system monitor.

3.3.10 Another environmental effect that should be accounted for in the ground system design is the errors due to multipath at the ground reference receivers, which depend on the physical environment of monitoring station antennas as well as on satellite elevations and times in track.

End of new text.

3.4 Continuity of service

...

3.4.3 Approach and landing

3.4.3.1 For approach and landing operations, continuity of service relates to the capability of the navigation system to provide a navigation output with the specified accuracy and integrity during the approach, assuming given that it was available at the start of the operation. In particular, this means that loss of continuity events that can be predicted and for which NOTAMs have been issued do not have to be taken into account when establishing compliance of a given system design against the SARPs continuity requirement. The occurrence of navigation system alerts, either due to rare fault-free performance or to failures, constitute continuity failures. In this case, the continuity requirement is stated as a probability for a short exposure time.

3.4.3.2 The continuity requirements for approach and landing operations represent only the allocation of the requirement between the aircraft receiver and the non-aircraft elements of the system. In this case, no increase in the requirement is considered necessary to deal with multiple aircraft use of the system. The continuity value is normally related only to the risk associated with a missed approach and each aircraft can be considered to be independent. However, in some cases, it may be necessary to increase the continuity values since a system failure has to be correlated between both runways (e.g. the use of a common system for approaches to closely-spaced parallel runways).

Insert new text as follows:

3.4.3.3 For GNSS-based APV and Category I approaches, missed approach is considered a normal operation, since it occurs whenever the aircraft descends to the minimum altitude for the approach and the pilot is unable to continue with visual reference. The continuity requirement for these operations applies to the average risk (over time) of loss of service, normalized to a 15 second exposure time. However, a safety assessment has shown that safety and efficiency are best assured by continuing to provide approach service even if the specific risk of loss of continuity exceeds the design requirement.

3.4.3.4 For those areas where the system design does not meet the average continuity risk specified into the SARPs, it is still possible to publish procedures. However, specific operational mitigations should be put in place to cope with the reduced continuity expected. For example, flight planning may not be authorized based on a GNSS navigation means with such a high average continuity risk.

End of new text.

...

4.2 GLONASS

Note.— Additional information concerning GLONASS can be found in the GLONASS Interface Control Document published by Scientific Coordination Information Center, Russian Federation Ministry of Defence, Moscow.

4.2.1 ~~Satellite selection.~~ The performance standard definitions are based upon the assumption that the channel of standard accuracy (CSA) receiver will select satellites based on the minimum PDOP every 5 minutes, or whenever a satellite used in the position solution sets below the mask angle. *Assumptions.* The performance standard is based upon the assumption that a representative channel of standard accuracy (CSA) receiver is used. A representative receiver has the following characteristics: designed in accordance with GLONASS ICD; uses a 5-degree masking angle; accomplishes satellite position and geometric range computations in the most current realization of the PZ-90 and uses PZ-90 – WGS-84 transformation parameters as indicated in Appendix B, paragraph 3.2.5.2; generates a position and time solution from data broadcast by all satellites in view; compensates for dynamic Doppler shift effects on nominal CSA ranging signal carrier phase and standard accuracy signal measurements; excludes GLONASS unhealthy satellites from the position solution; uses up-to-date and internally consistent ephemeris and clock data for all satellites it is using in its position solution; and loses track in the event that a GLONASS satellite stops transmitting standard accuracy code. The time transfer accuracy applies to a stationary receiver operating at a surveyed location.

4.2.2 *Accuracy.* ~~Accuracy is conditioned by coverage, availability and reliability standards, and a measurement interval of 24 hours for any point on the earth.~~ The accuracy is measured with a representative receiver and a measurement interval of 24 hours for any point within the coverage area. The positioning and timing accuracy are for the signal-in-space (SIS) only and do not include such error sources as: ionosphere, troposphere, interference, receiver noise or multipath. The accuracy is derived based on the worst two of 24 satellites being removed from the constellation and a 7-metre constellation RMS SIS user range error (URE).

4.2.3 ~~Time transfer accuracy.~~ Time transfer accuracy is conditioned by coverage, availability and reliability standards and a measurement interval of 24 hours for any point on the earth. It is based upon the GLONASS CSA receiver time as computed using the output of the position solution. Time transfer accuracy is defined with respect to Universal Coordinated Time as maintained by the National Time Service of Russia (UTC(SU)). *Range domain accuracy.* Range domain accuracy is conditioned by the satellite indicating a healthy status and transmitting standard accuracy code and does not account for satellite failures outside of the normal operating characteristics. Range domain accuracy limits can be exceeded during satellite failures or anomalies while uploading data to the satellite. Exceeding of the range error limit constitutes a major service failure as described in 4.2.6. The range rate error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The range acceleration error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The root-mean-square range error accuracy is the average of the

RMS URE of all satellites over any 24-hour interval for any point within the coverage area. Under nominal conditions, all satellites are maintained to the same standards, so it is appropriate for availability modelling purposes to assume that all satellites have a 7-metre RMS SIS URE. The standards are restricted to range domain errors allocated to space and control segments.

~~4.2.4 Availability. Availability is conditioned by coverage and a typical 24 hour interval (defined using an averaging period of 60 days) averaged over the earth.~~ Availability is the percentage of time over any 24-hour interval that the predicted 95 per cent positioning error (due to space and control segment errors) is less than its threshold, for any point within the coverage area. It is based on a 44-metre horizontal 95 per cent threshold; a 93-metre vertical 95 per cent threshold; using a representative receiver; and operating within the coverage area over any 24-hour interval. The service availability assumes the worst combination of two satellites out of service.

~~4.2.4.1 Relationship to augmentation availability.~~ The availability of ABAS, GBAS and SBAS does not directly relate to the GLONASS availability defined in Chapter 3, 3.7.3.2.2. Availability analysis is based on an assumed satellite constellation and the probability of having a given number of satellites. Twenty-four operational satellites are available on orbit with 0.95 probability (averaged over any day), where a satellite is defined to be operational if it is capable of but is not necessarily transmitting a usable ranging signal. At least 21 satellites in the 24 nominal plane/slot positions must be set healthy and must be transmitting a navigation signal with 0.98 probability (yearly averaged).

~~4.2.5 Reliability. Reliability is conditioned by coverage, service availability, 200 m not to exceed predictable horizontal reliability threshold, a maximum of 18 hours of major service failure behaviour over the sample interval, and a measurement interval of one year, average of daily values over the earth.~~ Reliability is the percentage of time over a specified time interval that the instantaneous CSA SIS URE is maintained within the range error limit, at any given point within the coverage area, for all healthy GLONASS satellites. The reliability standard is based on a measurement interval of one year and the average of daily values within the coverage area. The single point average reliability assumes that the total service failure time of 18 hours will be over that particular point (3 failures each lasting 6 hours).

~~4.2.5.14.2.6 Major service failure.~~ A major service failure is defined as a departure from the normal ranging signal characteristics in a manner that can cause a reliability or availability service failure. Specifically, a major service failure is defined as a departure from the normal ranging signal characteristics in one of the following ways:

- ~~a) a statistical departure from nominal system ranging accuracy that causes the CSA instantaneous ranging error to exceed 70 m; or~~
- ~~b) a fault in a CSA ranging signal, navigation message structure or navigation message content that impacts the CSA receiver's minimum ranging signal reception or processing capabilities.~~

to be a condition over a time interval during which a healthy GLONASS satellite's ranging signal error (excluding atmospheric and receiver errors) exceeds the range error limit 30 metres (as defined in Chapter 3, 3.7.3.2.1.3 a) and/or failures in radiofrequency characteristics of CSA ranging signal, structure or contents of navigation message deteriorate minimum capabilities to receive and process ranging signal in CSA receiver.

~~4.2.76 Coverage. Coverage is conditioned by the probability of four or more satellites in view over any 24 hour interval averaged over the earth, a PDOP of 6 or less from four satellites, a 5 degree mask angle, and a constellation of twenty four operational satellites as defined in the almanac.~~ The GLONASS

CSA supports the terrestrial coverage area, which is from the surface of the earth up to an altitude of 2 000 kilometres.

Editorial Note.— The remaining paragraphs will be renumbered, as necessary, in the final edition.

...

6. Satellite-based augmentation system (SBAS)

...

6.4 RF characteristics

6.4.1 ~~SBAS pseudo-random noise (PRN) codes. RTCA/DO-229C, Appendix A, provides two methods for SBAS PRN code generation.~~ *Minimum GEO Signal Power Level.* When planning for the introduction of new operations based on SBAS, States are expected to conduct an assessment of the signal power level as compared to the level interference from RNSS or non-RNSS sources. The minimum aircraft equipment (e.g. RTCA/DO-229D) is required to operate with a minimum signal strength of -158.5 dBW in the presence of non-RNSS interference (Appendix B, 3.7) and an aggregate RNSS noise density of -173 dBm/Hz. Receivers may not have reliable tracking performance for a signal strength between -158.5 dBW and -161 dBW (minimum signal strength as specified in the SARPs) in the presence of interference from RNSS or non-RNSS sources.

...

6.4.4 *Message timing.* The users' convolutional decoders will introduce a fixed delay that depends on their respective algorithms (usually 5 constraint lengths, or 35 bits), for which they must compensate to determine SBAS network time (SNT) from the received signal.

Insert new text as follows:

6.4.5 *SBAS signal characteristics.* Differences between the relative phase and group delay characteristics of SBAS signals, as compared to GPS signals, can create a relative range bias error in the receiver tracking algorithms. The SBAS service provider is expected to account for this error, as it affects receivers with tracking characteristics within the tracking constraints in Attachment D, 8.11. For GEOs for which the on-board RF filter characteristics have been published in RTCA/DO229D, Appendix T, the SBAS service providers are expected to ensure that the UDREs bound the residual errors including the maximum range bias errors specified in the MOPS. For other GEOs, the SBAS service providers are expected to work with equipment manufacturers in order to determine, through analysis, the maximum range bias errors that can be expected from existing receivers when they process these specific GEOs. This effect can be minimized by ensuring that the GEOs have a wide bandwidth and small group delay across the pass-band.

6.4.6 *SBAS pseudo-random noise (PRN) codes.* RTCA/DO-229D, Appendix A, provides two methods for SBAS PRN code generation.

End of new text.

6.5 SBAS data characteristics

6.5.1 *SBAS messages.* Due to the limited bandwidth, SBAS data is encoded in messages that are designed to minimize the required data throughput. ~~RTCA/DO-229C~~ **RTCA/DO-229D**, Appendix A, provides detailed specifications for SBAS messages.

6.5.2 *Data broadcast intervals.* The maximum broadcast intervals between SBAS messages are specified in Appendix B, Table B-54. These intervals are such that a user entering the SBAS service broadcast area is able to output a corrected position along with SBAS-provided integrity information in a reasonable time. For en-route, terminal and NPA operations, all needed data will be received within 2 minutes, whereas for precision approach operations, it will take a maximum of 5 minutes. The maximum intervals between broadcasts do not warrant a particular level of accuracy performance as defined in Chapter 3, Table 3.7.2.4-1. In order to ensure a given accuracy performance, each service provider will adopt a set of broadcast intervals taking into account different parameters such as the type of constellations (e.g. GPS with SA, GPS without SA) or the ionospheric activity.

~~6.5.2.1 For fast corrections, Table B-54 allows the maximum broadcast interval to be 60 seconds. Table B-56 gives data time-out intervals for the various data messages with reference to Table B-57 which shows the fast corrections time-out intervals as a function of the fast correction degradation factor indicator (ai_i). However, if the service provider chose 60 seconds for the fast corrections broadcast interval and the ai_i was 15, the user, due to data time-out prior to the next broadcast, would not have current fast corrections for 42 seconds of every minute for NPA and APV-I and for 48 seconds of every minute for APV-II and PA. In order to ensure that the aircraft element processes valid fast corrections without such interruptions, the maximum broadcast interval for fast corrections has to be set at a value that is one third of the NPA and APV-I time-out interval for fast corrections and one half of the APV-II and PA time-out interval for fast corrections as determined by ai_i .~~

~~Note. Maximum fast corrections broadcast intervals for each ai_i can be found in RTCA/DO-229C, Table A-8.~~

...

8. Signal quality monitor (SQM) design

...

8.11.6 For aircraft receivers using double-delta correlators and tracking GPS satellites, the precorrelation bandwidth of the installation, the correlator spacing and the differential group delay are within the ranges defined in Table D-13.

...

Replace Table D-13 with the following new table:

Table D-13. GPS tracking constraints for double-delta correlators

Region	3 dB precorrelation bandwidth, BW	Average correlator spacing range (chips), X	Instantaneous correlator spacing range (chips)	Differential group delay
1	$(-50 \times X) + 12 < BW < 7 \text{ MHz}$ $2 < BW \leq 7 \text{ MHz}$	0.1 – 0.2 0.2 – 0.6	0.09 – 0.22 0.18 – 0.65	$\leq 600 \text{ ns}$
2	$(-50 \times X) + 12 < BW < (40 \times X) + 11.2 \text{ MHz}$ $(-50 \times X) + 12 < BW < 14 \text{ MHz}$ $7 < BW \leq 14 \text{ MHz}$	0.045 – 0.07 0.07 – 0.1 0.1 – 0.24	0.04 – 0.077 0.062 – 0.11 0.09 – 0.26	$\leq 150 \text{ ns}$
3	$14 < BW \leq 16 \text{ MHz}$	0.07 – 0.24	0.06 – 0.26	$\leq 150 \text{ ns}$

...

— — — — —

ATTACHMENT B to State letter AN 7/1.3.91, AN 2/2-07/31

PROPOSED AMENDMENT TO ANNEX 11

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1. ~~Text to be deleted is shown with a line through it.~~ text to be deleted
2. New text to be inserted is highlighted with grey shading. new text to be inserted
3. ~~Text to be deleted is shown with a line through it~~
followed by the replacement text which is highlighted
with grey shading. new text to replace existing text

B-2

**PROPOSED AMENDMENT TO
INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES**

AIR TRAFFIC SERVICES

**ANNEX 11
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION**

CHAPTER 1. DEFINITIONS

...

Radio navigation service. A service providing guidance information or position data for the efficient and safe operation of aircraft supported by one or more radio navigation aids.

...

CHAPTER 4. FLIGHT INFORMATION SERVICE

...

4.2 Scope of flight information service

4.2.1 Flight information service shall include the provision of pertinent:

- a) SIGMET and AIRMET information;
- b) information concerning pre-eruption volcanic activity, volcanic eruptions and volcanic ash clouds;
- c) information concerning the release into the atmosphere of radioactive materials or toxic chemicals;
- d) information on changes in the ~~serviceability of navigation aids~~ availability of radio navigation services;
- e) information on changes in condition of aerodromes and associated facilities, including information on the state of the aerodrome movement areas when they are affected by snow, ice or significant depth of water;
- f) information on unmanned free balloons;

and of any other information likely to affect safety.

...

CHAPTER 7. AIR TRAFFIC SERVICES REQUIREMENTS FOR INFORMATION

...

7.3 Information on the operational status of navigation aids services

7.3.1 ATS units shall be kept currently informed of the operational status of ~~non-visual navigation aids~~ radio navigation services, and those visual aids essential for take-off, departure, approach and landing procedures within their area of responsibility and those radio navigation services and visual ~~and non-visual~~ aids essential for surface movement.

7.3.2 **Recommendation.**— *Information on the operational status, and any changes thereto, of radio navigation services and visual ~~and non-visual~~ aids as referred to in 7.3.1 should be received by the appropriate ATS unit(s) on a timely basis consistent with the use of the service(s) and aid(s) involved.*

Note.— *Guidance material regarding the provision of information to ATS units in respect to visual and non-visual navigation aids is contained in the Air Traffic Services Planning Manual (Doc 9426). Specifications for monitoring visual aids are contained in Annex 14, Volume I, and related guidance material is in the Aerodrome Design Manual (Doc 9157), Part 5. Specifications for monitoring non-visual aids are contained in Annex 10, Volume I.*

...

ATTACHMENT C to State letter AN 7/1.3.91, AN 2/2-07/31

PROPOSED AMENDMENT TO ANNEX 15

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1. ~~Text to be deleted is shown with a line through it.~~ text to be deleted
2. New text to be inserted is highlighted with grey shading. new text to be inserted
3. ~~Text to be deleted is shown with a line through it~~
followed by the replacement text which is highlighted
with grey shading. new text to replace existing text

C-2

**PROPOSED AMENDMENT TO
INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES**

AERONAUTICAL INFORMATION SERVICES

**ANNEX 15
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION**

CHAPTER 1. DEFINITIONS

...

Radio navigation service. A service providing guidance information or position data for the efficient and safe operation of aircraft supported by one or more radio navigation aids.

...

CHAPTER 5. NOTAM

5.1 Origination

...

5.1.1.1 A NOTAM shall be originated and issued concerning the following information:

...

- a) establishment, closure or significant changes in operation of aerodrome(s)/heliport(s) or runways;
- b) establishment, withdrawal and significant changes in operation of aeronautical services (AGA, AIS, ATS, COM, MET, SAR, etc.);
- c) establishment, ~~or withdrawal~~ and significant changes in operational capability of ~~electronic and other aids to air navigation and aerodromes/heliports~~ radio navigation and air-ground communication services. This includes: interruption or return to operation, change of frequencies, change in notified hours of service, change of identification, change of orientation (directional aids), change of location, power increase or decrease amounting to 50 per cent or more, change in broadcast schedules or contents, or irregularity or unreliability of operation of any ~~electronic aid to air navigation~~ radio navigation, and air-ground communication services;
- d) establishment, withdrawal or significant changes made to visual aids;

...

CHAPTER 8. PRE-FLIGHT AND POST-FLIGHT INFORMATION/DATA

8.1 Pre-flight information

...

8.1.2.1 Additional current information relating to the aerodrome of departure shall be provided concerning the following:

...

- h) failure or irregular operation of part or all of the aerodrome lighting system including approach, threshold, runway, taxiway, obstruction and manoeuvring area unserviceability lights and aerodrome power supply;
- i) failure, irregular operation and changes in the operational status of ~~I LS (including markers), MLS, basic GNSS, SBAS, GBAS, SRE, PAR, DME, SSR, VOR, NDB~~ radio navigation services, VHF aeromobile channels, RVR observing system, and secondary power supply; and
- j) presence and operation of humanitarian relief missions, such as those undertaken under the auspices of the United Nations, together with any associated procedures and/or limitations applied thereof.

...

8.3 Post-flight information

8.3.1 States shall ensure that arrangements are made to receive at aerodromes/heliports information concerning the state and operation of air navigation facilities **or services** noted by aircrews and shall ensure that such information is made available to the aeronautical information service for such distribution as the circumstances necessitate.

Note.— See Annex 14, Volume I, Chapter 9, Section 9.4.

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ATTACHMENT D to State letter AN 7/1.3.91, AN 2/2-07/31

**RESPONSE FORM TO BE COMPLETED AND RETURNED TO ICAO TOGETHER WITH
ANY COMMENTS YOU MAY HAVE ON THE PROPOSED AMENDMENTS**

To: The Secretary General
International Civil Aviation Organization
999 University Street
Montreal, Quebec
Canada, H3C 5H7

(State) _____

Please make a checkmark (✓) against one option for each amendment. If you choose options “agreement with comments” or “disagreement with comments”, **please provide your comments on separate sheets.**

	<i>Agreement without comments</i>	<i>Agreement with comments*</i>	<i>Disagreement without comments</i>	<i>Disagreement with comments</i>	<i>No position</i>
Amendment Annex 10 — <i>Aeronautical Telecommunications</i> and Volume I — <i>Radio Navigation Aids</i> (Attachment A refers)					
Amendment to Annex 11 — <i>Air Traffic Services</i> (Attachment B refers)					
Amendment to Annex 15 — <i>Aeronautical Information Services</i> (Attachment C refers)					

*“Agreement with comments” indicates that your State or organization agrees with the intent and overall thrust of the amendment proposal; the comments themselves may include, as necessary, your reservations concerning certain parts of the proposal and/or offer an alternative proposal in this regard.

Signature _____

Date _____

— END —