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**MEETING OF THE METEOROLOGY PANEL (METP)**

**FOURTH MEETING**

**Montréal, 10 to 14 September 2018**

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| **Agenda Item** | **6:****4.4:** | **Meteorological Operations Group****World area forecast system** |
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PROPOSED REVISION to eddy dissipation rate (EDR) values in Annex 3

(Presented by Colin Hord – Rapporteur MET Operations Group)

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| **SUMMARY** |
| This paper presents revised values of eddy dissipation rate (EDR) for aircraft turbulence within Annex 3 to be consolidated with other changes for Amendment 79 to Annex 3 (applicable November 2020).Action by the METP/4 is in paragraph 4. |

1. INTRODUCTION
	1. The Roadmap for the World Area Forecast System (WAFS), version 3.1, which was endorsed by METP at their second meeting (October 2016) (METP/2 Decision 4/6) calls for the World Area Forecast Centres (WAFC) to implement turbulence forecasts utilizing eddy dissipation rate (EDR) during the Aviation System Block Upgrades (ASBU) Block 1 time frame (2019-2024)[[1]](#footnote-1).
	2. EDR is the index-based metric for reporting aircraft turbulence and has been included in Annex 3 - *Meteorological Service for International Air Navigation* since Amendment 72 (2001). These EDR values were revised for Amendment 74 (2007) as an improved EDR algorithm had been developed and the results indicated that the EDR thresholds for reporting turbulence should be revised. Since then scientific studies of over 100 million aircraft turbulence reports have shown that EDR values in Annex 3 require another revision.
	3. This paper presents draft changes to the EDR values in Annex 3 for consideration with other proposals for Amendment 79 of Annex 3 (applicable November 2020).
2. DISCUSSION
	1. **Background**:
		1. The current thresholds for EDR in Annex 3 (which have existed since Amendment 74 in 2007) are as follows:

(*Excerpt of current Annex 3 (Amendment 77, 2016), Appendix 4, paragraph 2.6.2*):

a) severe when the peak value of the cube root of EDR exceeds 0.7;

b) moderate when the peak value of the cube root of EDR is above 0.4 and below or equal to 0.7;

c) light when the peak value of the cube root of EDR is above 0.1 and below or equal to 0.4; and

d) nil when the peak value of the cube root of EDR is below or equal to 0.1.

*Note.— The EDR is an aircraft‑independent measure of turbulence. However, the relationship between the EDR value and the perception of turbulence is a function of aircraft type, and the mass, altitude, configuration and airspeed of the aircraft. The EDR values given above describe the severity levels for a medium-sized transport aircraft under typical en‑route conditions (i.e. altitude, airspeed and weight).*

* + 1. Since 2005, the United States (US) National Science Foundation’s National Center for Atmospheric Research (NCAR) has continued to improve the algorithms as well as derive climatologies of EDR reports. The background and results were published in the American Meteorological Society’s Journal of Applied Meteorology and Climatology (JAMC) in 2014[[2]](#footnote-2) (Robert Sharman, et al.). During a 10-year period (2004-2013) 128.3 million United Airline (UAL) B-737 and B-757 (medium-sized aircraft) EDR reports were recorded. Additional B-737 aircraft reports recorded were also in the millions. The work by Sharman, et al., compared EDR reports with thousands of pilot reported turbulence. Sharman, et al., concluded that the EDR threshold values in Annex 3 (Amendment 74 through the present Amendment 77) were too high.
	1. **WG-MOG World Area Forecast System (WAFS):**
		1. The Fourth Meeting of the WG-MOG in April 2017 was informed about the need for the revision EDR thresholds in Annex 3 (METP-MOG/4/SN/29 refers). The meeting agreed that the threshold values should be revised and formed an ad hoc group to further review the information and produce a paper for METP/4 (Agreed Action 4/WAFS8 refers).
		2. The Seventh Meeting of the WG-MOG in April 2018 reviewed the report and EDR thresholds from the ad hoc group (METP-MOG/7/SN/xx refers).
	2. **Proposed Amendment to Annex 3:**
		1. The appendix to this paper contains the proposed changes relating to EDR for Amendment 79 to Annex 3 (2020 intended applicability).
		2. In addition to the revised EDR values, the proposed changes remove the text “of the cube root” relating to the EDR values. Technically the terminology “EDR” refers to the cube root of the energy or eddy dissipation rate estimated from aircraft data parameters (e.g., vertical wind velocity or aircraft vertical acceleration), i.e.,

EDR $≡$ $∛ε$, where $ε$ is the eddy dissipation rate in units $∛$m2 s-3

But the text in Annex 3 states “the cube root of EDR”. This can be confusing to some users if they believe they need to derive the cubic root of the EDR value reported by the aircraft when referring to the values in Annex 3. Clearly this is not the intention, thus the text “of the cube root” is removed from all EDR related provisions in Annex 3, but a statement that *EDR refers to the cubic root of the energy or eddy dissipation rate as based on estimated vertical wind velocity or aircraft vertical acceleration* is added to the existing note in Annex 3.

* 1. The Action 4/WAFS8 also called upon the ad hoc group to consider bringing this change to the attention of the Flight Operations Panel (FLTOPSP). The Secretary to the METP (Neil) contacted the Secretary of the FLTOPSP who informed Neil that he saw no reason to involve the FLTOPSP in any decisions, rather he believes the FLTOPSP would welcome an Information Paper informing them of the changes and reasons, which can be written after METP/4.
	2. The lowering of the turbulence thresholds for moderate and severe turbulence will increase the number of turbulence reports for these categories. On at least one airline, its pilots see the EDR values in the cockpit, thus depending on the airline, voice reports of turbulence will likely be reflecting the observed EDR value. If more severe turbulence reports are relayed by voice, it would likely increase the number of SIGMETs issued. It is beyond the scope of this group to conduct the research to determine the possible increases in SIGMETs or any impact on operations.
	3. Lastly, a review of the Doc 4444 - PANS-ATM, Doc 8896 – Manual of Aeronautical Meteorological Practice and Doc 9377 – Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services, showed there are no consequential amendments needed to these documents.
1. CONCLUSION
	1. Research has shown that EDR thresholds for turbulence in Annex 3 are too high. Given the above discussion the Panel is invited to formulate the following draft recommendation:

**Draft Recommendation 4/xx — Revised eddy dissipation rate (EDR) threshold values in Annex 3 - *Meteorological Service for International Air Navigation***

That, the Panel

a) endorse the proposed changes to Annex 3 as shown in the appendix to this paper; and

b) consolidate with other proposed changes for Amendment 79 to Annex 3 - *Meteorological Service for International Air Navigation*.

* 1. As stated in paragraph 2.4, the FLTOPSP would welcome an Information Paper informing them of the changes and reasons, which can be written after METP/4.

**Draft Recommendation 4/xx — Information Paper to the next meeting of the FLTOPSP on the revised eddy dissipation rate (EDR) threshold values in Annex 3 - *Meteorological Service for International Air Navigation***

That, the Rapporteur of WG-MOG prepare and information paper on the changes to EDR values in Annex 3 in time for the next meeting of the FLTOPSP.

1. ACTION BY THE METP/4
	1. The METP is invited to:

a) note the information contained in this paper; and

b) formulate the draft recommendations contained in 3.1 and 3.2.

**APpendix**

The following are proposed revisions to Appendix 4, 2.6.2 and 2.6.3, and Appendix 6, 4.2.6 of Annex 3:

(*Changes proposed are highlighted as* ~~deletions~~ *or* additions)

**APPENDIX 4. TECHNICAL SPECIFICATIONS RELATED TO**

**AIRCRAFT OBSERVATIONS AND REPORTS**

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**2.6 Turbulence**

…

2.6.2    Interpretation of the turbulence report

Turbulence shall be considered:

 a) severe when the peak value ~~of the cube root~~ of EDR equals or exceeds ~~0.7~~ 0.45;

 b) moderate when the peak value ~~of the cube root~~ of EDR is equal to or above ~~0.4~~ 0.20 and below ~~or equal to 0.7~~ 0.45;

 c) light when the peak value ~~of the cube root~~ of EDR is above 0.10 and below ~~or equal to 0.4~~ 0.20;

 d) nil when the peak value ~~of the cube root~~ of EDR is below or equal to 0.10.

*Note 1.— The EDR is an aircraft‑independent measure of turbulence. However, the relationship between the EDR value and the perception of turbulence is a function of aircraft type, and the mass, altitude, configuration and airspeed of the aircraft. The EDR values given above describe the severity levels for a medium-sized transport aircraft under typical en‑route conditions (i.e. altitude, airspeed and weight).*

*Note 2.— EDR refers to the cube root of the energy or eddy dissipation rate estimated from aircraft data parameters (e.g., vertical wind velocity or aircraft vertical acceleration).*

2.6.3    Special air‑reports

Special air‑reports on turbulence shall be made during any phase of the flight whenever the peak value ~~of the cube root~~ of EDR equals or exceeds ~~0.4~~ 0.20. The special air‑report on turbulence shall be made with reference to the 1-minute period immediately preceding the observation. Both the average and peak value of turbulence shall be observed. The average and peak values shall be reported in terms of the cube root of EDR. Special air‑reports shall be issued every minute until such time as the peak values ~~of the cube root~~ of EDR fall below ~~0.4~~ 0.20.

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 APPENDIX 6. TECHNICAL SPECIFICATIONS RELATED TO

SIGMET AND AIRMET INFORMATION, AERODROME WARNINGS AND WIND SHEAR WARNINGS AND ALERT

…

4.2    Criteria related to phenomena included in

SIGMET and AIRMET messages and special air-reports (uplink

…

4.2.6    Turbulence shall be considered:

 a) severe whenever the peak value ~~of the cube root~~ of EDR equals or exceeds ~~0.7~~ 0.45; and

 b) moderate whenever the peak value ~~of the cube root~~ of EDR is equal to or above ~~0.4~~ 0.20 and below ~~or equal to~~ ~~0.7~~ 0.45.

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— END —

1. The Block 1 time frame referred to in METP/2 Decision 4/6 was 2018-2023, which was changed to 2019-2024 in the 5th Edition of the Global Air Navigation Plan. [↑](#footnote-ref-1)
2. Sharman, R.D., L. B. Cornman, G. Meymaris, J. Pearson, and T. Farrar, 2014: *Description and derived climatologies of automated in situ eddy-dissipation-rate reports of atmospheric turbulence*, Journal of Applied Meteorology and Climatology, volume 53, pages 1416-1432. [↑](#footnote-ref-2)