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| U.S. Radiocommunications SectorFact Sheet |
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| **Purpose/Objective:** This contribution provides updates for WP 5B’s consideration to Annex 3.6 of the Chair’s Report of the 34th Working Party 5B Meeting. |
| **Abstract:** This contribution provides updates for WP 5B’s consideration to Annex 3.6 of the Chair’s Report of the 34th Working Party 5B Meeting. Titled, WORKING DOCUMENT TOWARDS A [PRELIMINARY DRAFT NEW REPORT ITU-R M.[ITU-R M.2059 COMPARISON]] / WORKING DOCUMENT WITH ELEMENTS [IN VIEW OF A POSSIBLE NEW REPORT] ON RADIO ALTIMETER MEASUREMENTS COMPARED TO ITU-R DOCUMENTATION |

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| Additional technical information for sharing studies under WRC-27 agenda item 1.7 |

1. **Introduction**

At the last meeting (April to May 2025), Working Party (WP) 5B, started developing a working document comparing Recommendation ITU-R M.2059 with publicly available test data.

1. **Proposal**

The United States provides WP 5B proposed edits to the working document (Annex 3.6 of the Chair’s Report of the 34th Working Party 5B Meeting). The edits include adding an additional annex discussing the concept of an altitude adjustment factor to be applied to Recommendation ITU-R M.2059 protection criteria.

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| Comparison of ITU-R M.2059 with measured radio altimeter data |

Editor’s note: Views were expressed that measurements mentioned in this document derived from three volumes of public available data were made on limited number of radio altimeters from only four manufacturers below 4.2 GHz and only two manufacturers above 4.4 GHz.

It should be noted that,

– Only radio altimeter units manufactured after 2012 were considered except for one radio altimeter in the volume III (Model RA-F), which was manufactured after 2007. Radio altimeters still in use onboard aircraft but manufactured before these dates were not measured. Furthermore, it is recognised that an aircraft's lifecycle may last over 50 years,

– In this document, when extracting information from Volume III, only UC1 radio altimeters have been considered, excluding the measurements of the RA-W and RA-Z models (UC2 and UC3 equipped on helicopters, regional aircraft (up to 100 seats), general aviation aircraft (up to 19 seats) and business jets, and

– There are inconsistencies in testing procedures between Vol I and II with Vol III leading to as much as 20 dB difference in the result (eg RA-V 200ft 3930MHz).

Consequently, the radio altimeters tested and measured cannot be considered exhaustive and representative of all radio altimeters in use, and cannot be considered as conclusive.

# 1 Introduction

Recommendation ITU-R M.2059 (Rec. ITU-R M.2059), Operational and Technical Characteristics and Protection Criteria of Radio Altimeters (RAs), was approved in 2015 and provides characteristics of RAs, a system that operates under the aeronautical radionavigation service, including background information of how the system is used on aircraft. The characteristics include three protection criteria to ensure the operations of this system that is critical for safety and regularity of flight. Since the publication of Recommendation ITU-R M.2059, some RA data has been published, and it is useful to compare characteristics within Recommendation ITU-R M.2059 with this data.

ANNEX 1: Description [TBD]

ANNEX 2: Description [TBD]

ANNEX 3: Description [TBD]

*[Editor’s Note: Any content removed is for convenience only.]*

# 2 Summary

[To be developed in future meetings.]

**Attachment**: 1

ANNEX 3

## A3-1 RA Measured Data Potential Applications

Based on the AVSI data presented in Annexes 1 and 2, several RA test results suggest that RA units may exhibit improved resilience to both in-band and out-of-band interference at lower altitudes. This improvement appears to be:

1. specific to each tested model. and
2. a function of frequency.

Furthermore, the fundamental mechanisms contributing to this trend may also differ between each altimeter model. Nevertheless, this observed empirical trend could be useful to consider in conjunction with the guidance provided in Rec. ITU-R M.2059.

Notably, Rec. ITU-R M.2059 does not specify any form of altitude dependence for the three failure modes outlined within its Annex 3; however, introducing an altitude-dependent adjustment to these protection criteria could help reflect real-world performance as seen via publicly available test data.

From a first-principles perspective, an RA operating at or above its maximum reported altitude is operating in a condition where the desired signal is near the minimum detectable level. At lower altitudes, the desired signal strength typically increases which could be one element contributing the systems improved resilience to interference. Since RA systems often vary in design and implementation, each systems response to interference may differ, and no two RA systems may be expected to behave identically. Additionally, it may be overly simplistic to assume that the improvement in interference rejection improves indefinitely as the RA gets closer to it’s terrain target.

Given the above, it is possible to define two key altitudes:

* : The upper limit of the RAs maximum reported altitude, in meters, and
* : A threshold altitude, in meters, below which further interference resilience is not assumed

Based on these assumptions, and key inputs, a general altitude adjustment factor () can be crafted as follows:

 for, 0

 for,

 , for,

Equation A3-1

where:

 : Current altitude of the RA (meters)

 : Approximated interference resilience improvement factor (Empirically Derived)

 : The maximum operational altitude (meters)

This serves as a model to approximate the typically observed radio altimeters behaviour of improved resilience to interfering signals at lower altitudes. Parameters such as *IRI* and can be empirically derived based on publicly available test data, including radio altimeter breakpoints and interference tolerance thresholds from Annexes 2 and 3.

### A3-1.1 Methods to Calculate *IRI* and Variables

An example method to empirically calculate an *IRI* value is to look take the slope of the change in the log of the altitude over the change in BP value. The table below walks through this process for the AVSI Vol II and III data for Models F, L, T, X, and Y.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| RA Model | Max Height Tested (ft) | Min Height Tested (ft) | Δ Log(Height) | Max Height BP (dBm/MHz) | Min Height BP (dBm/MHz) | Δ BP | *IRI* |
| F | 5000 | 200 | 1.40 | -101 | -67 | -34 | 24.3 |
| L | 5000 | 200 | 1.40 | -88 | -74 (Vol II)-75 (Vol III) | -14-13 | 10.09.3 |
| T | 7000 | 200 | 1.54 | -91 | -62 (Vol II)-60.8 (Vol III) | -29-30.2 | 18.819.6 |
| X | 5000 | 200 | 1.40 | -98 | -58 | -40 | 28.6 |
| Y | 5000 | 200 | 1.40 | -101 | -64 | -37 | 26.5 |

Various averaging or other numerical approaches can be used to calculate a single IRI based on each models IRI. It can be seen that for models, F, L, T, X, and Y the IRI ranges from 9.3 to 28.6.

Furthermore, since the lowest altitude data is collected for is 61 m (200 ft), the value may be assumed to be 61 m (200 ft).

### A3-1.1 Applied Example

The can be applied to any protection criteria contained in Rec. ITU-R M.2059. For example, when considering the receiver desensitization protection criteria in located at the radio altimeter receive and applying an , the generic expression may look as follows:

For FMCW radio altimeters:

Equation A3-2

For pulsed radio altimeters:

Equation A3-3

where:

 : IF bandwidth of the altimeter in MHz

 : Chirp bandwidth of the altimeter in MHz

 : Noise figure at the receiver input in dB

Recommendation ITU-R M.2059 Radio Altimeter Model Specific Parameters

| Parameter | Units | Radio Altimeter Model |
| --- | --- | --- |
| A1 | A2 | A3 | A4 | A5 | A6 | D1 | D2 | D3 | D4 |
|  | **m** | 2500 | 2438 | 6000 | 1524 | 1524 | 457 | 1676 | 1737 | 6000 | 2424 |
|  | **km** | 12 | 12 | 20 | 12 | 12 | 12 | 12 | 12 | 20 | 12 |
|  | **MHz** | 2 | 0.25 | 2 | 9.2 | 6 | 16 | 0.312 | 1.95 | 2 | 30 |
|  | **dB** | 10 | 6 | 6 | 10 | 10 | 10 | 8 | 9 | 8 | 10 |
| **(Note 1)** | **MHz** | 104 | 132.8 | 133 |  |  |  | 150 | 176.8 | 133 |  |
| Note 1: Models with a listed are FMCW radio altimeters, and models without are pulsed radio altimeters |

The following figure plots the assuming an of 16 and an of 61.

