Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports

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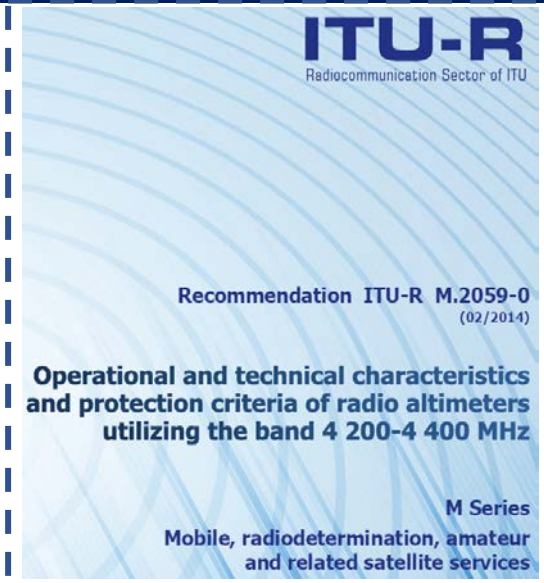
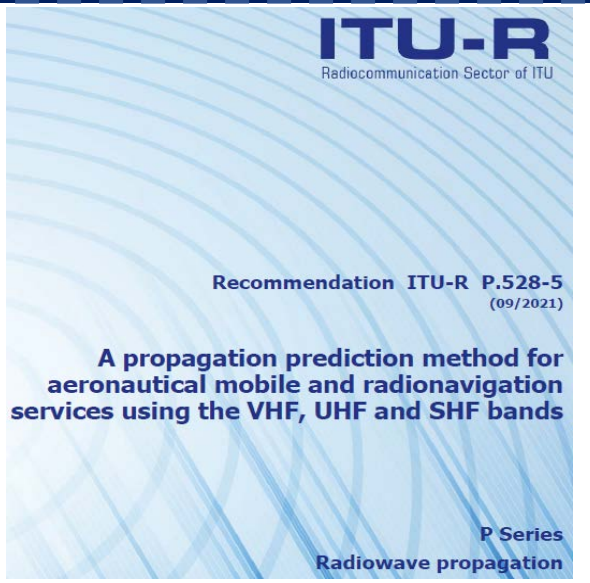
Guidance on Safeguarding measures to protect Radio Altimeter from potential harmful interference from Cellular 5G Communications

ICAO MID Guidance Guidance on Safeguarding measures to protect Radio Altimeter from potential harmful interference from Cellular 5G Communications

- Record of amendments & Abbreviations
- Executive Summary
- Chapter 1 - Background on 5 G and frequency band allocation
- Chapter 2 - Potential impacts of 5G on Radio Altimeters during aircraft operations
- Chapter 3 – Short Term Safeguarding measures adopted at regional and global levels /Long Term Planning
- **Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports**
- Appendix A – French Methodology to set the dimensions of Special Protection Zones around airports

Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports: Main references used





International Civil Aviation Organization

FSMP-WG/11 WP/27 rev1
2021-03-09

WORKING PAPER

FREQUENCY SPECTRUM MANAGEMENT PANEL (FSMP)

Eleventh Working Group meeting

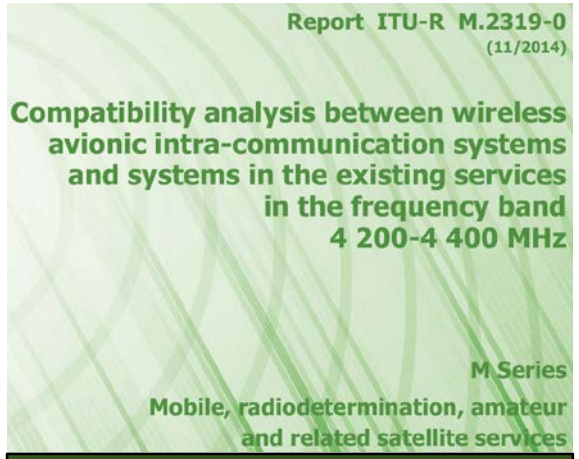
Web Meeting, 1 – 12 March 2021

Agenda Item 3.: Radio Altimeter and Wireless Aircraft Intra-Communications (WAIC) Issues
c) National efforts to implement broadband mobile near 4200-4400 MHz

UK Deployment of Mobile Systems in the Frequency Range 3.6-4.2 GHz and the Theoretical Impact on Radio Altimeters

(Presented by .John Mettrop)

Recommendation ITU-R M.1461 is used as a guideline in analysing the compatibility between radars (including radio altimeters) operating in the radiodetermination service with systems in other services



Radio-altimeter antenna beam is modeled based on the antenna pattern formula provided in this report

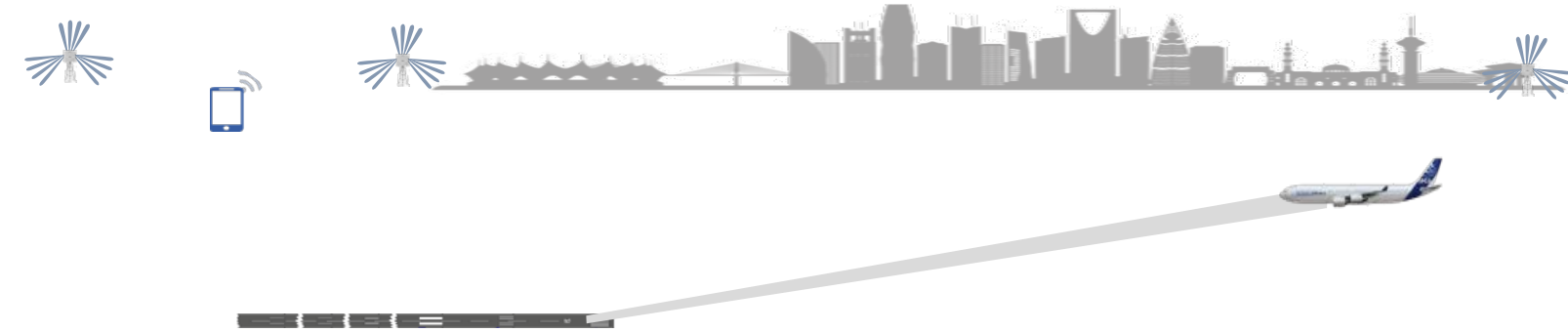
Rec. ITU-R SM.337-6

RECOMMENDATION ITU-R SM.337-6*

Frequency and distance separations

(1948-1951-1953-1963-1970-1974-1990-1992-1997-2007-2008)

Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports: Overview on the Contents



Chapter 1 - Background on 5 G and frequency band allocation

Chapter 2 - Potential impacts of 5G on Radio Altimeters during aircraft operations

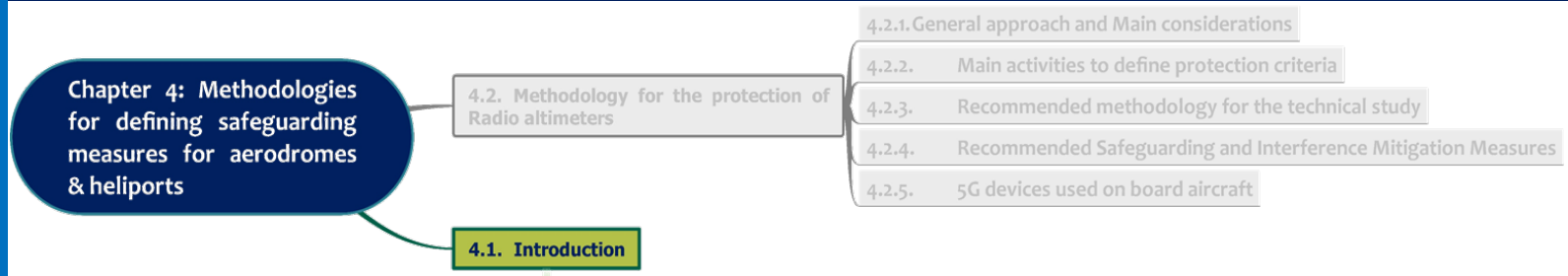
Chapter 3 – Short Term Safeguarding measures adopted at regional and global levels /Long Term Planning

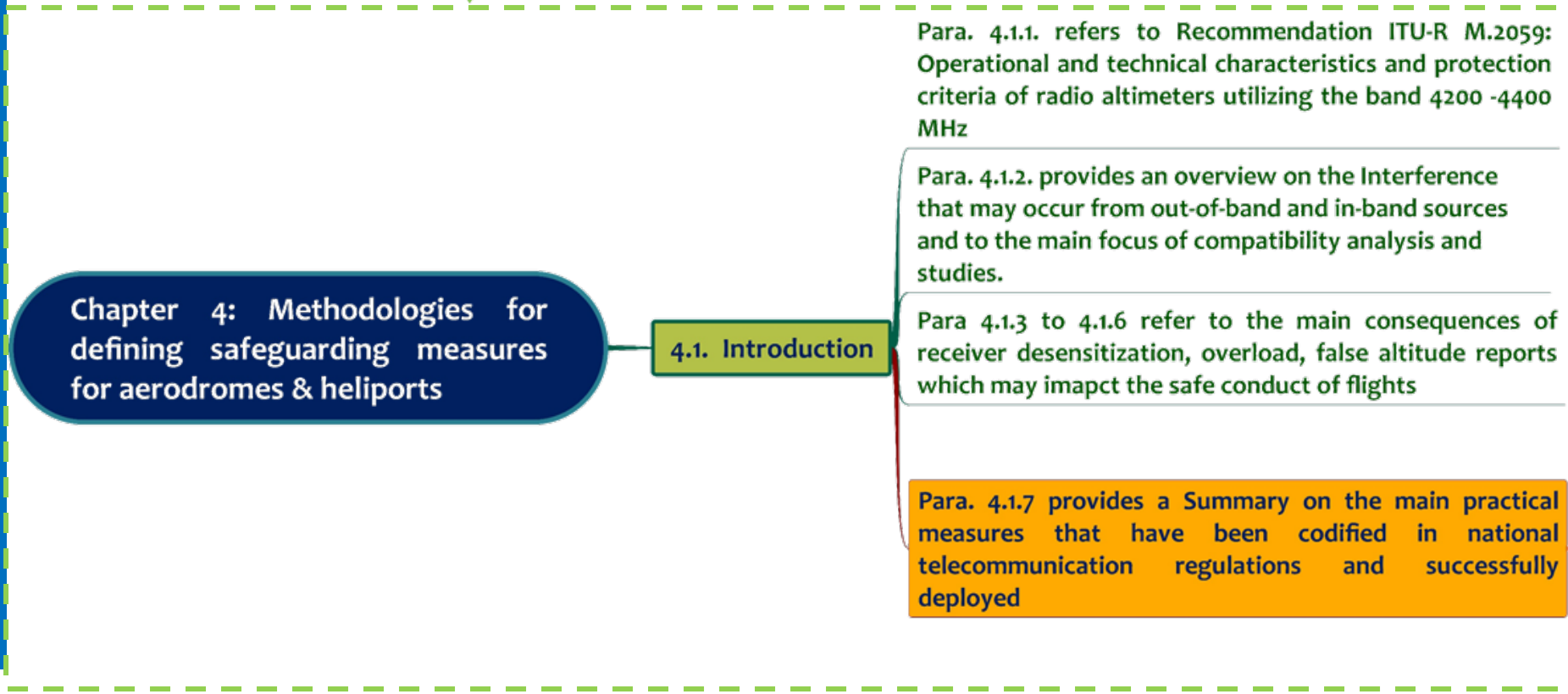
Chapter 4: Methodologies for defining safeguarding measures for aerodromes & heliports

- 4.1. Introduction
- 4.2. Methodology for the protection of Radio altimeters
  - 4.2.1. General approach and Main considerations
  - 4.2.2. Main activities to define protection criteria
  - 4.2.3. Recommended methodology for the technical study
  - 4.2.4. Recommended Safeguarding and Interference Mitigation Measures
  - 4.2.5. 5G devices used on board aircraft

Appendix A – French Methodology to set the dimensions of Special Protection Zones around airports

Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports: Introduction





Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports: Introduction

Cont'd

Three primary electromagnetic interference coupling mechanisms between radio altimeters and interfering signals from other transmitters

Criteria 01

Receiver overload:
Receiver front-end overload where the value depends on each radio altimeters type

Criteria 02

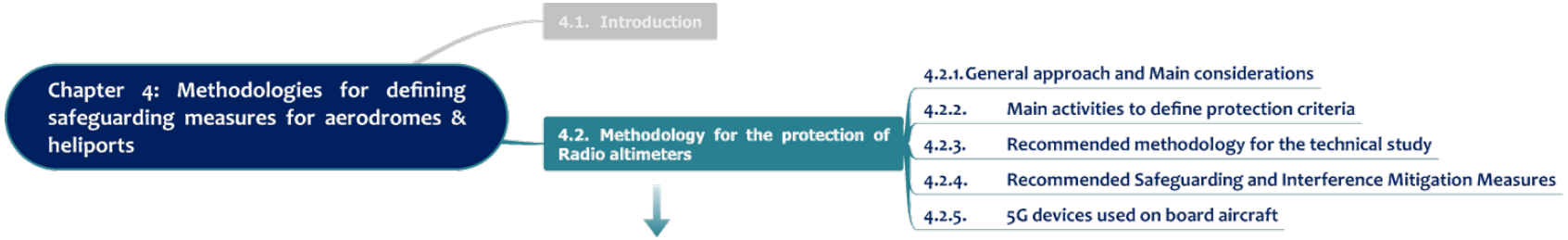
Desensitization
Receiver desensitization which is the common I/N protection criteria of -6dB

Criteria 03

False Altitude Generation:
the False altitude reports which are defined by -143 dBm/100 Hz (–143 dBm considering 100 Hz detector bandwidth

Compatibility studies and protection criteria

Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports: Overview on Section 4.2



General approach and Main considerations

4.2.1. General approach and Main considerations

- **Objective:** identify the protection areas around airports and heliports for proper mitigations
  - maximum roll of up to +/-30 degrees from the horizontal in all directions,
  - The air-to-ground propagation model base don ITU Recommendation ITU-R P.528-4
- Characteristics of 5G Base Station to check whether the protection criteria are met for an airplane flying at different heights (50, 200, 1000 ft and 2000 ft (15, 61, 310 and 610 meters)) above the Base Station.
- Initial Analysis based on a single base station to verify whether it can pose a threat to the aeronautical systems in the band (for simplicity the aircraft can have zero roll and pitch). If a single base station is predicted to not cause interference, the analysis can be expanded to consider the aggregation of multiple interferers and the roll and pitch of the aircraft.
- Considerations of the main parameters and factors of 5G network: Power of the 5G base station, Antenna gain, Maximum Effective Isotropic Radiated Power, Location of Base Station, The antenna tilt, Scan angle, rate of use, ground scattering and altitude, Frequency band, Aggregated unwanted emission level, Filtering characteristics of each radio altimeters and associated installation)

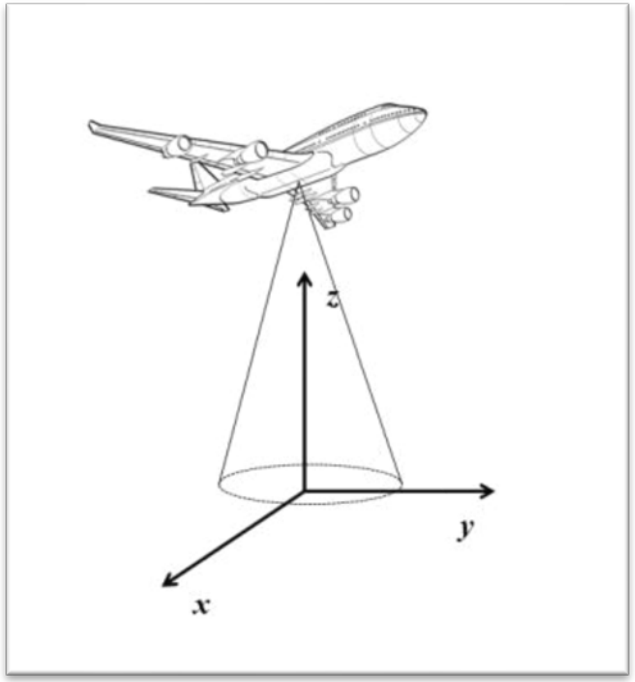
General approach and Main considerations

Cont'd

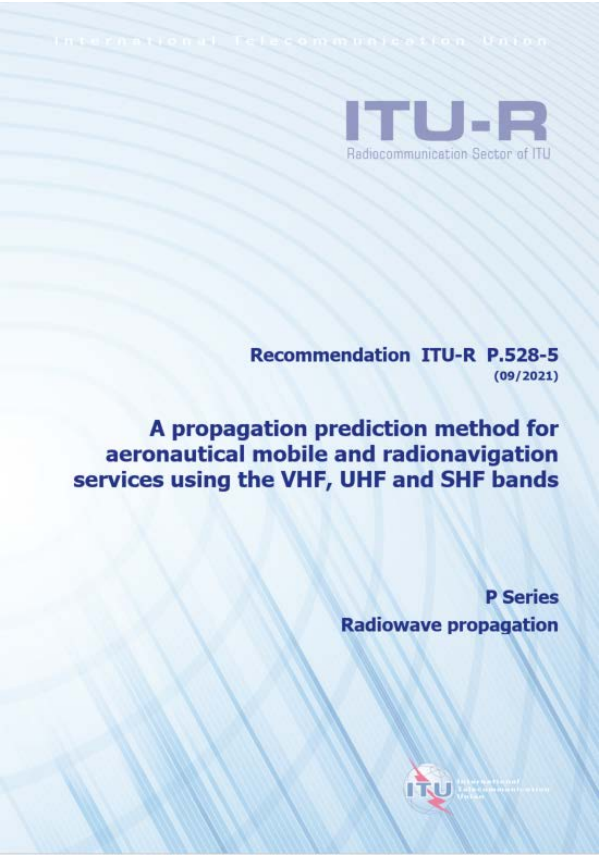
ICAO recommends to consider the following parameters when performing the analysis:

The air-to-ground propagation model (Recommendation ITU-R P.528-427)

The aircraft can have a maximum roll of up to +/-30 degrees from the horizontal in all directions,



- The base station is located at (0,0,0);
- The aircraft is flying along a horizontal path defined by the coordinates (0, ya, ha). The altitude ha of the aircraft is fixed, so that its position varies along the axis y only;
- The radio-altimeter antenna beam is modeled based on the antenna pattern formula available in Report ITU-R M.231928 (§A-3.1.1).



Main activities to define protection criteria

4.2.2 Main activities to define protection criteria

- Setting of joint working group(s)/committees between national spectrum and aviation regulatory authorities
- Drafting of detailed report summarizing the main findings of the international working groups and the corresponding administrations. The results and recommendations will be used as temporary and interim measures to protect the radio altimeters until the review of technical standards for RADALTs has been completed.
- Conduct a detailed scientific technical study including simulations, and lab experiments.
- perform a field trial, if feasible, to validate the scientific studies, simulations, and lab experiments findings and to ensure the coexistence between the RADLAT and 5G networks based on the applied protection criteria. The research project team should prepare a detailed report summarizing the main findings of field trials.
- share the detailed report summarizing the main findings of scientific studies and lab experiments with all stakeholders
- Collect views and concerns and review the interim protection criteria according to the reported findings of scientific studies and lab experiments

Main activities to define protection criteria

Cont'd

To identify the protection criteria for RADALT systems from the 5G networks, the regulators should perform the following approach is proposed for joint activities by relevant national spectrum and aviation regulatory authorities:

International activities

summarizing the main findings of the international work. he results and recommendations will be used as temporary and interim measures to protect the radio altimeters

Scientific Study

Conduct a detailed scientific technical study including simulations, and lab experiments

Field Trial and update

The research project team, in coordination with national spectrum and aviation regulators should perform a field trial. the protection criteria should be updated based on the reported findings of field trials.

Stakeholders

The spectrum and aviation regulators should share the detailed report summarizing the main findings of scientific studies and lab experiments with all stakeholders;

Update

The protection criteria will be updated according to the reported findings of scientific studies and lab experiments.

Recommended methodology for the technical study

4.2.3 Recommended methodology for the technical study

- Identify the frenquency spectrum range and the area of interest (Usually around aerodromes and heliports)
- Identify the locations of base stations or IMT mobile network (Base stations installed or to be installed). The study considers the separation distance relative to the mobile base station's antenna required between a rural mobile base station and an aircraft in flight
- Identify the list of parameters considering the aircraft operations and the 5G base stations and network deployments: Pitch/Roll, Base station Antenna Heigh & Tilt, Aggregate Effects, Radio Altimeter Receiver Frequency Dependent Rejection
- Identify the separation distance relative to the mobile base station's antenna and an aircraft in flight (Slant angle) at different heights/altitudes
- For each angle during the approach of an aircraft, the separation distance is calculated using the appropriate ITU formula assuming free space path loss (baseline scenario)
- Generalize the baseline scenario, to all possible scenarios and investigate the impact on all radio altimeters taken from Recommendation ITU-R M.2059.
- Summarizes the impact of 5G base stations network and recommend the mitigations measures and required safeguarding and protection areas.

Recommended methodology for the technical study

Cont'd

The UK presented a study at FSMP-Working Group (WG)/11 WP/27 outlining a methodology which could be used to assess the impact of 5G on RADALT. It investigates the potential interference from 5G base stations operating in the frequency range 3.6-4.2 GHz into radio altimeters under various scenarios

01 The study considers the separation distance relative to the mobile base station's antenna required between a rural mobile base station and an aircraft in flight level flight, as illustrated in the next Figure.

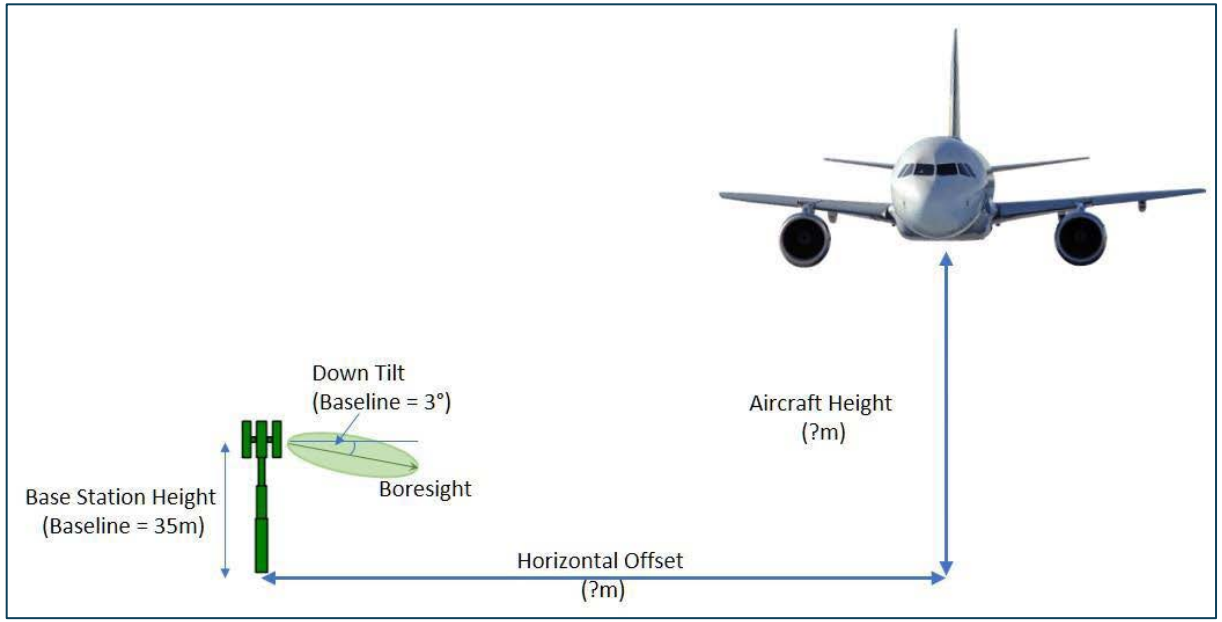
02 The study does not consider the impact of active antenna systems due to modelling difficulties and user equipment as the power levels are significantly lower and therefore presumed not to be a threat.

03 For each angle during the approach of an aircraft, the required separation distance is calculated using the following ITU formula assuming free space path loss:

04 $$PRx=PTx+GTx+AFTx-FSPL+GRx+RxRej-FLRx+SM$$

After re-arranging the above equation, it can be re-written as follow:

$$DKM=10^{\left(\frac{PTx+GTx+AFTx+GRx+RxRej-FLRx-32.4\ 20\ Log\ (FMHz)+SM}{20}\right)}$$



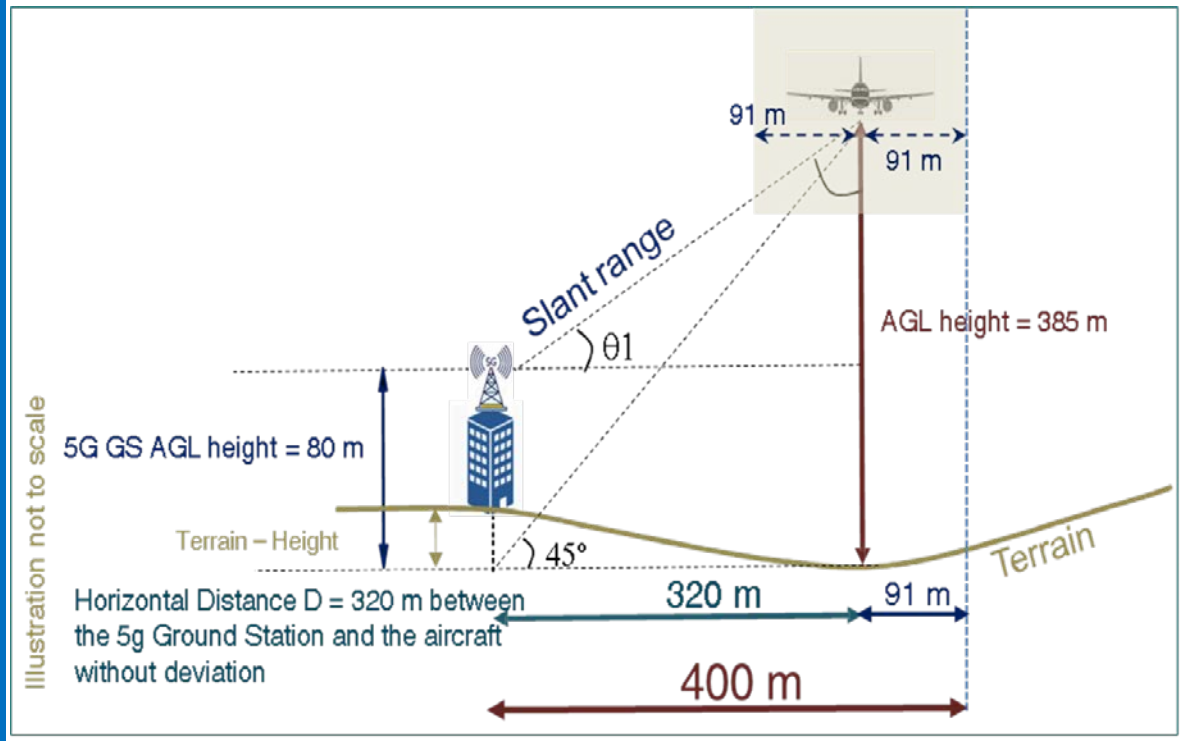
Where:
PRx = Power received (assumed to be the receiver overload threshold)
PTx = Mobile base station power supplied to the antenna port
GTx = Gain of the mobile base station antenna in the direction of the aircraft
AFTx = Transmitter activity factor
FSPL = Free space path loss (=32.4+20log(FMHz)+20Log(Dkm)
FMHz = Frequency
Dkm = Separation distance
GRx = Gain of the radio altimeter antenna in the direction of the mobile base station
RxRej = Adjacent channel rejection of the radio altimeter receiver
FLRx = Feeder loss in the radio altimeter
SM = Safety margin (assumed to be 6dB)

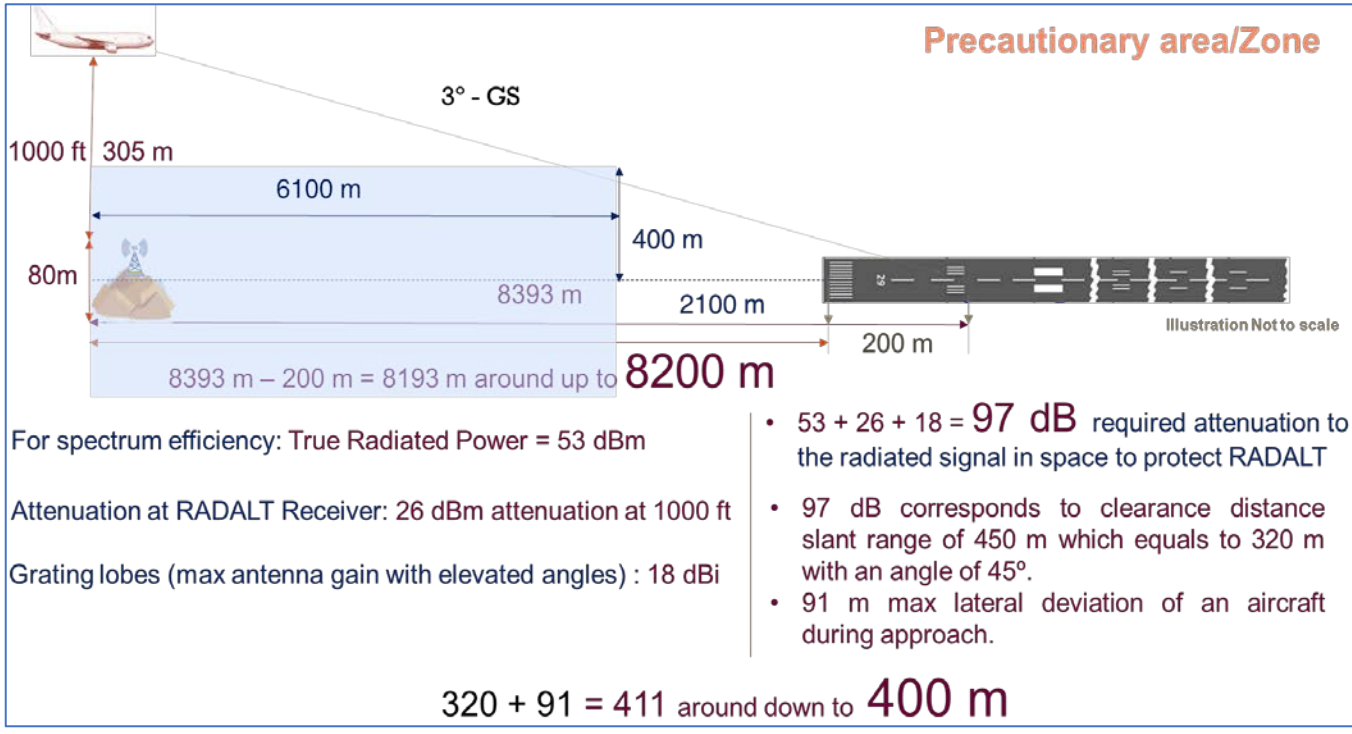
Having established the above baseline scenario, the following variations in the baseline scenario should be investigated for radio altimeters A1 and A3 taken from Recommendation ITU-R M.2059.

Recommended methodology for the technical study

Cont'd

Sample of calculation: Separation distance btw a BS and RADALT





For spectrum efficiency: True Radiated Power = 53 dBm

Attenuation at RADALT Receiver: 26 dBm attenuation at 1000 ft

Grating lobes (max antenna gain with elevated angles) : 18 dBi

- 53 + 26 + 18 = 97 dB required attenuation to the radiated signal in space to protect RADALT
- 97 dB corresponds to clearance distance slant range of 450 m which equals to 320 m with an angle of 45°.
- 91 m max lateral deviation of an aircraft during approach.

320 + 91 = 411 around down to 400 m

Recommended methodology for the technical study

Cont'd

The following parameters should be considered in the study:

Pitch/Roll

The impact of the aircraft pitching/rolling by 15°, 30°, 45° towards the mobile base station antenna.

1

Mobile Antenna Height & Tilt

Variations in the height and down tilt angle of the mobile base station for urban (25m & 6°) and suburban masts (20m & 10°) and this is based on

2

Aggregate Effects

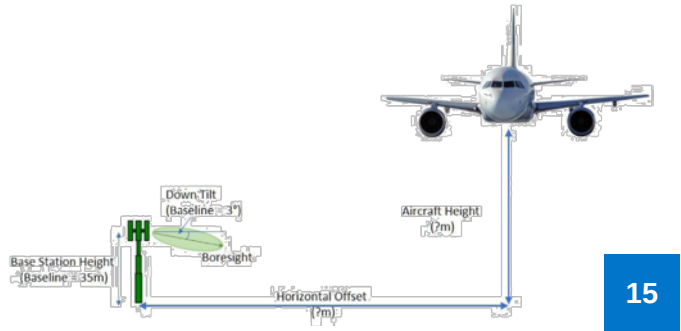
The level of aggregate interference that should be applied assuming a standard rural macro deployment scenario taken from Recommendation ITU-R M.2101 &Report ITU-R M.2292

3

Radio Altimeter Receiver Frequency Dependent Rejection

Use the frequency dependent rejection at 3.75 GHz based on ITU-R M.2059 assuming the octave is based on the size of the frequency band & band edge frequency, radio regulatory guidance, RTCA worst case measured results.

4

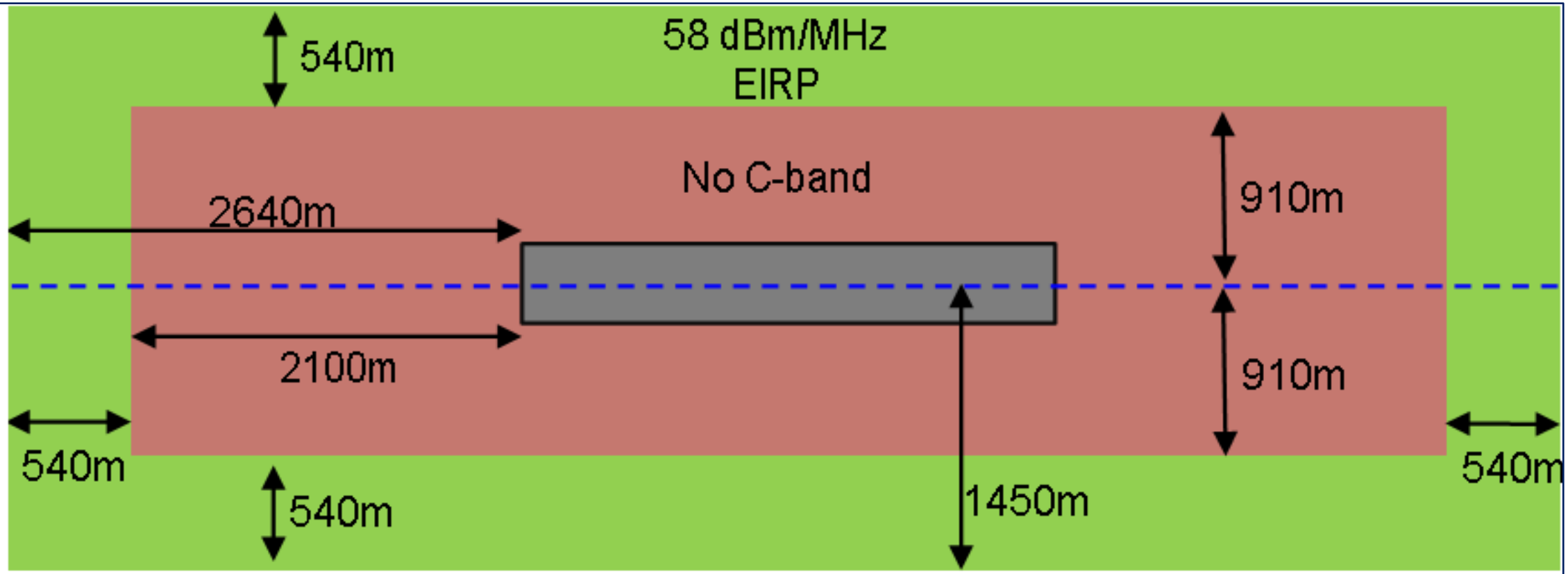


Recommended Safeguarding and Interference Mitigation Measures

4.2.4. Recommended Safeguarding and Interference Mitigation Measures

- Issuing of safety notices or circulars to aircraft operators highlighting the potential interference of 5G network emissions with aircraft RADALTs
- Adoption of safeguarding measures, and mitigations to protect RADALT around aerodromes/Heliports. The measures should be issued jointly between frequency spectrum management and Civil Aviation Authorities and considered as main requirements to approve the deployment of 5G ground Stations (Base Stations) and associated network.
- Establish protection zones, namely Safety and Precautionary zones, around aerodromes with sufficient technical conditions (such as restricting 5G transmission power) for each zone considering the best practices. The plotting of the RADLAT protection zoning should be shared with all stakeholders.
- Organize regular communications with stakeholders including 5G service provider to share informaiton on the last development and any reported interference.
- Setup appropriate oversight processes to monitor the level of compliance of 5G service providers with the requirements and conditions for the deployment of base stations and network around the aerodromes
- Setup joint investigation committee between frequency spectrum management and Civil Aviation Authorities to analyse any reported interference

Recommended Safeguarding and Interference Mitigation Measures: Sample of protection zones



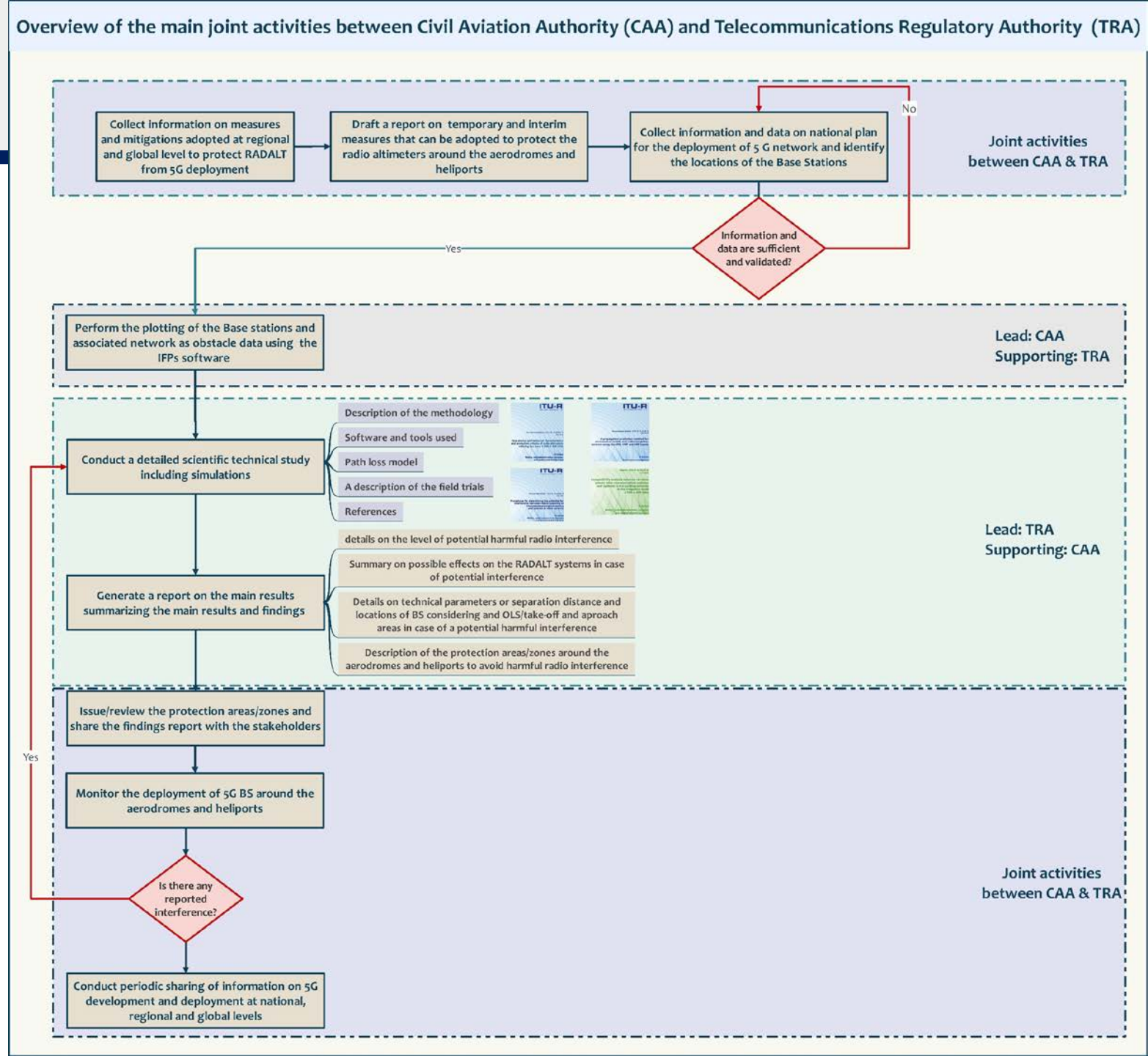
Note: This illustration is for guidance on the protection zones at an aerodrome. The green area is defined as buffer zone that depends on the location of BS and several other factors.

5G Devices used on board

4.2.5. 5G devices used on board aircraft

- Issuing of safety notices or circulars to aircraft operators highlighting the potential interference that may be caused by user equipment used on board
- Define operational recommendations for aircraft operators and pilots related to the user equipment with 5G capabilities
  - Remind passengers that all portable electronic devices allowed for transport in checked baggage (including smartphones and other devices) should be turned off and protected from accidental activation
  - Remind passengers to set all portable electronic devices in the cabin and any carried on the aircraft to a non-transmitting mode or turn them off
  - Instruct crew to use 3G or 4G communication devices only when essential communication is required, such as during emergency medical service operations.
- Organize regular communications with aircraft operators and airspace users to share informaiton on the last development and any encountered interference during flights.
- Setup joint investigation committee between frequency spectrum management and Civil Aviation Authorities to analyse any reported interference by user equipment used on board.

Joint activities btw CAA and TRA



Chapter 4 - Methodologies for defining safeguarding measures for aerodromes & heliports

Q & A