| Form | | - | **CIVIL AVIATION AUTHORITY**  **Directorate General for Civil Aviation Regulation**  **Air Navigation Safety Department** | | | | | |  |
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| Revision | | Initial |
| Date | | 30 Nov 2024 |
| **ORGANIZATION CARRYING OUT BRA INFRINGEMENT STUDY**  **COMPLIANCE STATEMENT** | | | | | | | | | |
| **Date** | | **:** | | **Applicant Name** | | | **:** | | |
| **SR** | **Regulatory**  **Reference** | | **Regulatory Requirement** | | **Compliance with Regulatory Requirement** | | | **Simulation Tools Document/Manual**  **(Fill with Doc name, page , section/chapter, paragraph)** | |
| **Comply** | **Not Comply** | **Partially Comply** |
| **1** | **CAR 171 APPENDIX C**  **PART II -9.1(1)** | | **GENERAL SIMULATION TOOLS REQUIREMENT** | |  |  |  |  | |
|  |  | | **The General BRA Infringement Study Including:**   1. CAD modelling of the environment around CNS equipment antennas, taking into consideration the electric properties of the materials constituting each element | |  |  |  |  | |
| **(b)** Geographical utilities (GIS) for locating elements on a geographic continuum using most common types of datum and projections including WGS84. | |  |  |  |  | |
| * + - 1. The modelling functionality (including terrain models, obstacles, interfering system, ground and airborne NAV-AIDs equipment characteristic etc.) to model the real propagation phenomena in a complex electromagnetic airport scenario where signals (VOR, DME, ILS, TLS, ATC Radar) interfere with artificial or natural obstruction. | |  |  |  |  | |
| * + - 1. General antenna pattern definition and modelling | |  |  |  |  | |
| * + - 1. Terrain Clutter Analysis and EM Visibility analysis (for ATC Radar) | |  |  |  |  | |
| * + - 1. Performance Simulation of CNS Equipment in the real site considering multipath effect from elements such as terrain, obstacles and other site elements (such as fences, wires and towers). | |  |  |  |  | |
| * + - 1. Interference analysis between two system | |  |  |  |  | |
| * + - 1. The post-processing of the EM analysis results. | |  |  |  |  | |
| * + - 1. Digital terrain Model Inspection. | |  |  |  |  | |
| * + - 1. Optical Visibility Analysis for minimum Radio Altitude to see the antenna (line of sight) for all CNS equipment | |  |  |  |  | |
| * + - 1. Radio Coverage Analysis (field Strength) as per ICAO Limit for all CNS equipment, including PSR/SSR coverage analysis at constant altitude or height and along a route segment for all CNS equipment. | |  |  |  |  | |
| * + - 1. Basic Coverage.  1. The calculation shall be based on the antenna pattern transmission characteristics (operating frequency and transmitted power). 2. Terrain and environment obstruction shall be considered. 3. Using the Multi-coverage add on, it must be evaluated redundancy areas in configuration of Nav-Aids and simulate possible faults of the sensors involved. | |  |  |  |  | |
| * + - 1. Having capability of coping with EMC (electromagnetic Compatibility) and EMI (Electromagnetic Interference) issues in complex airport and air navigation scenarios. | |  |  |  |  | |
| **2** | **CAR 171 APPENDIX A**  **PART II -9.1(2)** | | **SPECIFIC EQUIPMENT BRA INFRINGEMENT SIMULATION SOFTWARE** | | | | | | |
| **CAR 171 APPENDIX A**  **PART II -9.1(2)(a)** | | **INSTRUMENT LANDING SYSTEM (ILS)** | | | | | | |
|  |  | | 1. ILS Simulation software must have the capability of Localizing and gliding path antenna modeling, CAD modeling for the environment around the Localizer and Glide path antennas to display environmental models around the installed equipment to implement the Flight Inspection simulations of ILS equipment. | |  |  |  |  | |
| 1. ILS simulation software must be able to evaluate ILS (LLZ, GP) performance including the scope of the beam and the level of accuracy (Signal strength, DDM and SDM Analysis precision analysis) based on:   a. Frequency / Channel  b. Antenna Geometry / feeding and parameters  c. Airport Layout  d. Terrain model digital operational area of ILS equipment  e. Barrier geometry and parameters defined in ICAO Standard | |  |  |  |  | |
| 1. The software must have capability for: 2. "what if analysis" before starting work, 3. "benefit analysis" if there is a change in location, 4. evaluation of new building clearance, | |  |  |  |  | |
| 1. Critical and Sensitive calculation and analysis of ILS areas and consider the amount of static disturbance, location, sizes and orientation of the aircraft operated in the airport and other vehicles, runway and taxiway layout and the antenna location of LLZ and GP.   In particular, the maximum heights of vertical aircraft tail surfaces likely to be encountered must be established, together with all possible orientations at a given location, which may include non-parallel or non-perpendicular orientations with respect to the runway. | |  |  |  |  | |
| 1. Selection of types and number of antennas for replacement or procurement of new ILS equipment and "Bend analysis" to determine the ILS signal interference source. | |  |  |  |  | |
| **3** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(b)** | | **VHF OMNI RANGE (VOR)** | | | | | | |
|  |  | | 1. Simulation tools must have the ability to simulate all the available types of signal performance VOR systems on the market (Conventional VOR or Doppler VOR) in the actual location. It can also be used to evaluate the elements of cartography, terrain morphology, distribution of artificial obstacles including buildings and the effect of season (weather) on the parameters of the existing equipment at the affected location. | |  |  |  |  | |
| ii. Simulation for VOR must have the option to select equipment antenna model, network, surrounding environment (3D site/obstacles) and VOR receiver system on the aircraft. | |  |  |  |  | |
| 1. VOR simulation software must have the capability to run “what if” analysis before execution any site work. | |  |  |  |  | |
| 1. VOR modules must have the ability to calculate the Error Bearings related to the multipath effect of the environment around the VOR antenna. | |  |  |  |  | |
| 1. Simulation tools shall have the capability to perform numerical analysis for the evaluation of the dynamic impact on Wind Turbine on VOR equipment in term of: 2. VOR System definition 3. Wind Farm characteristics definition 4. Operational scenario definition 5. Static bearing Error analysis 6. Dynamic Bearing Error Analysis | |  |  |  |  | |
| **4** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(c)** | | **MULTILATERATION** | | | | | | |
|  |  | | The MLAT simulation software must be capable to compute the following set of parameters:   1. Number of sensors in view from each point belonging to the analysis domain. | |  |  |  |  | |
|  | ii. Area of radio coverage of each sensor | |  |  |  |  | |
| 1. Dilution of Precision (Horizontal and Vertical) | |  |  |  |  | |
| 1. Aircraft position error components by means of Multilateration algorithm taking into account such as masking and multipath effects, thermal noise and RX synchronization noise, and TX and RX antenna pattern | |  |  |  |  | |
| 1. SSR pulse reply reconstruction in a specific point belonging to the analysis domain, taking into account such as masking and multipath effects, thermal noise and RX synchronization noise, and TX and RX antenna pattern | |  |  |  |  | |
| **5** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(d)** | | **WIDE AREA MULTILATERATION (WAM)** | | | | | | |
|  |  | | WAM simulation software must have capability to perform the evaluation of a WAM configuration in terms of:   * + 1. number of usable (or in coverage) sensors. | |  |  |  |  | |
| * + 1. geometrical benefit (DOPs); | |  |  |  |  | |
| * + 1. statistical positioning accuracy estimation; | |  |  |  |  | |
| * + 1. Performance verification with additional receiving stations, defined by the user during data analysis. | |  |  |  |  | |
| **6** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(e)** | | **DME - N** | | | | | | |
|  |  | | * + 1. DME simulation software must be able to compute:  1. the DME indication error due to multipath i.e. the difference between the exact transponder-to interrogator distance and the one measured by means of DME. | |  |  |  |  | |
| 1. the Path Following Error (PFE) and Control Motion Noise (CMN) error components of the DME/P error; | |  |  |  |  | |
| 1. the multipath power delay profile, i.e. the computation, in a select observation point, of the amplitude of the DME signal components (propagating along reflection and diffraction paths) versus the transmission delay respect to the direct signal; | |  |  |  |  | |
| 1. the signal strength along the aircraft path under analysis. | |  |  |  |  | |
| * + 1. DME simulation software must have the capability to model the antenna and related feeding Network, surrounding environment (3D site/obstacles), aircraft receiving system and conduct performance simulation of DME (DME/N and DME/P) equipment in real site. Considering the elements such as: cartography, morphological properties of the terrain, artificial obstacles scattering, including material properties and season effects on radio electrical parameters of site elements. | |  |  |  |  | |
| * + 1. DME simulation software must consider the following data input during conducting the performance:  1. Frequency 2. Transmitted power 3. Antenna geometry/feeding and related parameters 4. Airport layout, 5. Digital terrain model of the area within the DME operative area 6. Obstacles geometry and parameters | |  |  |  |  | |
|  |  | | * + 1. DME simulation software must allow the user to model all the types of DME system available on the market i.e. DME/N and DME P. | |  |  |  |  | |
| **7** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(f)** | | **AIR – GROUND RADIO COMMUNICATION** | | | | | | |
|  |  | | i. G/A communication simulation software must be able to inspect the Ground –Air Communication system performance in terms of the signal strength at the area of interest for the ground-air TLC operations, ray tracing, near field, hazard simulations and antenna pattern modification due to the surrounding environment by modelling environment to simulate the inspection executed during flight Inspection. | |  |  |  |  | |
| ii. G/A simulation software must consider the following data input in conducting the performance:  a. Frequency  b. Transmitted power  c. Antenna geometry/feeding and related parameters  d. Airport layout,  e. Digital terrain model of the area within the G-A Communication system operative area  f. Obstacles geometry and parameters | |  |  |  |  | |
| **8** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(g)** | | **RADAR** | | | | | | |
|  |  | | 1. RADAR simulation software must have the capability to: 2. inspect the RADAR (primary, secondary and SMR) performance in terms of: 3. Radar LOS and signal coverage 4. the signal strength in the area of interest for the RADAR operations; 5. the antenna gains modifications due to the multipath contributions from environment obstacles; 6. antenna pattern degradation, shadow regions, probability of detection and OBA (Off Bore-sight Angle) 7. false targets detection caused by reflection/diffraction from obstacles placed around the radar antenna; 8. False replies analysis for PSR-SSR equipment | |  |  |  |  | |
| 1. modeling environment, which enables the user to simulate the inspection executed during the Nav-aid flight checks. | |  |  |  |  | |
| 1. evaluate the joint coverage and visibility of the RADARs configuration. The configuration may be also a hybrid one, which means a configuration of both PSR and SSR. | |  |  |  |  | |
| 1. Radar simulation software must be able to execute the following set of analyses: 2. What if analysis before the execution of any site work 3. Cost/benefit analysis of the site modification 4. New building clearance; 5. Antenna selection for new installations and/or equipment replacement; 6. Analysis for the search of most powerful sources of interference | |  |  |  |  | |
| 1. Radar simulation software must consider the following input data: 2. Frequency 3. Transmitted power 4. Antenna geometry/feeding and related parameters 5. Airport layout, 6. Digital terrain model of the area within the RADAR operative area 7. Obstacles geometry and parameters | |  |  |  |  | |
| 9 | **CAR 171 APPENDIX A**  **PART II -9.1(2)(h)** | | **EMI** | | | | | | |
|  |  | | i. EMI simulation software must have the capability to solve problems related to the radiated components of the electromagnetic interference. | |  |  |  |  | |
| ii. The software must be able to perform the following task:  a. Rx and TX equipment modeling starting from constructor data sheets.;  b. CAD modeling the environment;  c. Interference ratio analysis;  d. Electric field: the value of electromagnetic field (in V/m).  e. S/ (N+I) ratio: the ratio of signal to Noise+ Interference on the selected point.  f. Critical systems: it is indicated all the possible transmitters that can interfere with on board receiver.  g. Interference zones: the region in which it is possible to interfere with on board receiver  h. Interference contours: the contour of interference zones.  i. Interference margins | |  |  |  |  | |
| iii. EMI software must have the capability to perform simulation for fixed interfered object and moving interfered object. | |  |  |  |  | |
| **10** | **CAR 171 APPENDIX A**  **PART II -9.1(2)(i)** | | **WIND FARM** | | | | | | |
|  |  | | Wind Farm simulation software must have capability to:  i. evaluate the effects of wind farm effects, in terms of false echoes, on the PSR (Primary Surveillance Radar), SSR (Secondary Surveillance Radar) and VOR. | |  |  |  |  | |
| ii. perform false echo analysis in order to evaluate if the metallic supports of the wind turbines give arise to the false echoes for a fixed aircraft domain. | |  |  |  |  | |
| iii. Execute a PSR or SSR Wind Farm Post Processing, with the following outputs:   1. False target Probability and total 2. False Target percentage of occurrences 3. STC Map 4. Air Traffic Statistics | |  |  |  |  | |
| **11** | **CAR 171 APPENDIX A**  **PART II -9.2** | | **OUTPUT OF SIMULATION SOFTWARE** | | | | | | |
|  |  | | 1. Standard Cartesian diagrams or 2D surface mapping of each parameter (color coded). | |  |  |  |  | |
| ii. Flight inspection style outputs. | |  |  |  |  | |
| **12** | **CAR 171 APPENDIX A**  **PART II -9.3** | | **COMPUTATIONAL ELECTROMAGNETIC TECHNIQUE** | | | | | | |
|  |  | | The numerical tools shall cover the whole aeronautical frequency band and be based on the most sophisticated and widely known computational electromagnetic techniques, such as:  (a) Geometrical Theory of Diffraction (GTD/UTD)  (b) Physical Optics (PO/PTD/ITD)  (c) Method of Moments (MOM)  (d) Deygout Method  (e) Parabolic Equations (PE) | |  |  |  |  | |