Comprehensive Solution for the Complex Electromagnetic Environment of Aeronautical Radio Aids
1. Background

1.1 The electromagnetic environment of aeronautical radio aids is crucial for ensuring flight safety

Case A: due to multipath interference, a B777 approaching Munich Airport experienced a runway excursion safety incident.

Case B: the hangar resulted in the failure of F/I check for the ILS at a major airport.
1. Background

1.2 With the development of airport and economic zones, the electromagnetic environment protection of radio aids faces more formidable challenges.

- Large hangar located on the side of the runway
- Signal deterioration caused by existing obstacles
- Dilemma between airport and urban expansion
- Numerous urban plans around en-route station
1. Background

1.3 Description of difficulties

(1) The plethora of standards for electromagnetic environment calculations.

(2) Wide distribution of obstacles poses a high computational challenges.

(3) High cost of manual monitoring and unable to perform calculations.
1.4 Reflecting on Solutions

Based on extensive research, we proposed a digitized and intelligent approach to address the aforementioned issues.

- The first tools for analyzing and managing the electromagnetic environment of aeronautical radio stations.
- It is a cross-disciplinary applied innovation in the integration of electromagnetic environment and geographic information systems.
- It is a significant practice to enhance the governance capability and management level of the CNS profession.
2. Preliminary management system

2.1 Functions

- The system operates with convenience, enabling the standard compliance audit work for obstacle construction before development through the processes of import, calculation, and export.
- Modeling the antennas, terrain, and existing structures, achieving a digitized and a 1:1 representation of both the station and its surrounding environment.
2. Preliminary management system

2.2 Import - a one-click import function for obstacle/station latitude, longitude, and elevation data.

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2. Preliminary management system

2.3 Computation

- automatically matches all surrounding radio stations.
- performs violation calculation of the electromagnetic environment protection zone.
- draws conclusions, and visual displays the results.
2. Preliminary management system

2.4 Export - after the calculation is completed, you can export the analysis conclusions with a single click, clearly identifying which stations' electromagnetic environment protection zones are violated by specific obstacles.
3. Simulation and Assessment

3.1 Modelling

- Antenna pattern
  - LLZ radiation pattern
  - GP radiation pattern
  - VOR radiation pattern

- Terrain & Obstacle

- Flight route
3. Simulation and Assessment

3.2 Case A

仿真与校飞和的结果基本一致。

机库为设计时仿真。
3. Simulation and Assessment

3.2 Case B
In cases where simulation and assessment cannot provide a solution, we will...

3.3 Optimization scheme

- Elevation control
- Layout relocation
- Structural & material alterations
An attempt was made to achieve radio stealth at Toulouse Airport in France with a diffraction-based facade cladding structure.

Disadvantages:
- Reserved installation space needs to be allocated.
- Large size (width:1m), difficult to install, safety hazards.
- May lead to signal deterioration of the LLZ on the other side.

Currently, there is no practical experimental verification and application case for radio stealth materials in China.
This project is the world's first study on the low-frequency miniaturization application of metamaterials in civil aviation, marking the pioneering application of electromagnetic new materials in civil aviation navigation technology.
3.4 Features & achievements

➢ Suitable for the LLZ frequency range with features of: ultra-thin, low-frequency absorption and large incident angle adaptability.

- Applicable to an incident angle range from 0° to 85°, with a thickness of 15mm achieving an absorption rate of 20dB, realizing a high absorption efficiency with a small contact area.
- With an absorption bandwidth of up to 4MHz which could completely cover LLZ frequency range.
4. Application of metamaterials
1.4 A 3-phase management/solution for the electromagnetic environment of radio stations

- **Preliminary management for planning and station siting**: a digitized and intelligent system for analyzing the electromagnetic environment of aeronautical radio aids.

- **Assessment when impact is introduced in the planning phase**: a simulation and analysis assessment to evaluate the impact of obstacles or sources of interference on radio aids, also provides optimization schemes.

- **Solutions for situations involving unavoidable impacts**: a solution for eliminating the multipath interference by addressing the application of metamaterials.
THANKS