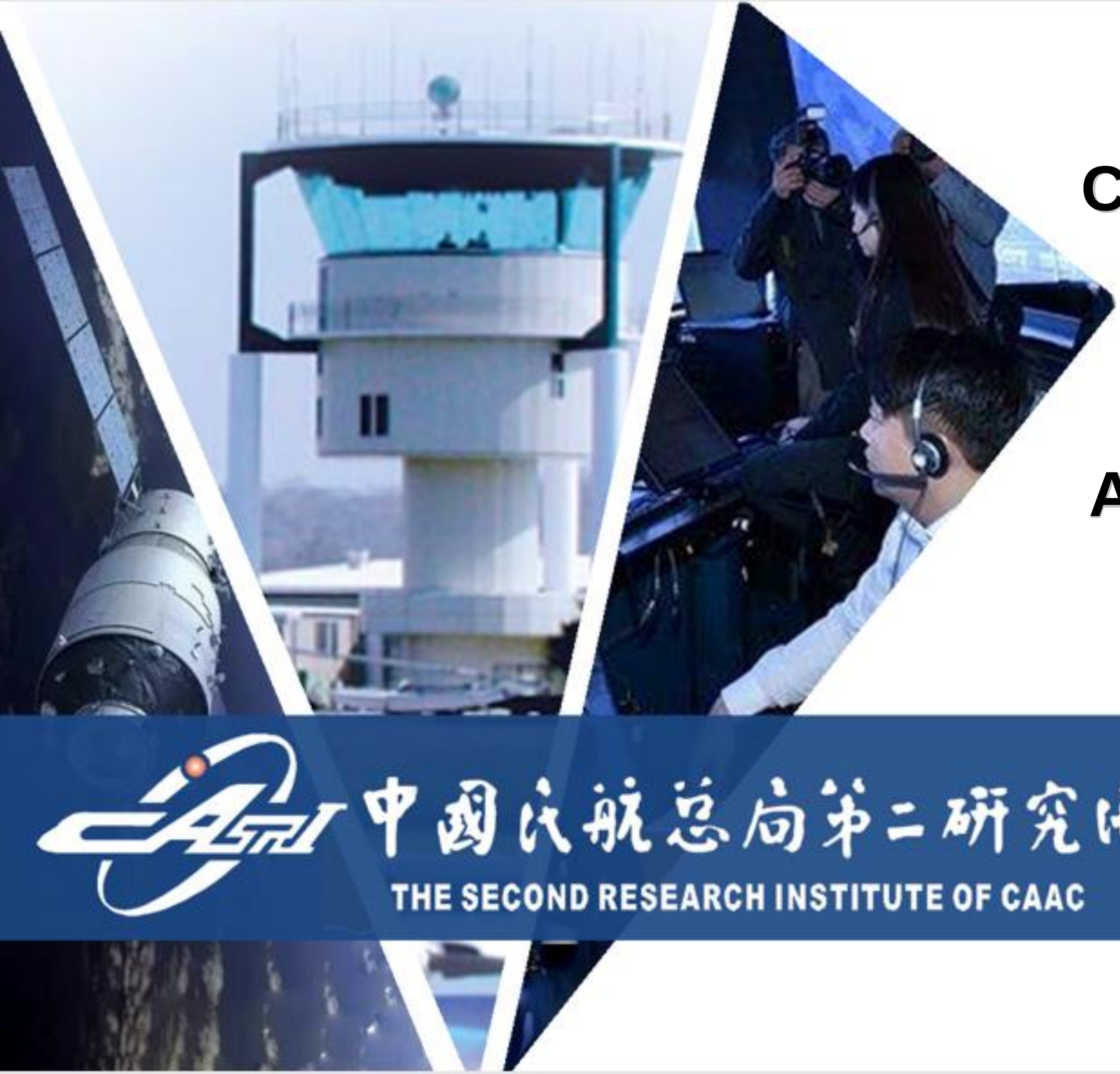


Comprehensive Solution for the Complex Electromagnetic Environment of Aeronautical Radio Aids

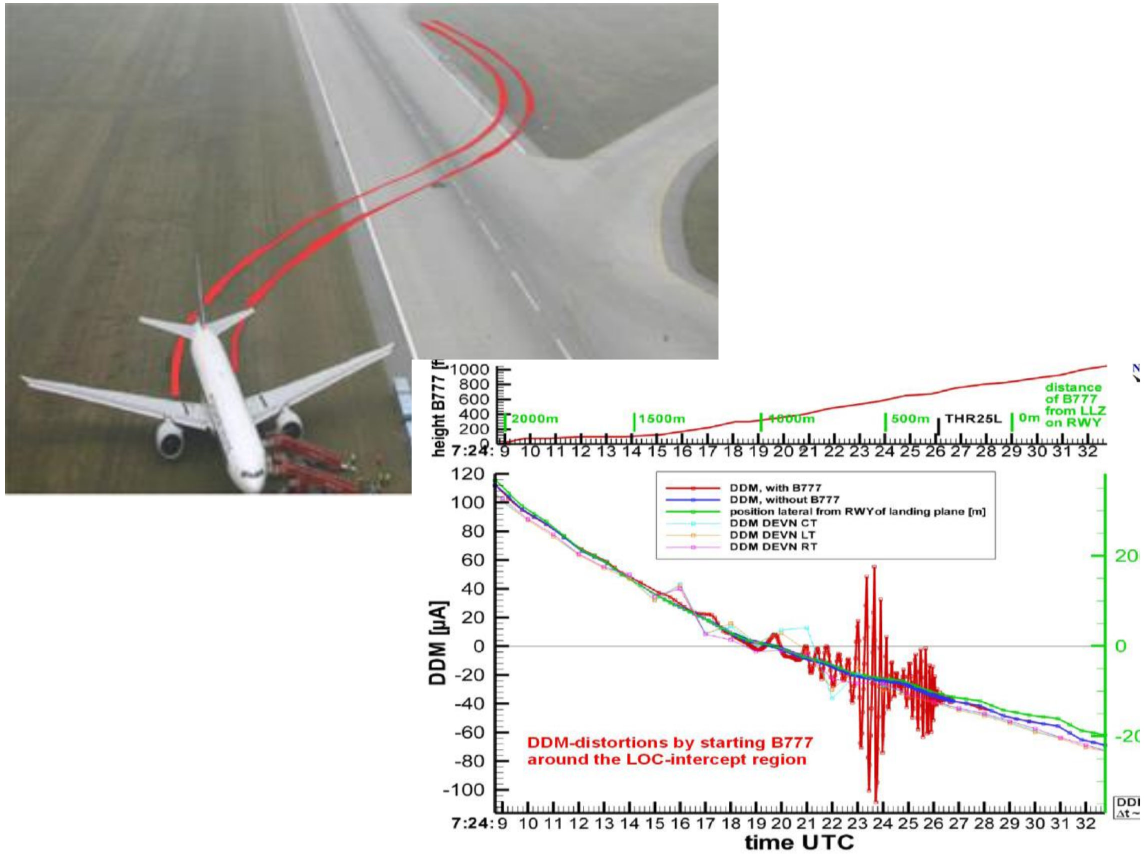
中国民航总局第二研究所

THE SECOND RESEARCH INSTITUTE OF CAAC

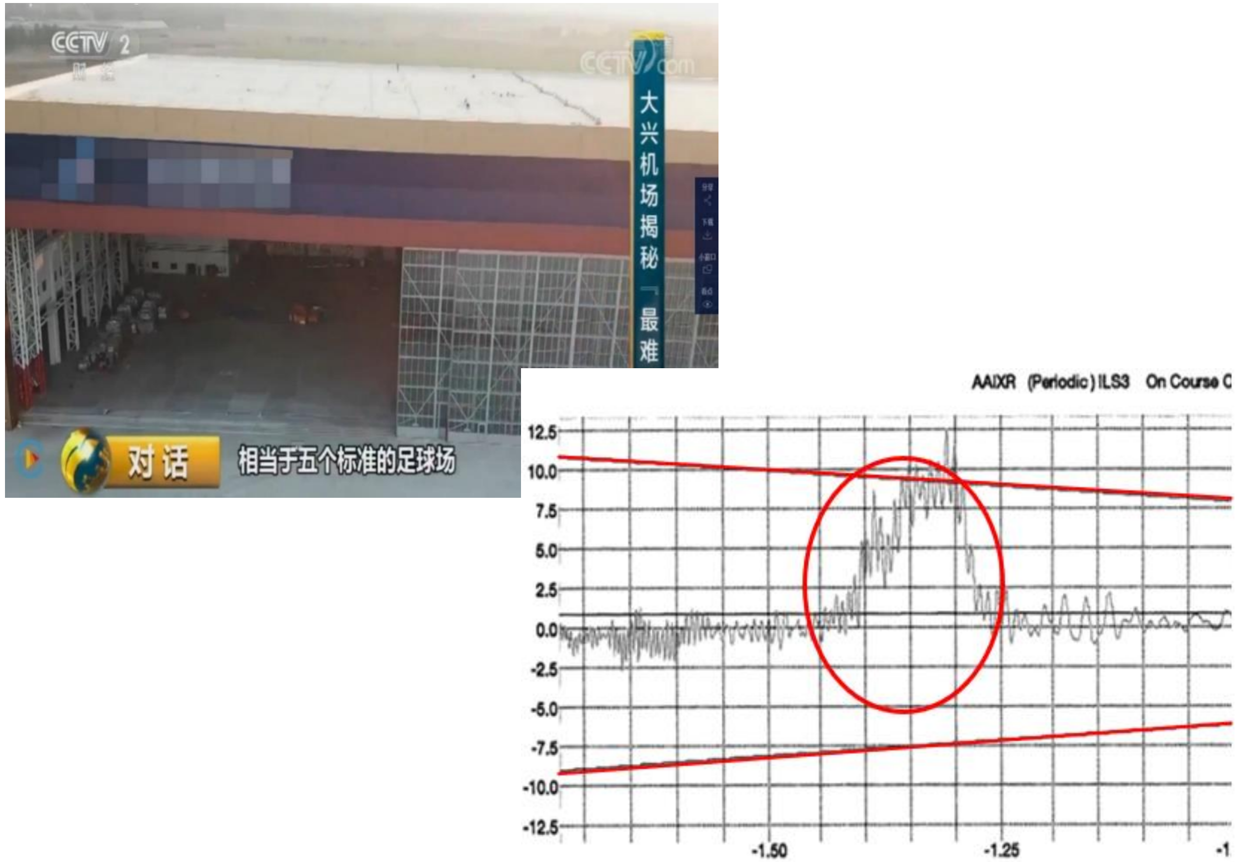
CONTENTS

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

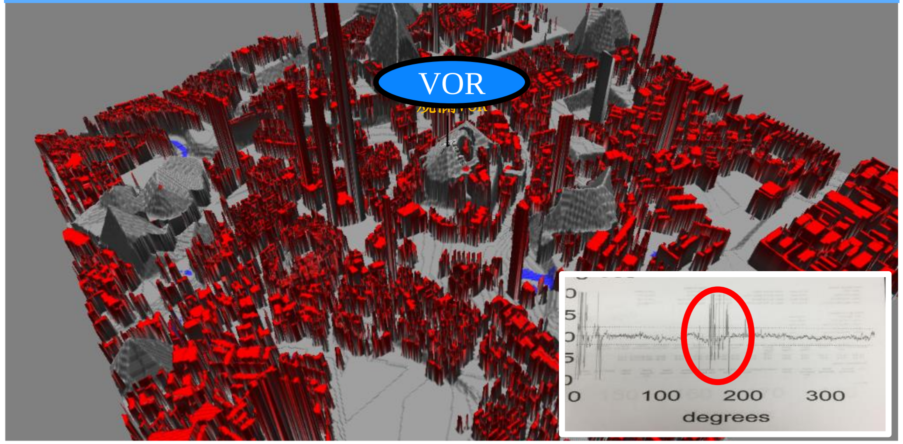
1.2 With the development of airport and economic zones, the electromagnetic environment protection of radio aids faces more formidable challenges.

Large hangar located on the side of the runway

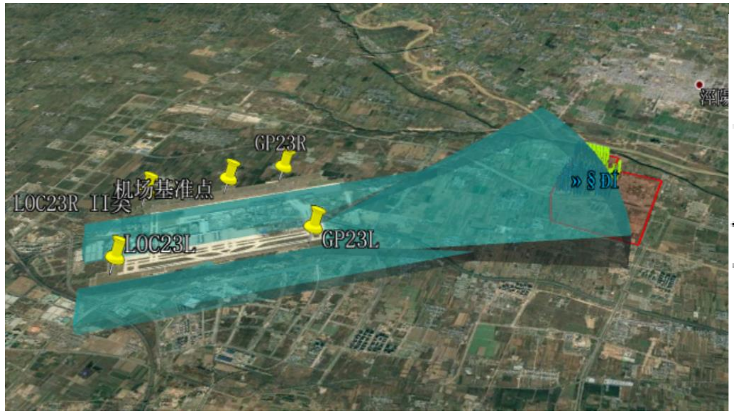
Signal deterioration caused by existing obstacles

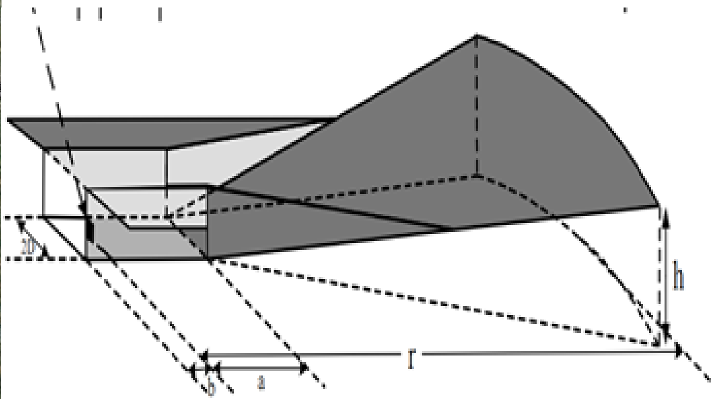
Dilemma between airport and urban expansion

Numerous urban plans around en-route station

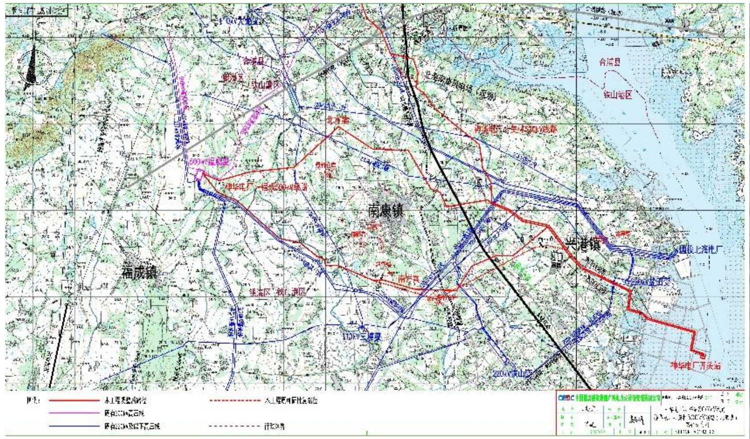


1.3 Description of difficulties





(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. Background

1.4 Reflecting on Solutions

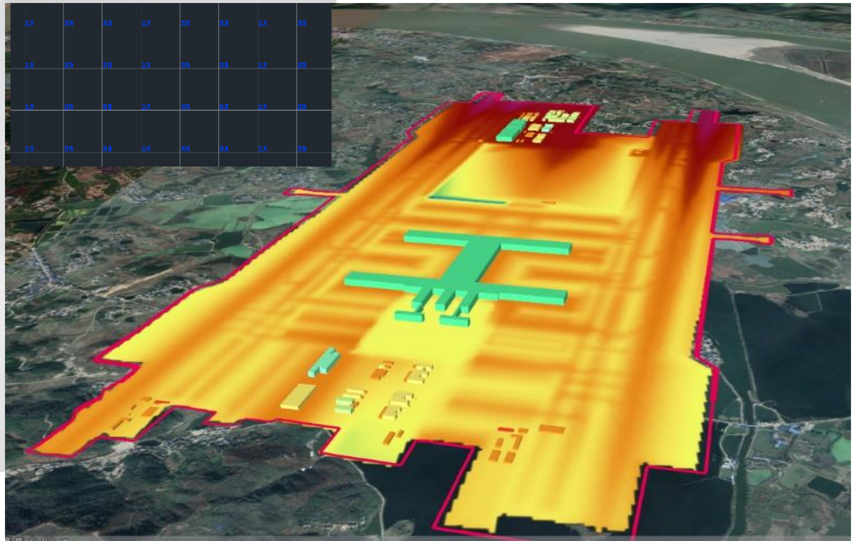
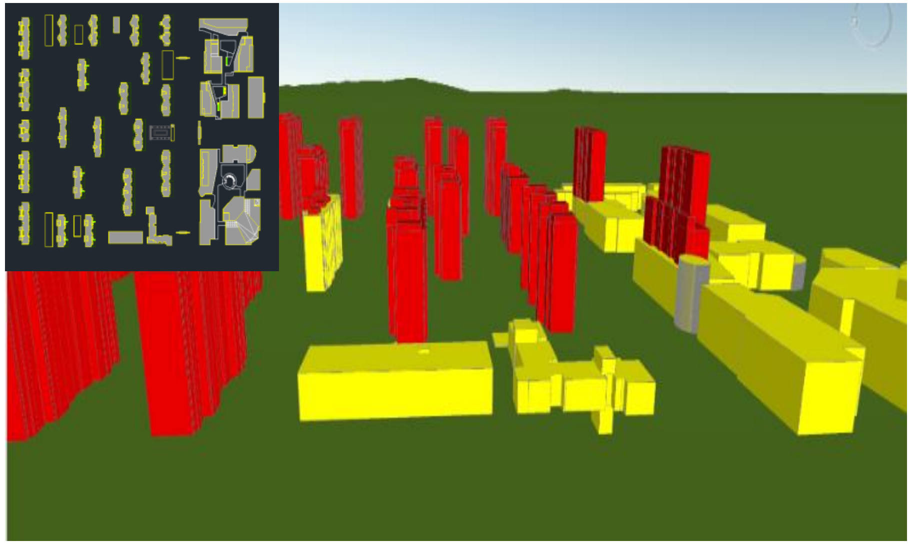
Based on extensive research, we proposed a digitized and intelligent approach to address the aforementioned issues.

- 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

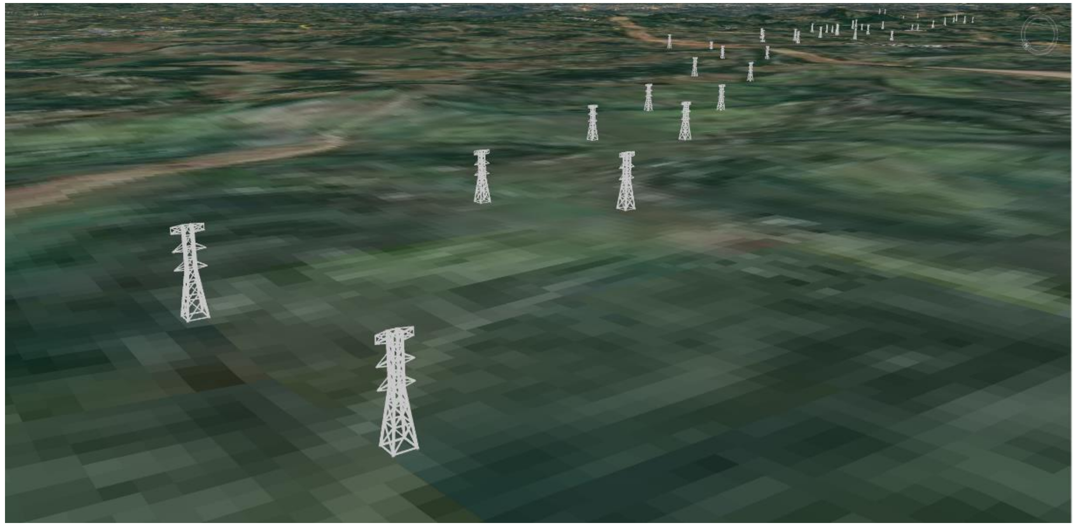
- The system operates with convenience, enabling the standard compliance audit work for obstacle construction before development through the processes of import, calculation, and export.
- Modeling the antennas, terrain, and existing structures, achieving a digitized and a 1:1 representation of both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

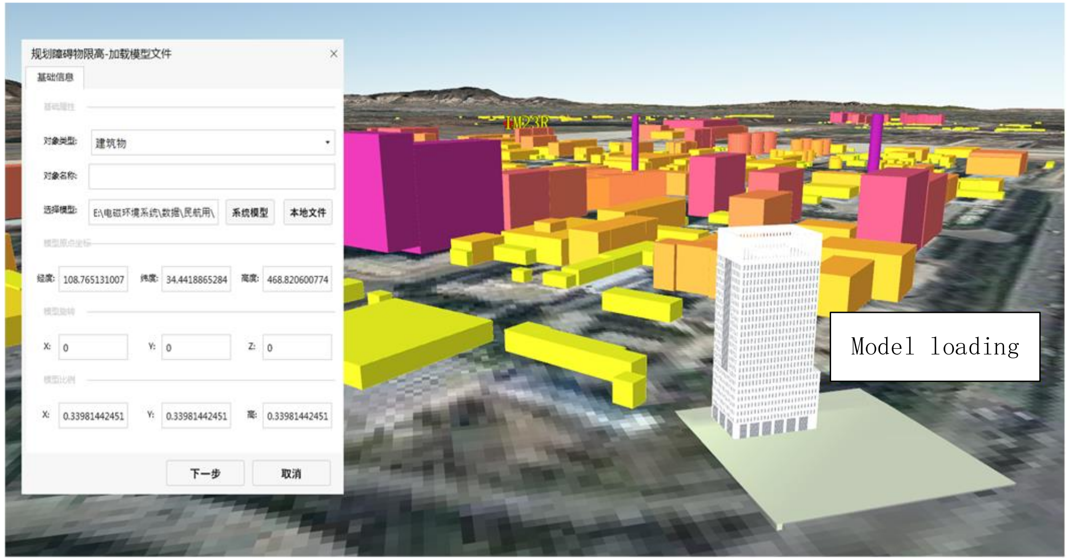




2. Preliminary management system

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

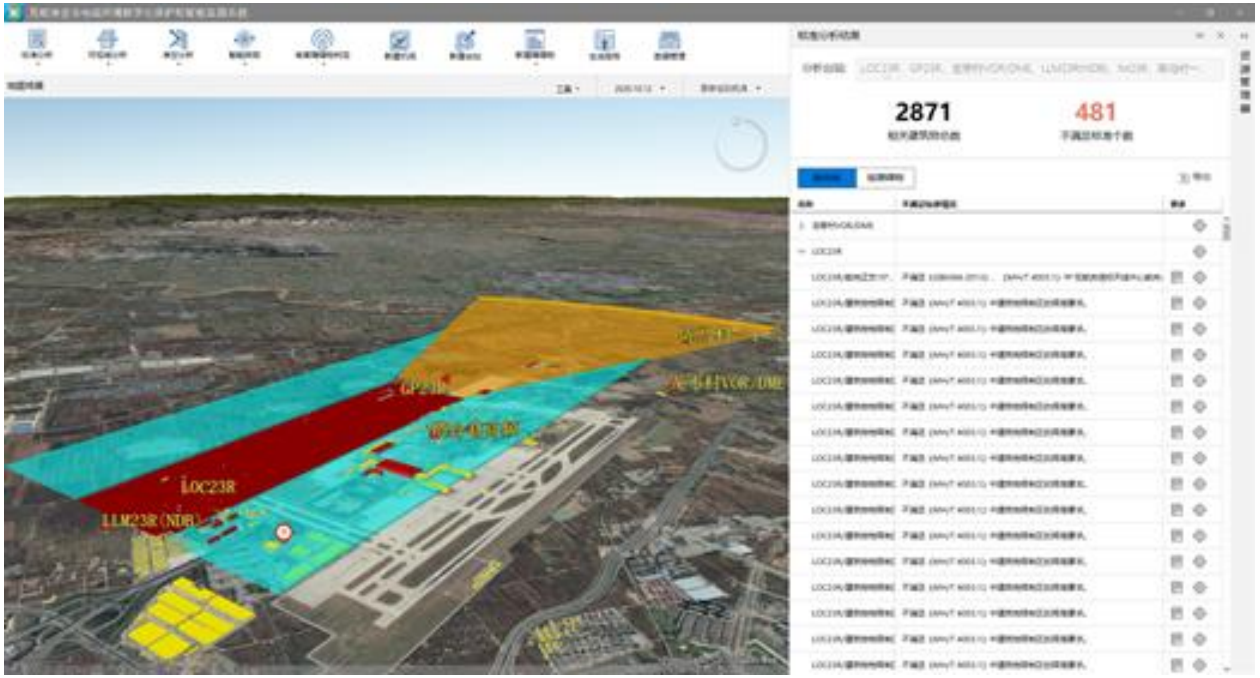
1	JA1	030°53′03.033267″	104°40′44.052344″	515.7
2	JA2	030°53′07.976376″	104°40′35.079535″	521.1
3	JA3	030°53′16.747945″	104°40′26.488153″	564.5
4	JA4	030°53′29.502263″	104°40′30.646106″	521.3
5	JA5	030°53′44.811386″	104°40′27.184872″	523.1
6	JA6	030°53′54.823874″	104°40′28.085587″	525.3
7	ZA7	030°54′05.904368″	104°40′27.842064″	533.1
8	ZA8	030°54′15.504008″	104°40′27.631071″	551
9	JA7	030°54′23.441034″	104°40′27.456610″	519.5
10	ZA10	030°54′36.732368″	104°40′22.547056″	529.2
11	ZA11	030°54′47.284600″	104°40′18.648974″	554.2
12	ZA12	030°54′59.879751″	104°40′13.995895″	568
13	ZA13	030°55′06.282218″	104°40′11.630458″	575.6
14	JA8	030°55′19.686469″	104°40′06.677877″	520.1
15	JA9	030°55′26.642709″	104°40′13.054261″	550.7
16	ZA16	030°55′39.748624″	104°40′16.221499″	541.8

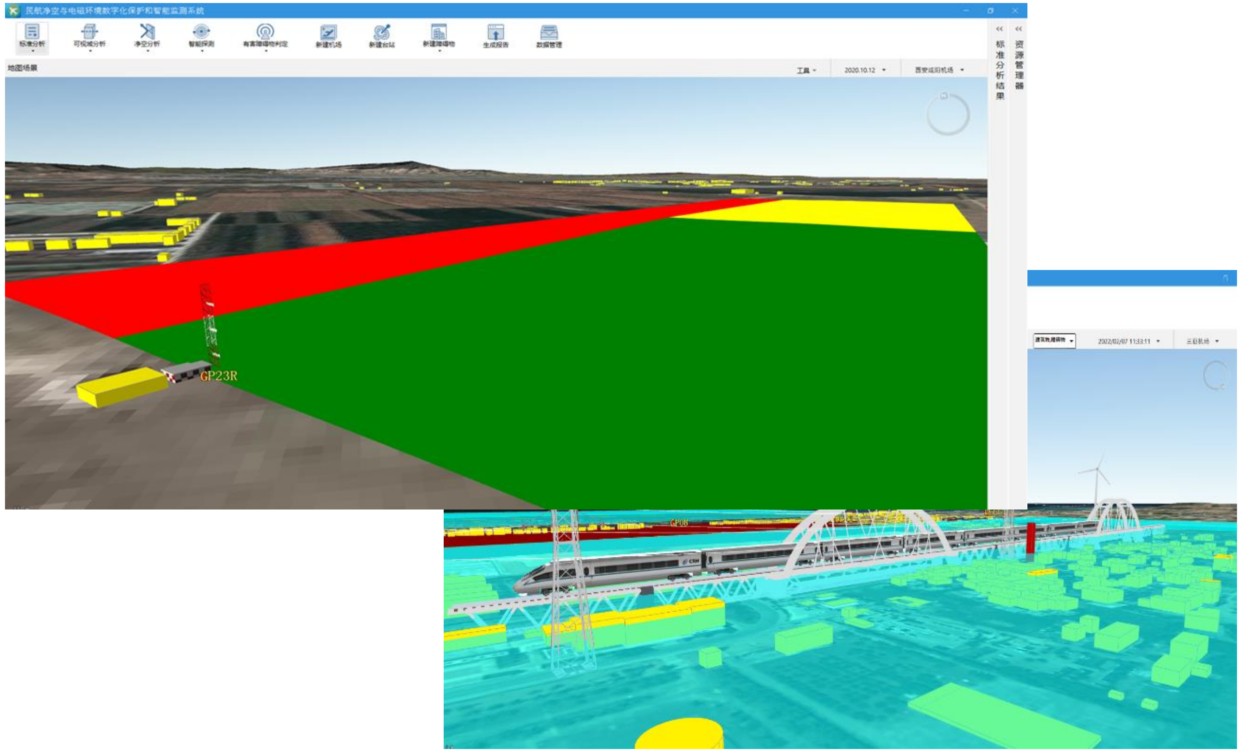




2.3 Computation

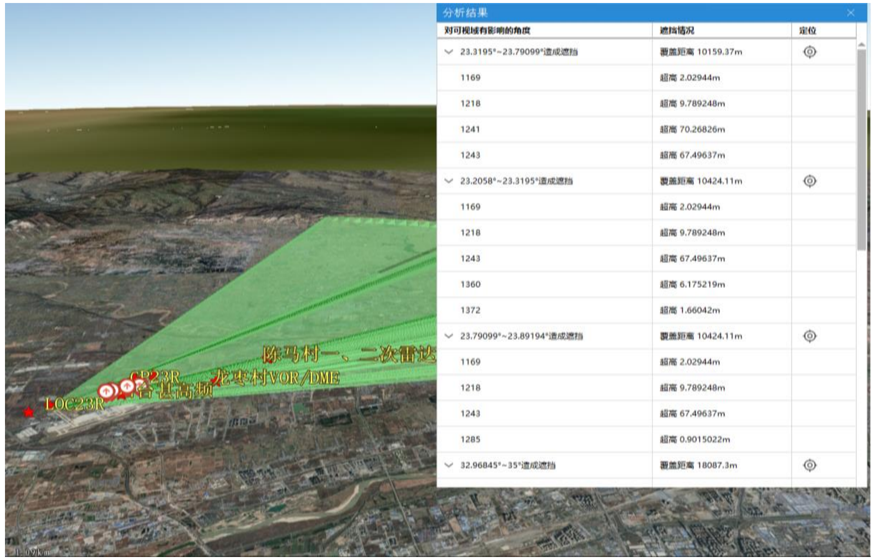
- automatically matches all surrounding radio stations.
- performs violation calculation of the electromagnetic environment protection zone.
- draws conclusions, and visual displays the results.





2. Preliminary management system

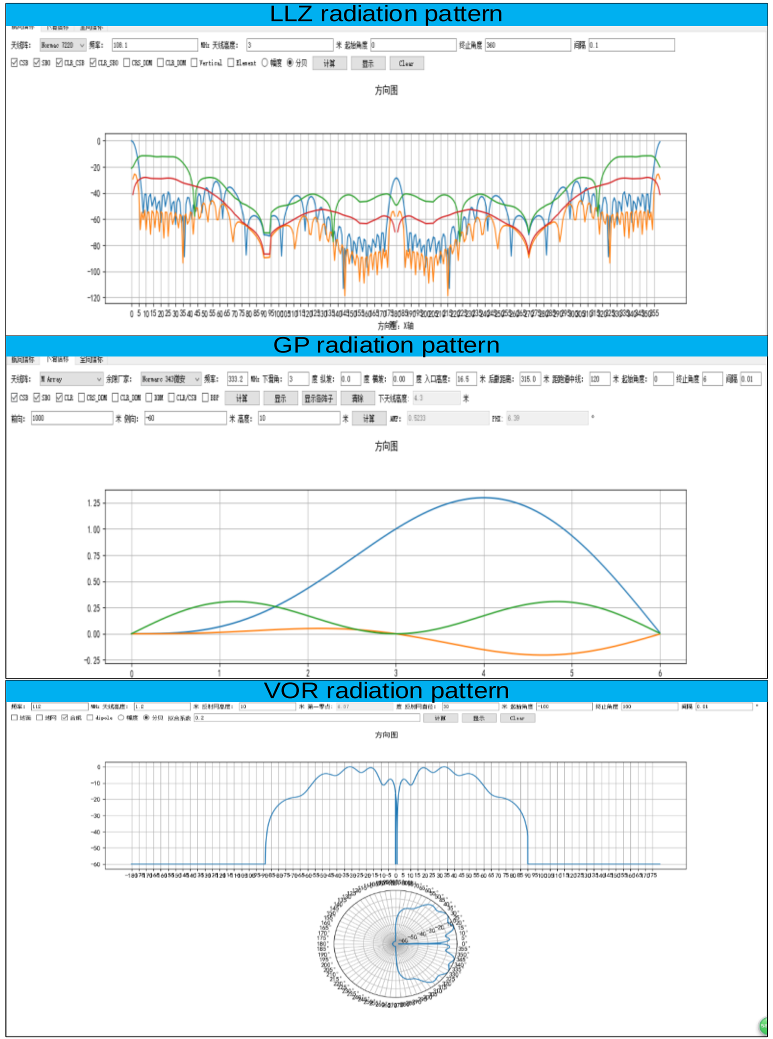
2.4 **Export-** after the calculation is completed, you can export the analysis conclusions with a single click, clearly identifying which stations' electromagnetic environment protection zones are violated by specific obstacles.



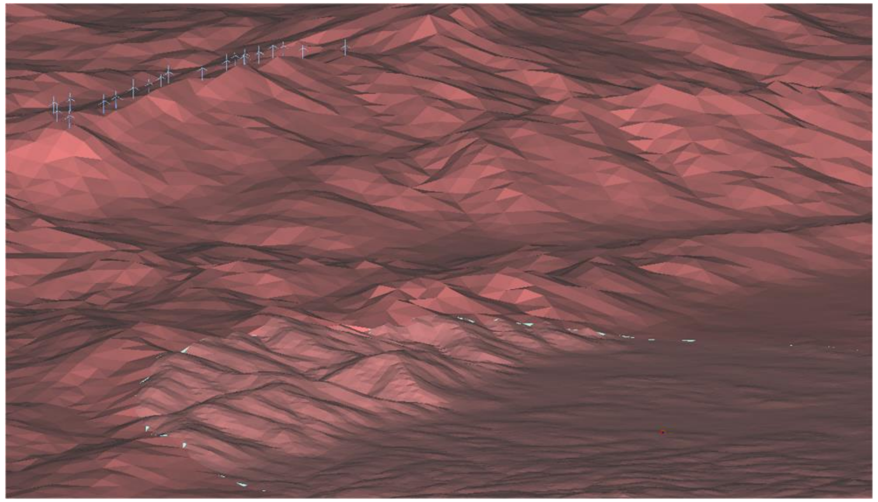
3. Simulation and Assessment

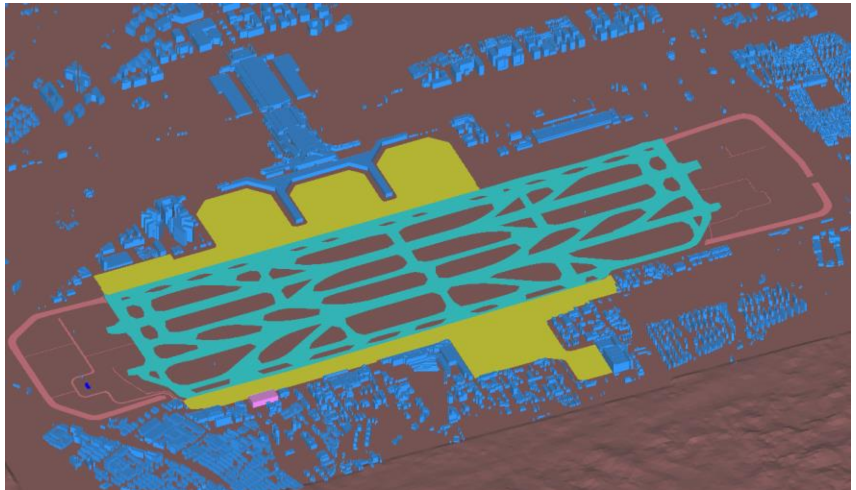
3.1 Modelling

- Antenna pattern

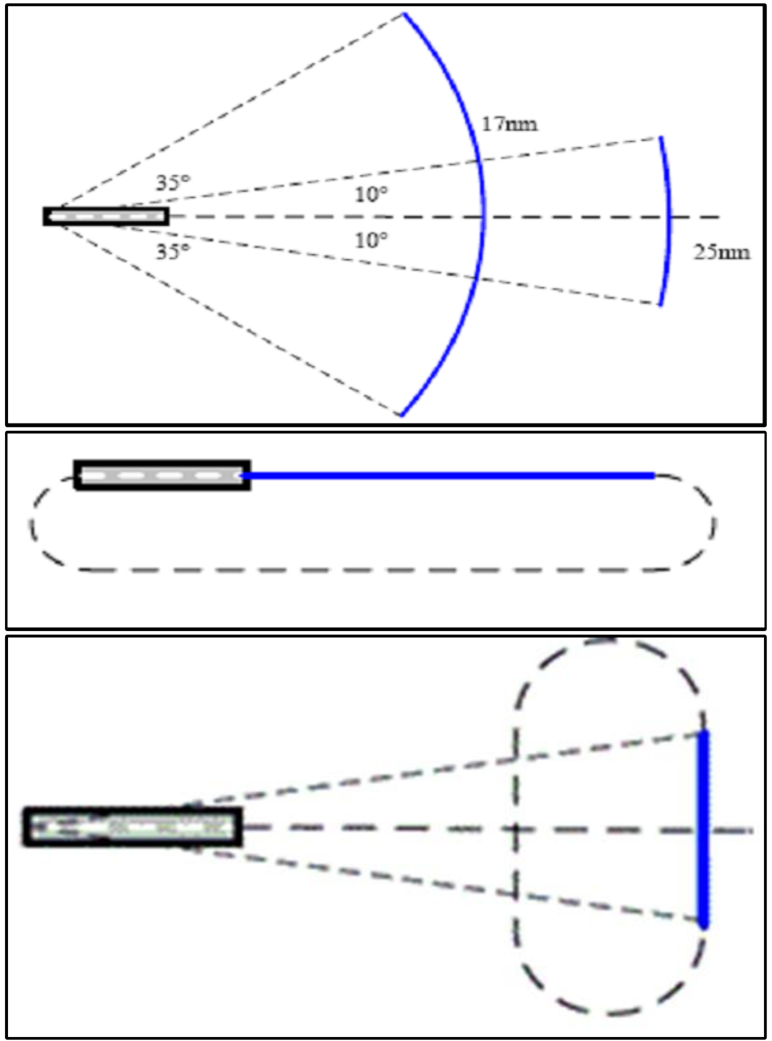


- Terrain&Obstacle

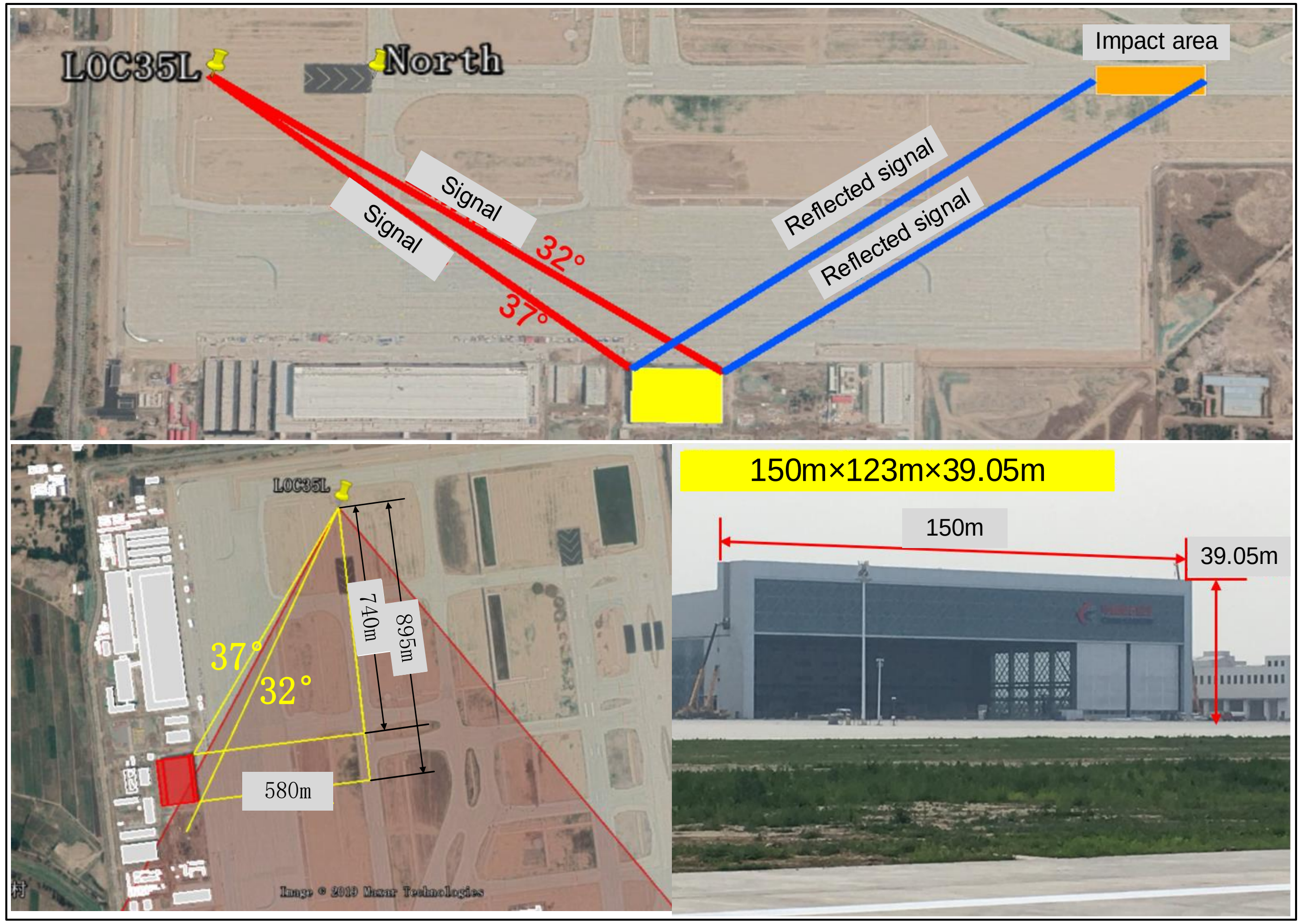


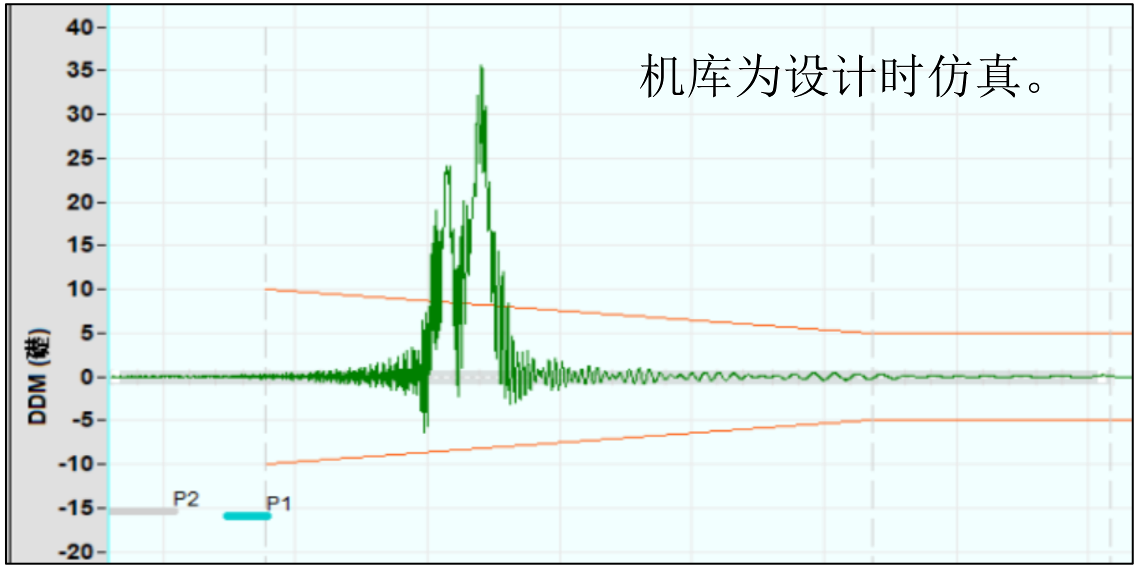


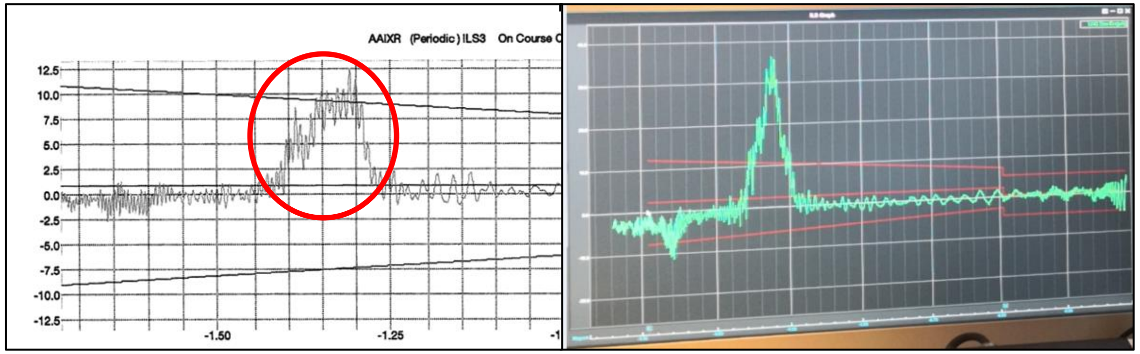
- Flight route



3.2 Case A



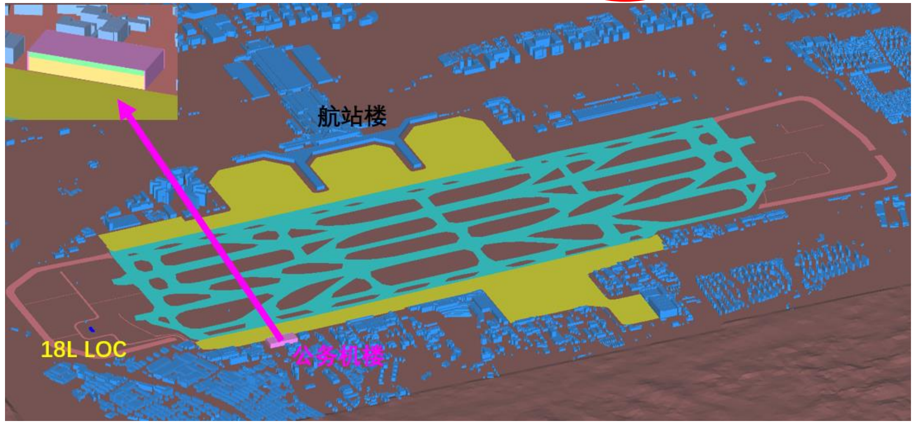


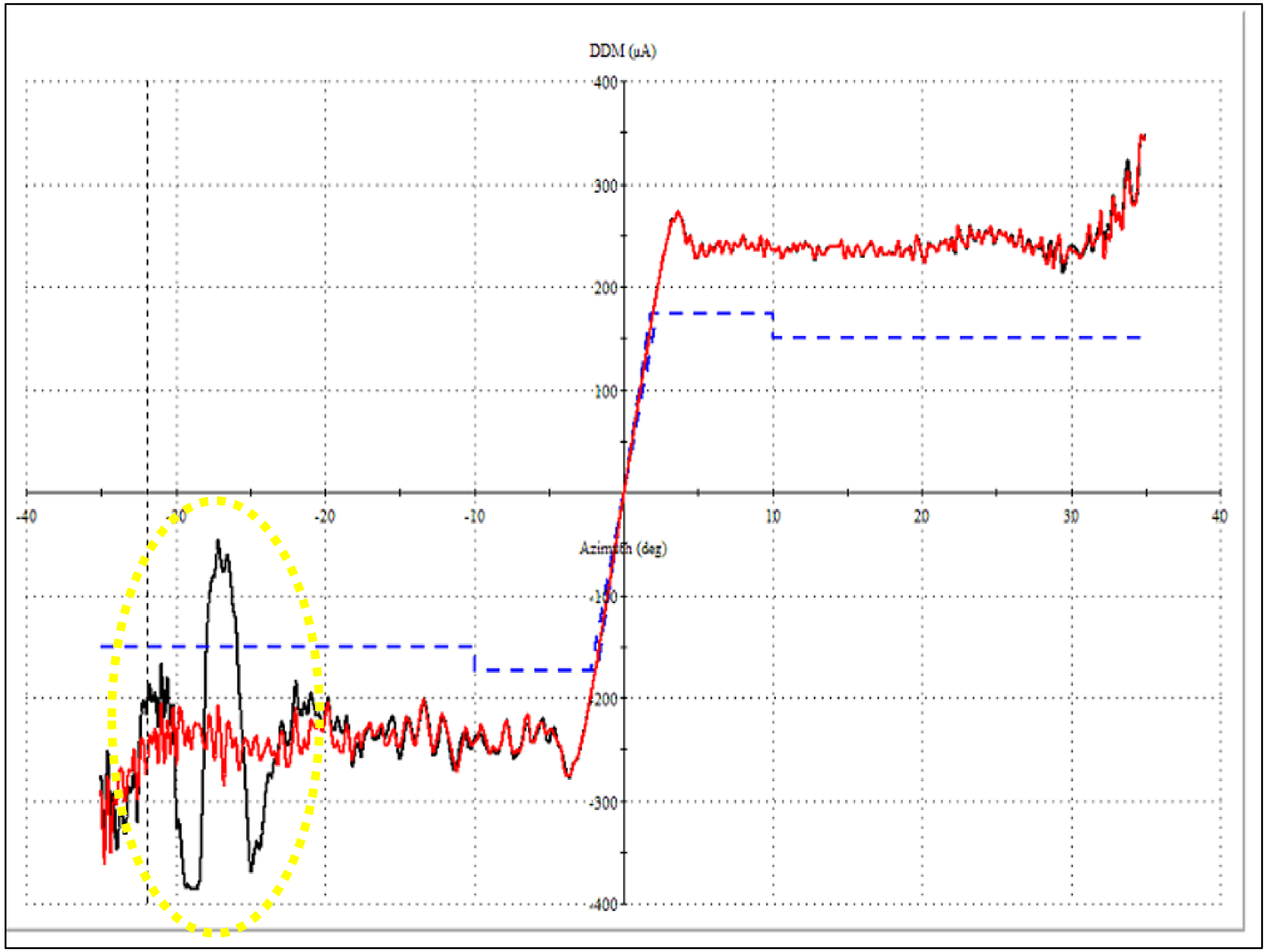


仿真与校飞和的结果基本一致。

3.2 Case B


26°~29°

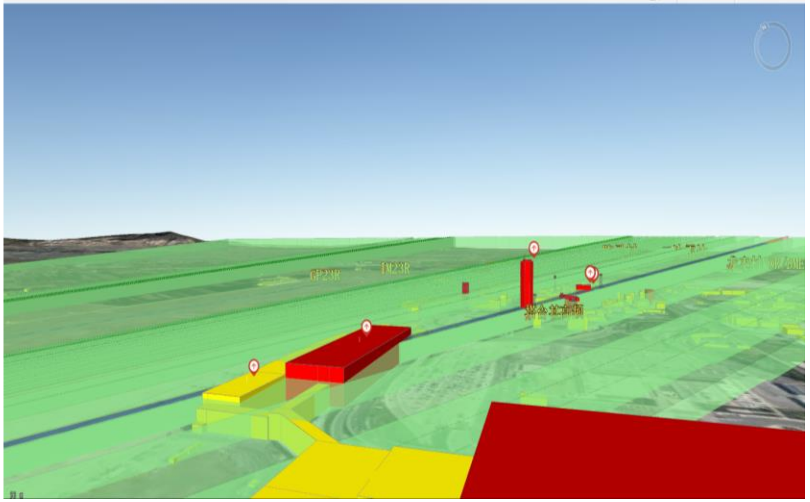

航站楼
18L LOC
公务机楼


DDM (μA)
Azimuth (deg)
400
300
200
100
-100
-200
-300
-400
-40
-30
-20
-10
10
20
30
40

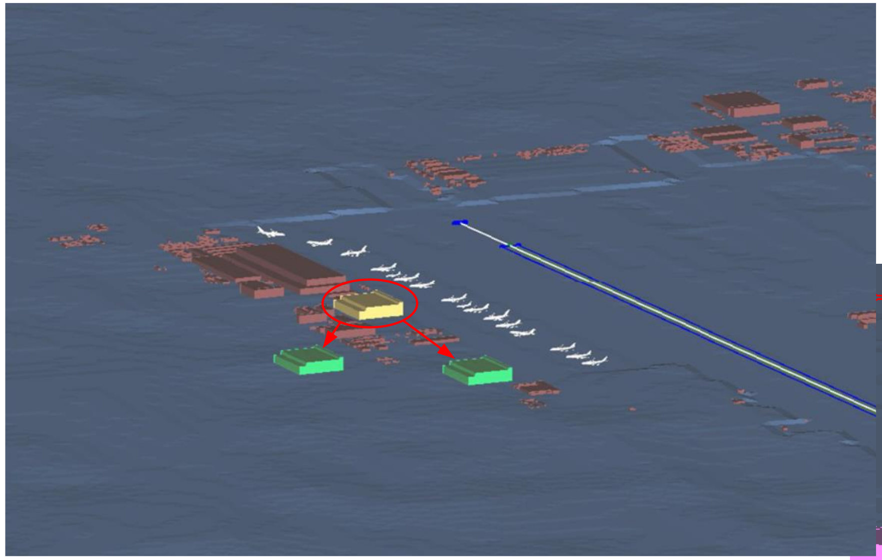
3. Simulation and Assessment

3.3 Optimization scheme

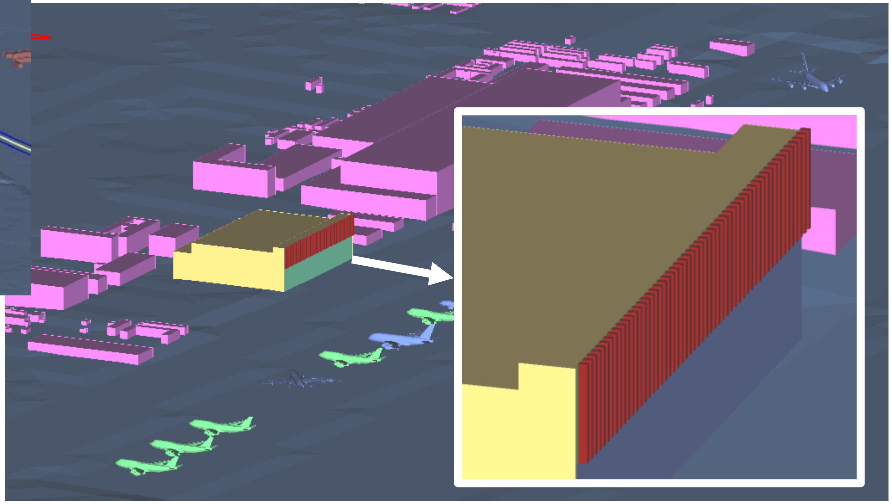
- Elevation control



- Layout relocation



- Structural & material alterations

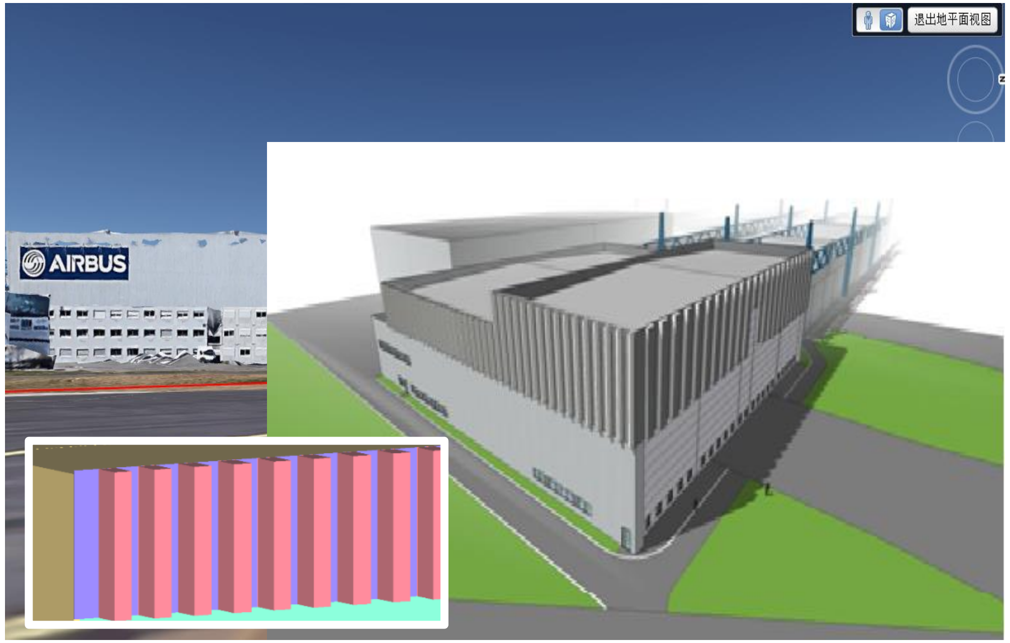


In cases where simulation and assessment cannot provide a solution, we will...

4. Application of metamaterials

International research status

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.

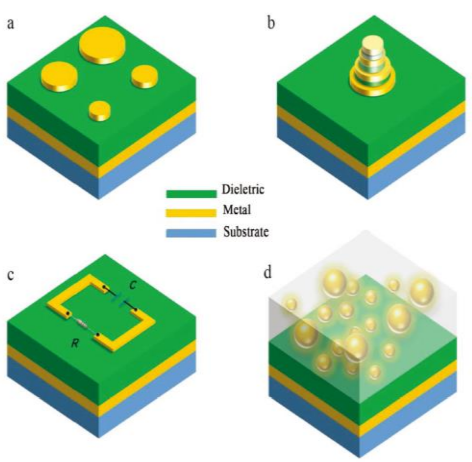
Research status in China

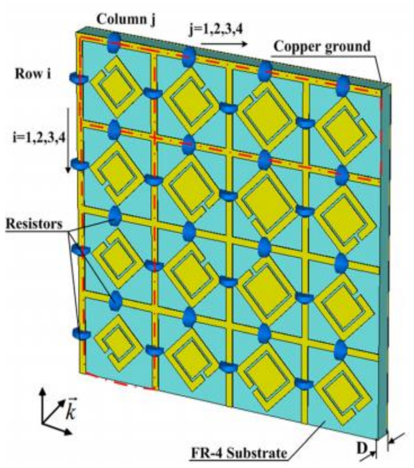
Currently, there is no practical experimental verification and application case for radio stealth materials in China.

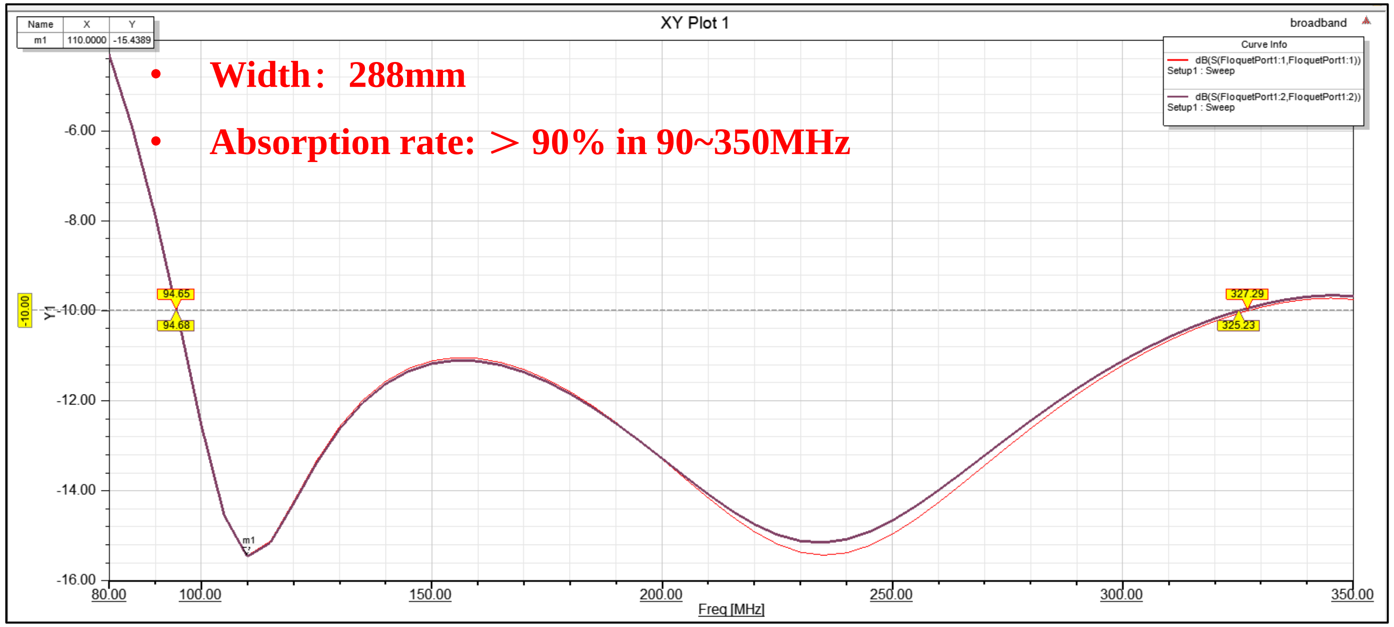
BUT!

4. Application of metamaterials

3.3 Metamaterials-radio absorbing material







Advantages:

- Thin layer.
- High structural controllability.
- Excellent absorption performance
- No additional deterioration in the LLZ signal on the other side.

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.

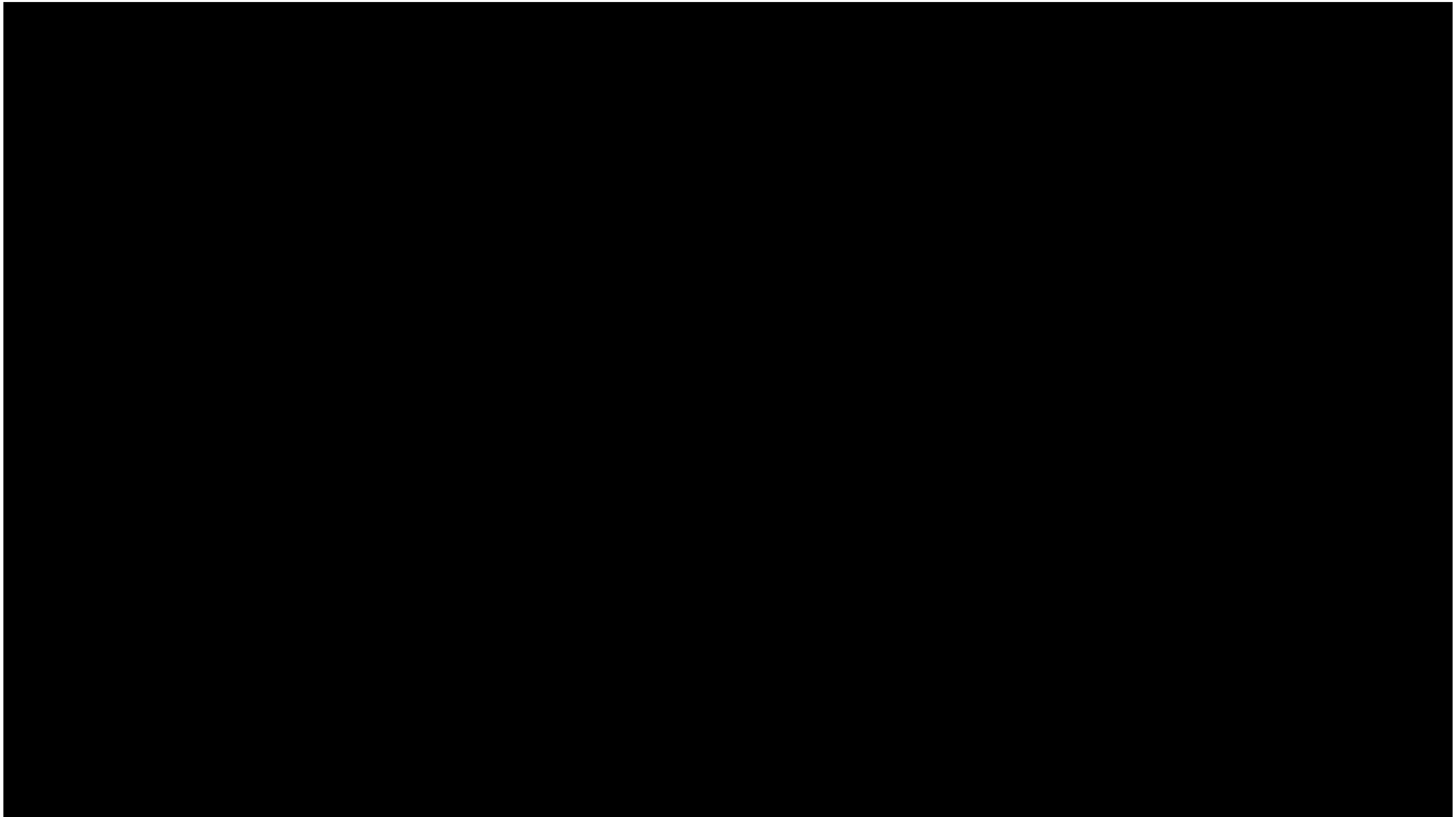
4. Application of metamaterials

3.4 Features & achievements

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

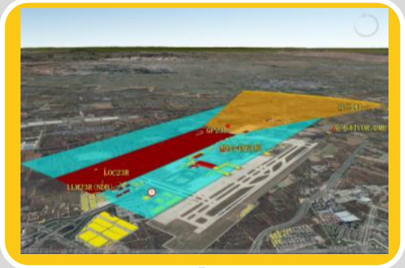
- Applicable to an incident angle range from 0° to 85°, with a thickness of 15mm achieving an absorption rate of 20dB, realizing a high absorption efficiency with a small contact area.
- With an absorption bandwidth of up to 4MHz which could completely cover LLZ frequency range.

4. Application of metamaterials

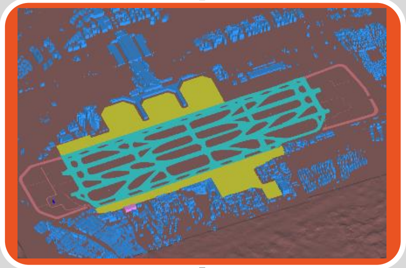


1.4 A 3-phase management/solution for the electromagnetic environment of radio stations

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

中国民航局第二研究所
THE SECOND RESEARCH INSTITUTE OF CAAC