

NORMARC ILS

ILS ASSESSMENT REPORT

**OR Tambo International Airport
Glide Path 03R scalloping problem**

SSR 15010/Rev.1.0/16-Apr-15

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Document Revisions and Changes Incorporated in this Document

Issue:	Paragraph:	Paragraph Heading/Description of Change
1.0		First issue

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1 General

This report deal with the reported problem of scalloping on the Glide Path 03R at OR Tambo International Airport. The scalloping that showed up during 2014 causes the flight management system of some aircraft to disengage from auto coupled mode during approach, even though the scalloping is well inside ICAO CAT II/III limits.

2 Executive summary

To investigate the possibility to reduce or solve the problem with the scalloping on the Glide Path structure, extensive computer simulations have been carried out. A working 3D computer model of the terrain and the new buildings was constructed and tested for validity for this purpose.

Results:

- Optimizing the antenna feeds of the M-Array Glide Path does **not** solve the problem.
- Changing to another Glide Path system (e.g. Null-reference or Sideband-reference) may reduce the scalloping slightly, but introduces new large bends in the vicinity of the runway threshold. Turning of antenna elements towards the runway increases the scalloping.
- Changing the Glide Path antenna elements to a different type (e.g. Watts GP5A) does probably not solve the problem.
- ***The computer simulations indicate that the problem may be solved by introducing an 18m by 10m metallic screen at the edge of the Glide Path Beam Forming Area in the direction of the buildings, as described in paragraph 4.5.***

3 Problem description

The scalloping problem developed from late 2013 to July 2014. The development of the problem is shown in Figure 1 to Figure 3. The figures show Flight Inspection recordings of the structure combined with aerial images from Google Earth. As can be seen, a building complex was developed in the vicinity of the Glide Path when the problem emerged. Figure 1 shows the situation before start of the construction of the buildings, no scalloping problem. Figure 2 shows the situation when the buildings were partly finished and Figure 3 shows the situation as it is today.

7. September 2013

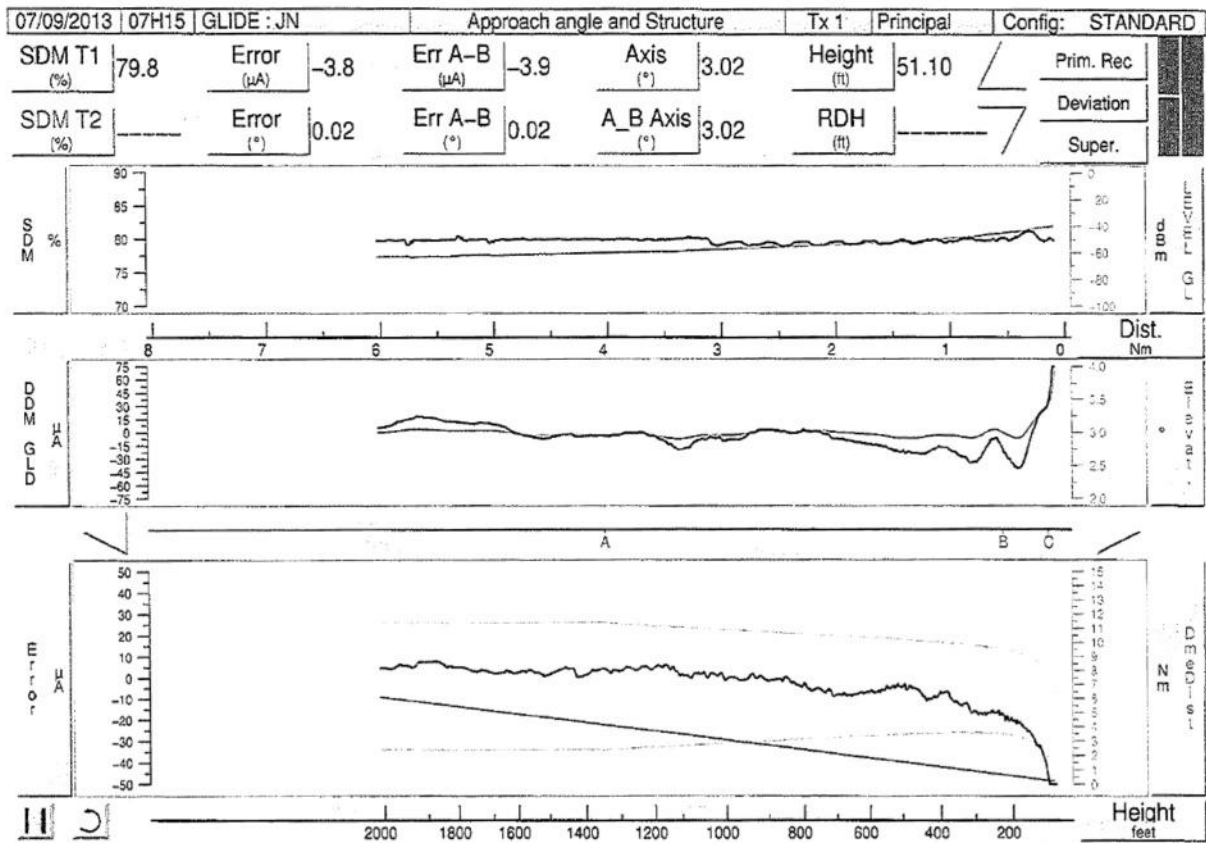


Figure 1

8. Feruary 2014

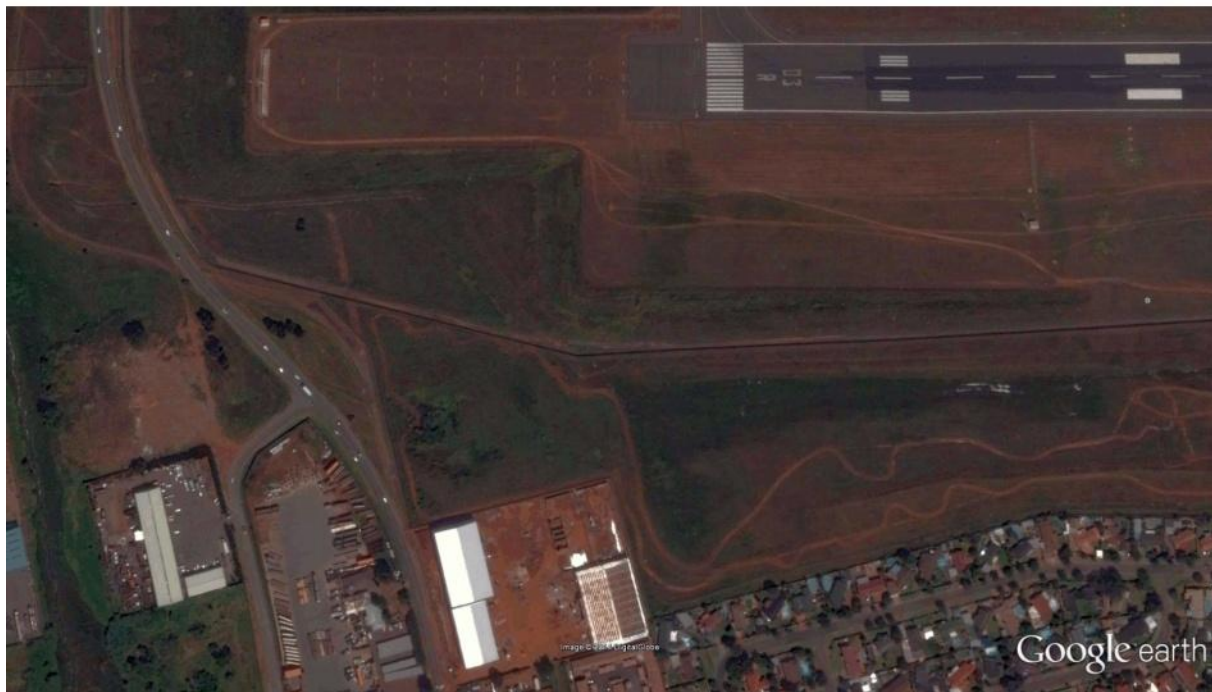
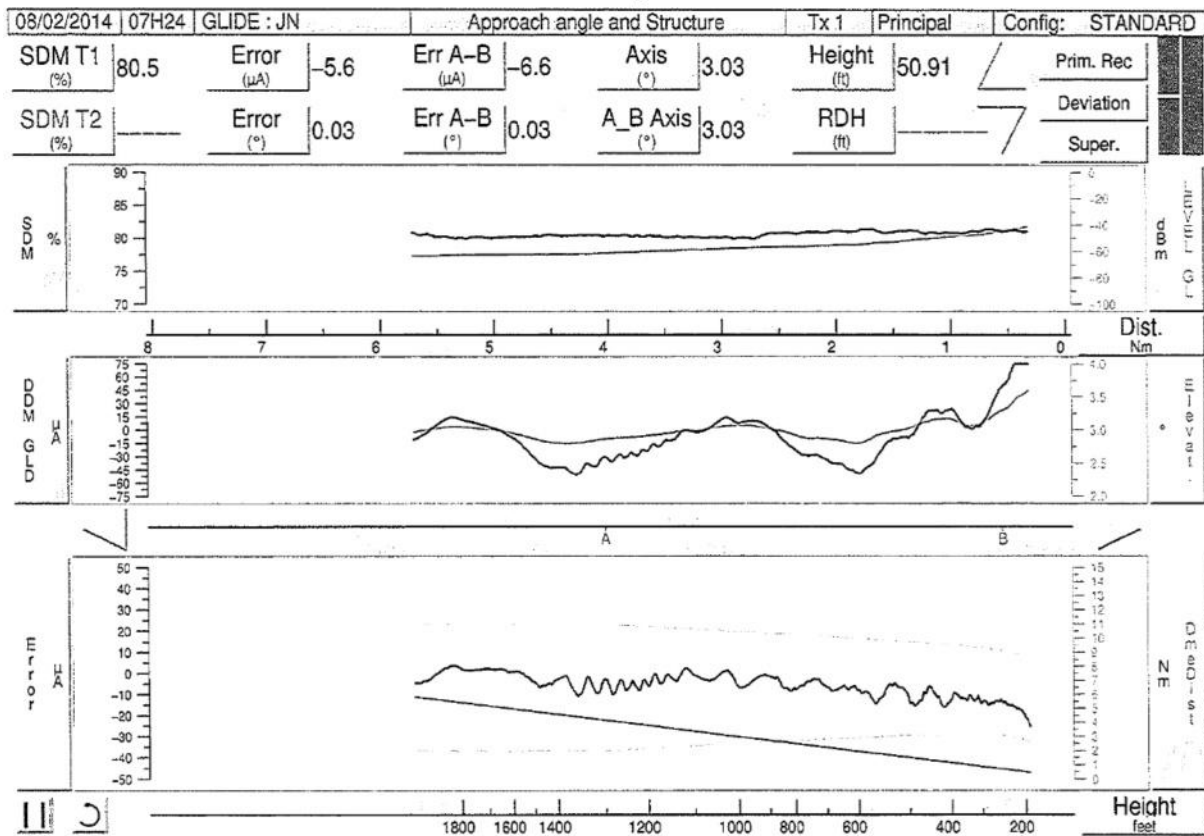


Figure 2

5. July 2014

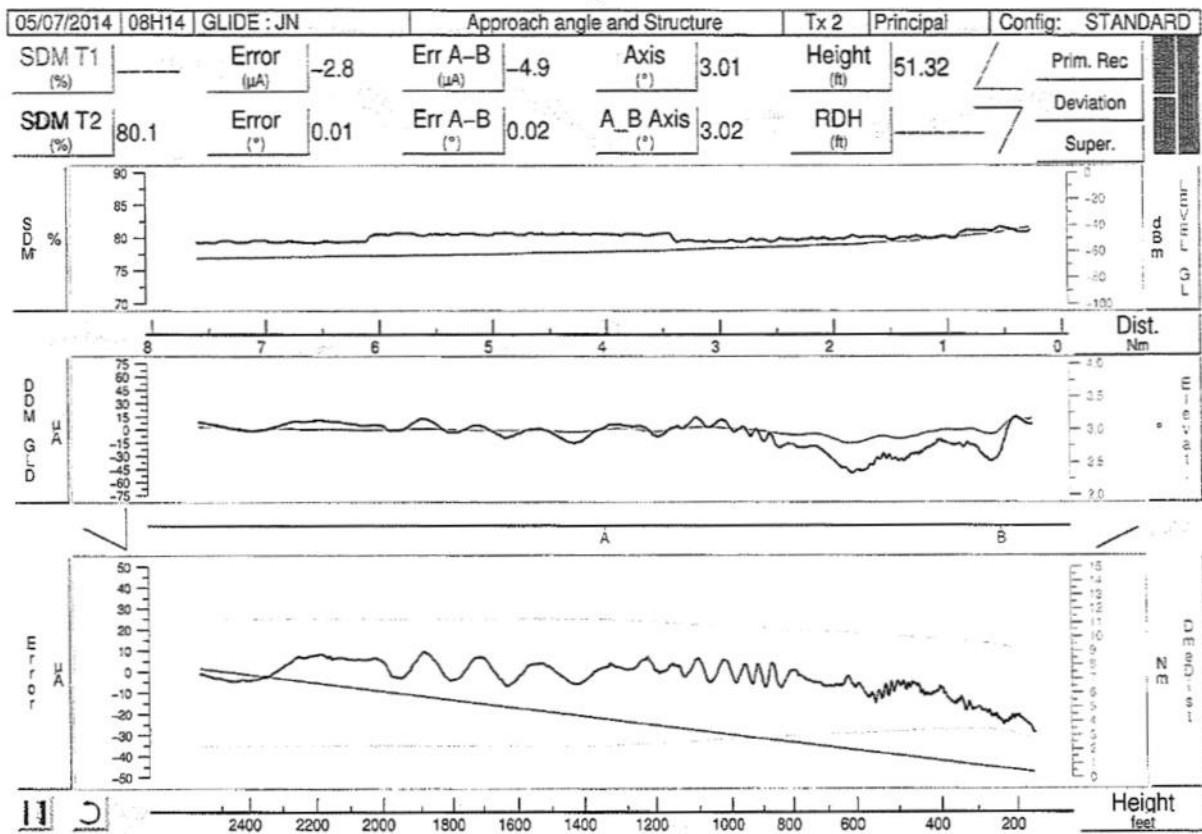


Figure 3

The new buildings can be seen in more detail in Figure 4 and Figure 5.



Figure 4
The buildings seen from the Glide Path antenna



Figure 5
A closer look of the buildings

4 Problem solving

To assist in the effort of finding a possible solution of the problem, Indra Navia AS has done extensive computer simulations to identify the cause of the problem and try to find a practical solution.

This process involved several steps:

1. Building a 3D terrain model which can be used for computer simulations
2. Confirming the validity of the model and identify the cause of the problem
3. Investigate if the problem can be solved by optimizing the feeds of the Glide Path antenna system
4. If step 3 fails, investigate if the Glide Path performance can be better by using a different Glide Path antenna system, e.g. Null-Reference or Sideband-Reference, possible positioned closer to the runway
5. If step 4 also fails, investigate the possibility of another solution.

4.1 Building a 3D terrain model

Based on the supplied surveyed terrain data, a 3D terrain model was constructed. Using all the data, the model consists of 2007 triangles. The model is shown in Figure 6.

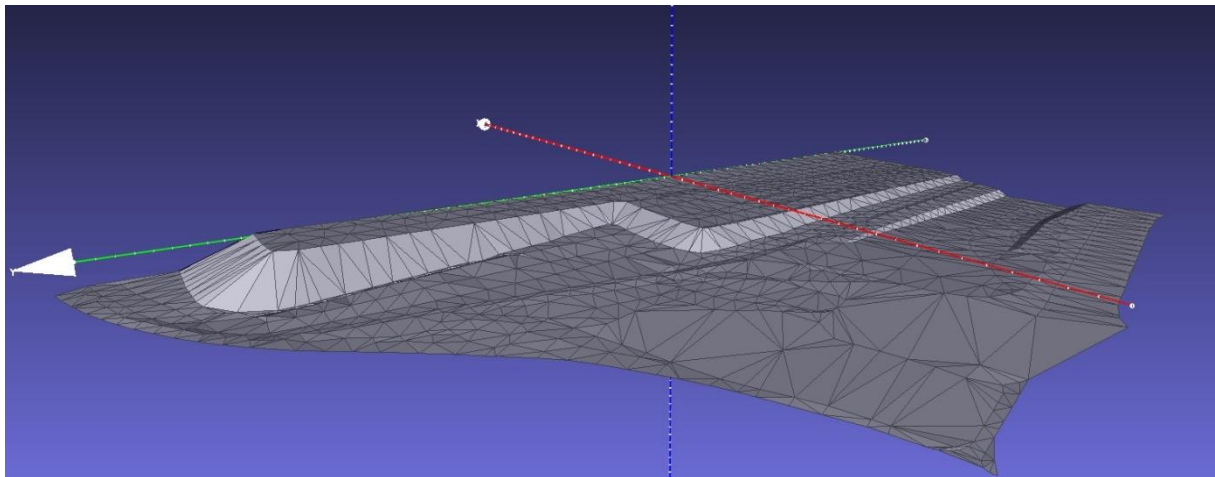


Figure 6
Full 2D terrain model

To generate a model that can be used for computer simulations, it is necessary to simplify the model to reduce the number of triangles to a number that can be handled by the computer simulation program and to reduce the computer run-time for the simulations. The simplified model must have the same topology as the full model to give valid results. The simplification process was done by partly manually removing surveyed terrain points and areas not needed, and partly using a computer program (MeshLab).

The simplified 3D terrain model is shown in Figure 7. To simulate one run (one approach flight or level flight) consumes 15 minutes computer time with this model.

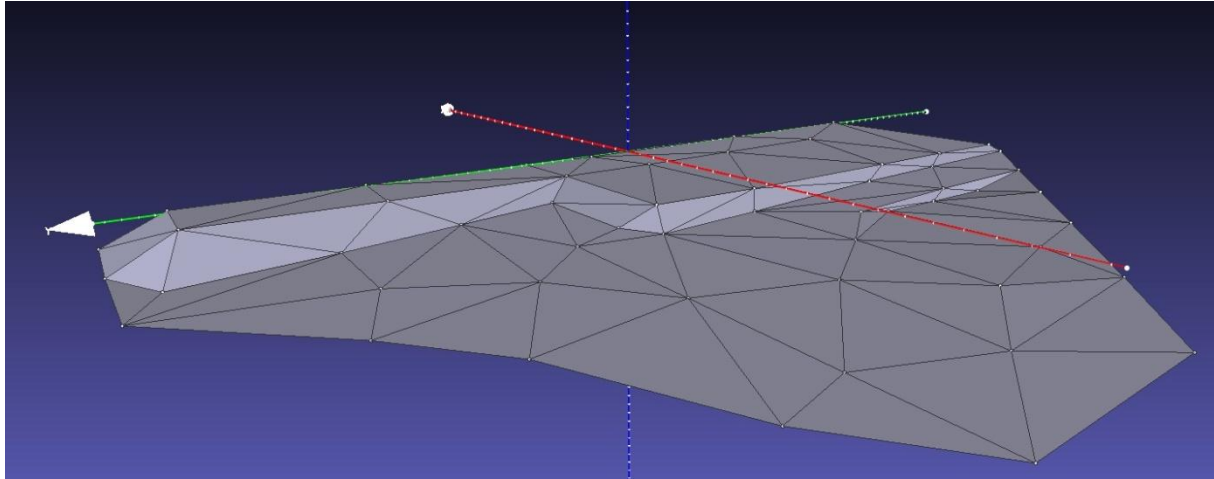


Figure 7
Simplified 3D terrain model

4.2 Confirming the validity of the model and identifying the cause of the problem

To verify the validity of the model, the facades of the two new buildings facing the runway were modelled as shown in Figure 13.

From the received flight inspection recordings it is evident that an incorrect Flight Inspection Aiming point (reference point) has been used, causing a “flare” in the approach recording that start already at ILS point A. With a correct aiming point, the “flare” should not start before ILS Point B.

To verify the validity of the model, the same error in the aiming point was introduced making it possible to compare the flight inspection recording and the computer simulation result directly.

The computer simulated structure is shown in Figure 8, superimposed on the flight inspection recording from 5th July 2014. The correlation between the actual flight inspection result and the computer simulation is very good, with the scalloping showing up in the same position and with the same magnitude on the simulation as in the actual flight inspection recording. The simulation also identified the cause of the problem to be edge diffracted signal from the top rim of the walls facing the runway rather than reflected signal from the wall itself. The signal illuminating the top rim of the buildings is a combined signal resulting from direct radiation, edge diffracted signal from the edge of the Beam Forming Area and ground reflected signal.

Computer simulated approach- and level-flights without the two buildings are shown in Figure 9 and Figure 10.

Computer simulated approach- and level-flights including the two buildings are shown in Figure 11 and Figure 12.

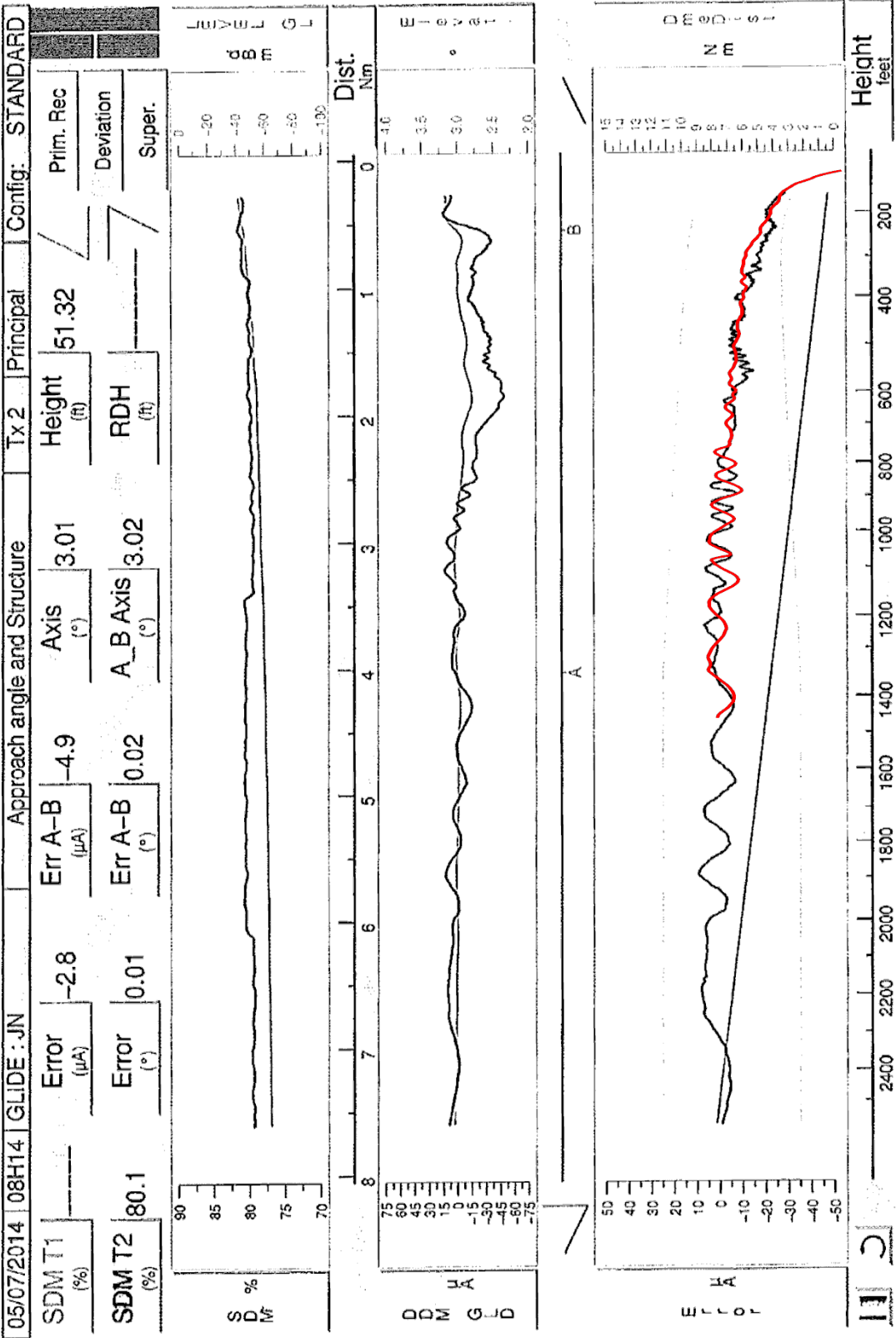


Figure 8
Flight Inspection recording from 5th July 2014 with computer simulation result
superimposed (red trace)

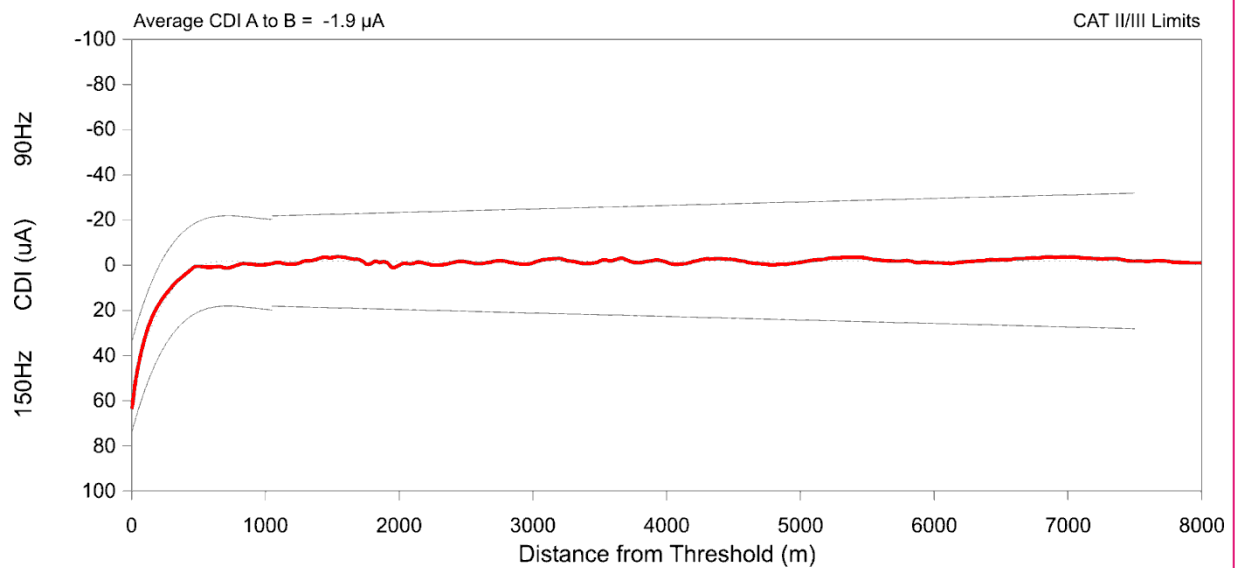


Figure 9
Computer simulated approach flight, only terrain model

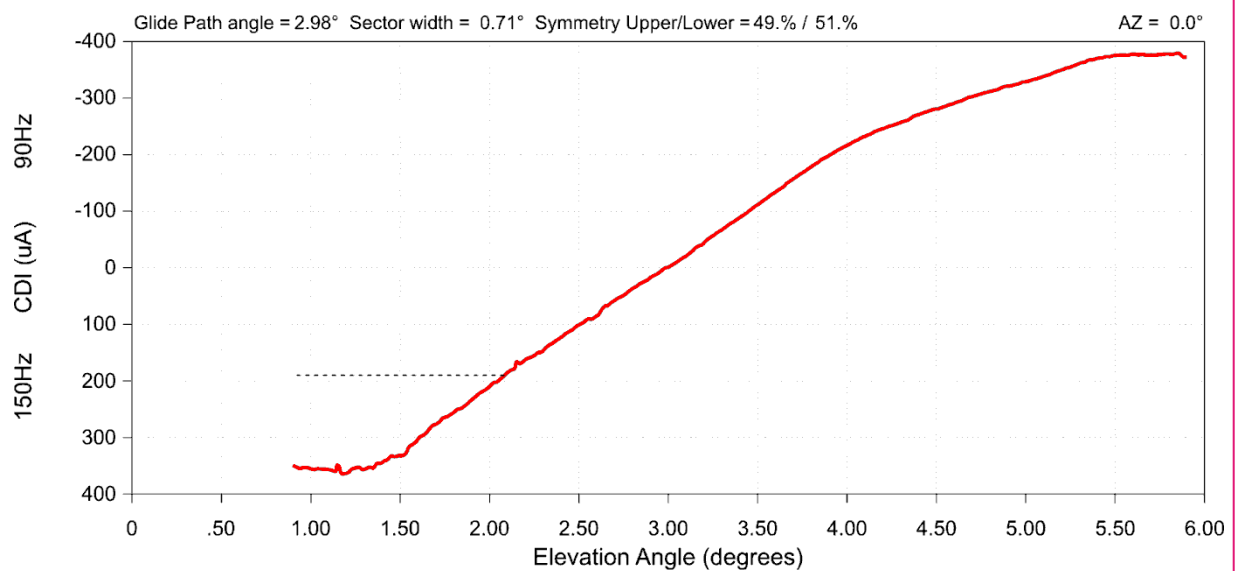


Figure 10
Computer simulated level flight, only terrain model

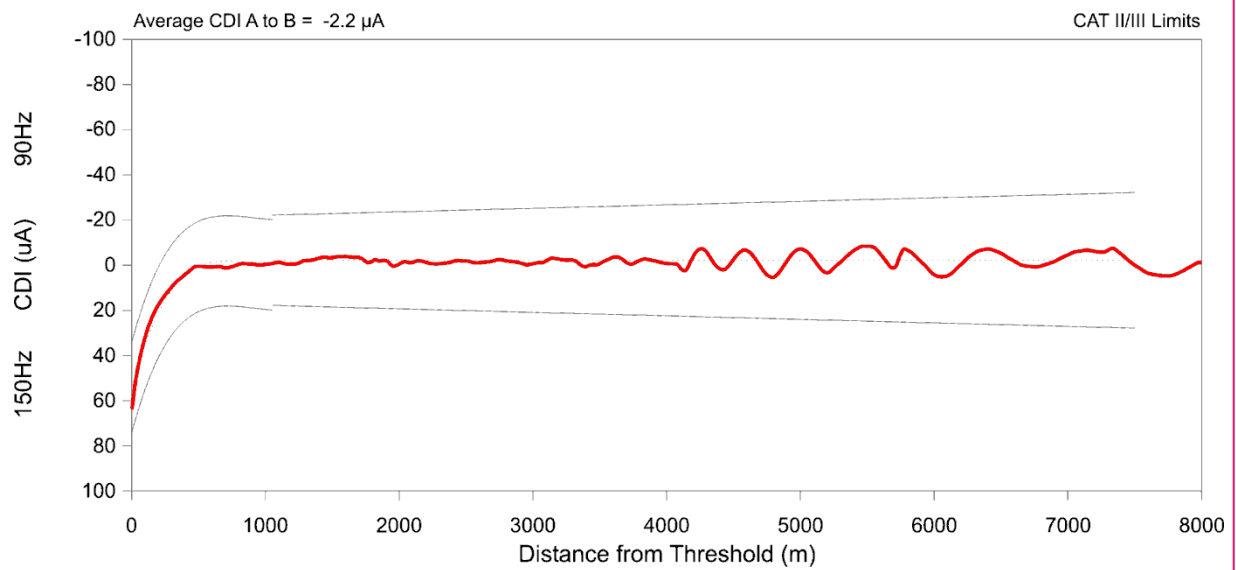


Figure 11
Computer simulated approach flight, terrain model and buildings

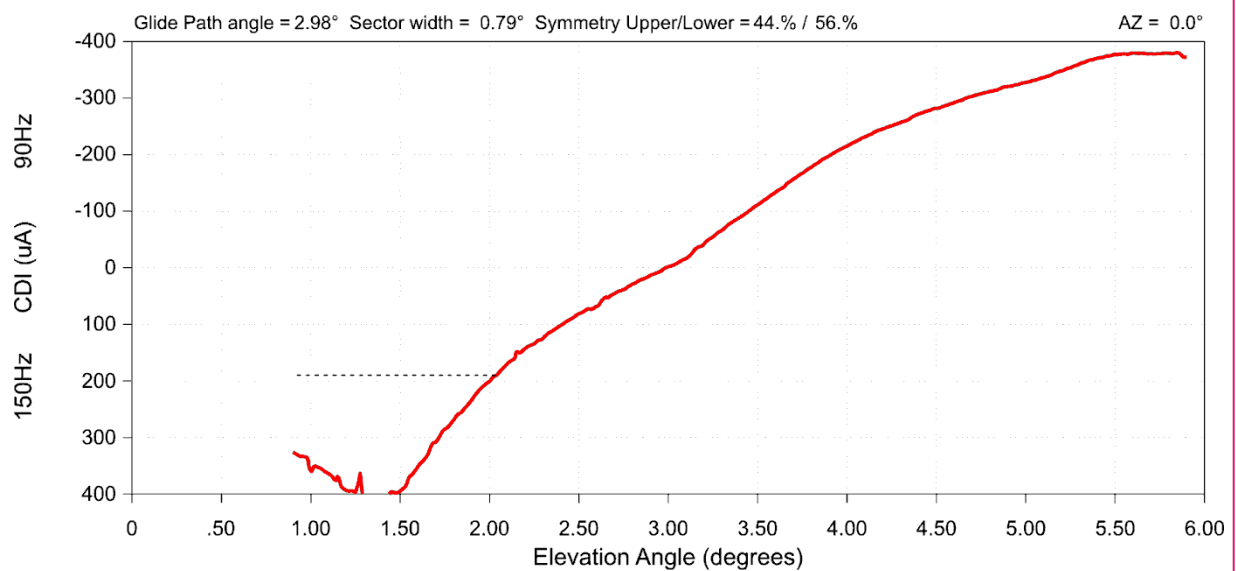


Figure 12
Computer simulated level flight, terrain model and buildings

4.3 Investigating if the problem can be solved by optimizing the feeds of the Glide Path antenna system

Extensive computer runs with different feeds of the antenna system were carried out to see if it was possible to reduce or solve the problem by optimizing the antenna feeds. Due to the short distance from the Glide Path antenna towards the edge of the Beam Forming Area (approx. 100m) in the direction of the buildings, it was not possible to optimize the feeds of the antenna system. All tested feeds resulted in increased scalloping.

Laterally rotation of the antenna elements was also investigated, with the same result. The direction from the Glide Path antenna towards the buildings is close to 30° from the runway direction, which is also the direction of the minimum radiation in the radiation pattern of the Kathrein antenna element.

It was also considered to use another Glide Path antenna element, the Watts Antenna company's GP5A Glide Path antenna element. Unfortunately, in the direction of the buildings there is little improvement in the radiation pattern of the GP5A antenna element compared to the Kathrein antenna.

4.4 Investigating the effect of changing the Glide Path antenna system

Extensive computer runs with alternative Glide Path antenna systems (e.g. Null-reference and Sideband-reference systems) were carried out.

Both these systems improve the scalloping problem slightly, but unfortunately they introduce a new problem, large bends close to the threshold region. This is also the case for a Sideband-reference Glide path positioned as close as 75m from the runway centreline.

4.5 Other possible solution, reducing radiation towards the buildings by screening of the signal

To reduce the radiation towards the buildings, a metallic screen was introduced in the model to block the direct signal towards the buildings and the lower ground between the Beam Forming Area and the buildings, and positioned to also reduce or eliminate the edge diffracted signal from the edge of the Beam Forming Area.

After several different tests, we ended up with a screen approx 18m wide and 10m high positioned with one edge approx. 80m forward from the Glide Path antenna on the edge of the Beam Forming Area (approx. 180m from the runway centreline), and oriented perpendicular to the direction to the Glide Path antenna.

The computer model with the façade of the two buildings and the screen and the Glide Path antenna mast included is shown in Figure 13.

The computer simulated approach flight with the screen in the model is shown in Figure 14, and the level flight in Figure 15. The below path fly-up signal within the lateral coverage sector at 0.45° (1.35°) is shown in Figure 16.

The computer simulated results indicate that a metallic screen as described may solve the scalloping problem.

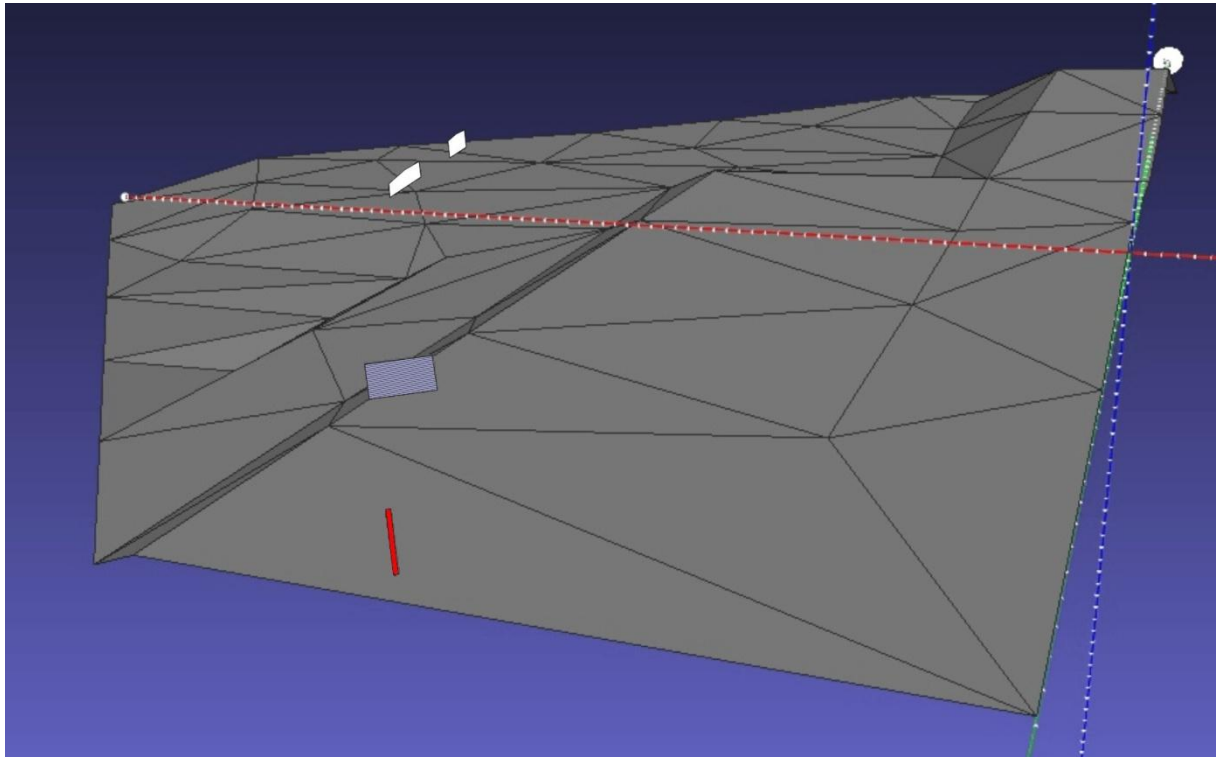


Figure 13
3D Terrain model showing the building facades and the modelled screen

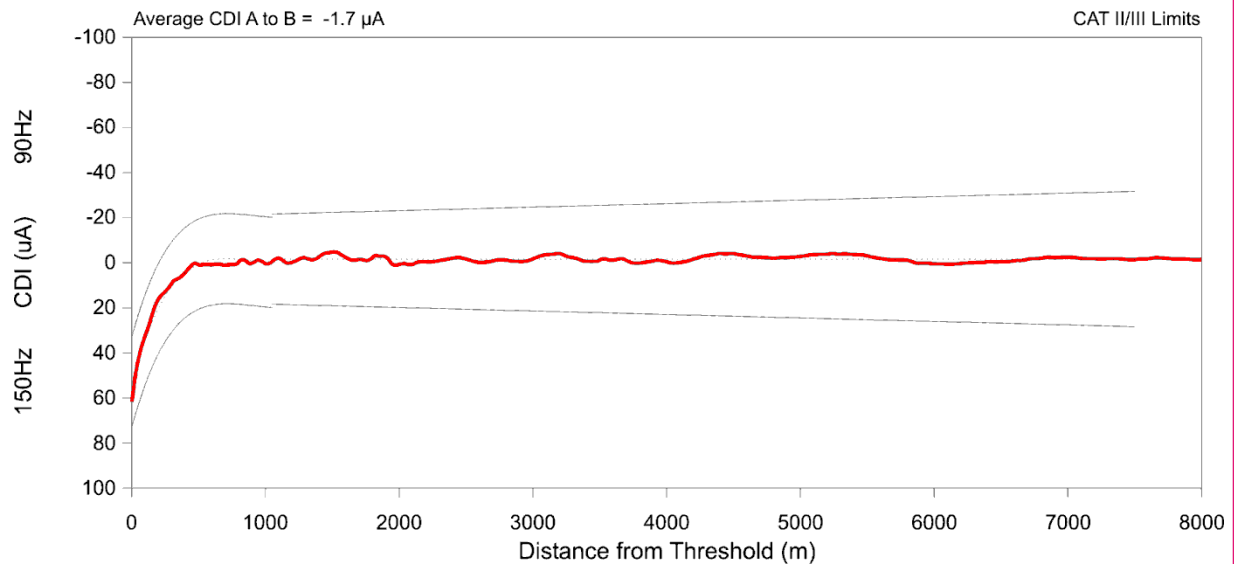
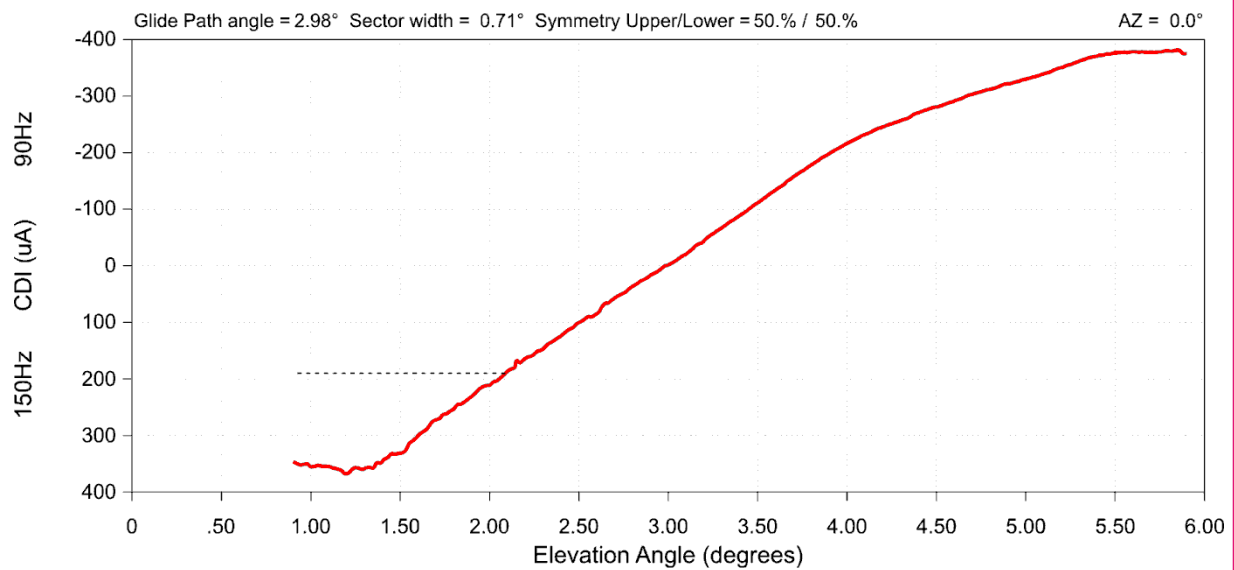
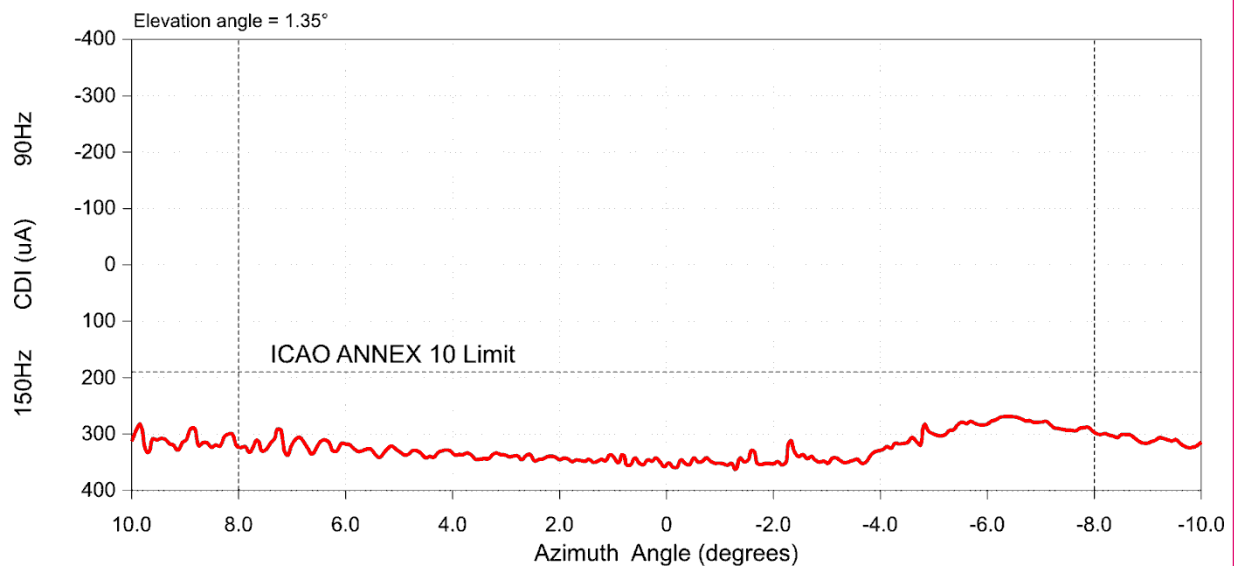


Figure 14
Computer simulated approach flight, terrain model including buildings and screen

**Figure 15**

Computer simulated level flight, terrain model including buildings and screen

**Figure 16**

Computer simulated low level semi-orbit, terrain model including buildings and screen

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