ร่างขอบเขตงานซื้อโปรแกรมจำลองสัญญาณระบบช่วยการเดินอากาศ

จำนวน ๓ License พร้อม Notebook Computer ๓ เครื่อง

๑. ความเป็นมา

ด้วย ระบบช่วยการเดินอากาศเป็นระบบที่ออกอากาศในรูปแบบสัญญาณเพื่อการนำทางสำหรับอากาศยาน โดยรูปแบบสัญญาณที่ออกอากาศต้องเป็นไปตามมาตรฐานที่ ICAO กำหนด แต่ปัจจุบัน วช.บว. พบเหตุปัจจัยที่ส่งผลกระทบต่อสัญญาณของระบบช่วยฯ ทำให้เกิดค่าพารามิเตอร์บางประเภทไม่เป็นไปตามมาตรฐาน ซึ่งเหตุปัจจัยดังกล่าวเป็นสิ่งที่ปลูกสร้างและสิ่งกีดขวางที่อยู่ภายในและภายนอกท่าอากาศยาน โดยเกิดจากการปรับปรุงและก่อสร้างระบบสาธารณูปโภคของท่าอากาศยานเพื่อรองรับจำนวนผู้โดยสารที่เพิ่มขึ้น อีกทั้งสภาพแวดล้อมโดยรอบระบบช่วยฯ เช่น กลุ่มต้นไม้ เสาไฟฟ้าแรงสูง และการดำเนินการต่าง ๆ เช่น การก่อสร้าง การใช้รถเครน ดังนั้น วช.บว. จึงจำเป็นต้องมีเครื่องมือสำหรับการวิเคราะห์สัญญาณของระบบช่วยฯ ในกรณีที่สิ่งปลูกสร้างหรือสิ่งกีดขวางติดตั้งอยู่บริเวณโดยรอบระบบช่วยฯ เพื่อให้รูปแบบสัญญาณของระบบช่วยฯ อยู่ในเกณฑ์มาตรฐาน และความปลอดภัยของการให้บริการการเดินอากาศ

๒. วัตถุประสงค์

จัดซื้อโปรแกรมจำลองสัญญาณระบบช่วยการเดินอากาศ จำนวน ๓ License พร้อม Notebook Computer ๓ เครื่อง เพื่อใช้ในการวิเคราะห์สัญญาณของระบบช่วยฯ

๓. คุณสมบัติของผู้ยื่นข้อเสนอ

๓.๑ จะต้องมีคุณสมบัติตามที่ระบุในแบบเอกสารประกวดราคาอิเล็กทรอนิกส์ของคณะกรรมการนโยบายการจัดซื้อจัดจ้างและการบริหารพัสดุภาครัฐ หรือคณะกรรมการวินิจฉัยปัญหาการจัดซื้อจัดจ้างและการบริหารพัสดุภาครัฐกำหนด

๓.๒ จะต้องเป็นนิติบุคคลผู้มีอาชีพขายพัสดุที่จัดซื้อโดยวิธีประกวดราคาอิเล็กทรอนิกส์ดังกล่าว

๓.๓ ต้องไม่มีกรรมการหรือพนักงาน บวท. เป็นผู้จัดการ หุ้นส่วนผู้จัดการ กรรมการผู้จัดการ ผู้บริหาร ผู้มีอำนาจในการดำเนินงานในกิจการของบุคคลธรรมดาหรือของนิติบุคคล เป็นหุ้นส่วนในห้างหุ้นส่วนสามัญหรือห้างหุ้นส่วนจำกัด เป็นผู้ถือหุ้นรายใหญ่ในบริษัทจำกัดหรือ บริษัทจำกัดมหาชน หรือเป็นที่ปรึกษาของกิจการนั้น

๔. กำหนดเวลาส่งมอบพัสดุ

ไม่เกิน ๑๘๐ วัน นับถัดจากวันลงนามในสัญญาซื้อขาย

๕. **หลักเกณฑ์ในการพิจารณาคัดเลือกข้อเสนอ**

พิจารณาจากราคารวมต่ำสุด

๖. **วงเงินงบประมาณ/วงเงินที่ได้รับจัดสรร**

เป็นเงิน ๓,๓๐๐,๐๐๐.- บาท

๗. **งวดงานและการจ่ายเงิน**

๑ งวด

๘. **อัตราค่าปรับ**

อัตราร้อยละ ๐.๒ ของราคารวมตามสัญญาต่อวัน

๙. **การกำหนดระยะเวลารับประกันความชำรุดบกพร่อง**

ไม่น้อยกว่า ๒ ปี นับจากวันที่ส่งมอบสิ่งของให้กับ บวท. เรียบร้อยแล้ว โดยภายในกำหนดเวลาดังกล่าวหากสิ่งของเกิดชำรุด หรือขัดข้องอันเนื่องมาจากการใช้งานปกติ ผู้ชนะการประกวดราคาจะต้องรีบจัดการซ่อมแซมหรือแก้ไขให้ใช้การได้ดีดังเดิมภายใน ๓๐ วัน นับถัดจากวันที่ได้รับแจ้งความชำรุดบกพร่อง หากมีค่าใช้จ่ายเกิดขึ้นขณะที่อยู่ในการรับประกัน ผู้ชนะการประกวดราคาจะต้องเป็นผู้ออกค่าใช้จ่ายทั้งหมด

๑๐. **กำหนดยืนราคา**

ไม่น้อยกว่า ๙๐ วัน ตั้งแต่วันเสนอราคา

๑๑. **รายละเอียดคุณลักษณะเฉพาะของพัสดุ**

๑๑.๑ รายละเอียดตามเอกสารแนบ Technical Specification for Navigation and Landing Systems Modeling Software

๑๑.๒ โปรแกรมจำลองสัญญาณระบบช่วยการเดินอากาศ จำนวน ๓ License จะต้องมีใบอนุญาติใช้งานแบบถาวร โดยไม่จำเป็นต้องมีค่าใช้จ่ายอื่น ๆ เพิ่มเติม

๑๒. **กำหนดหน้าที่ของคู่สัญญา**

คู่สัญญาต้องจัดทำแผนการทำงานมาให้ภายใน ๑๕ วัน นับถัดจากวันลงนามในสัญญา ทั้งนี้แผนการทำงานดังกล่าวให้ถือเป็นเอกสารส่วนหนึ่งของสัญญา

Technical Specification for Navigation and Landing Systems Modeling Software

1. General Requirements

1.1 The software shall support signal modelling and analysis for navigation aids (navaids) facilities including Localizer (LOC), Glide Path (GP), and VOR.
1.2 The software shall be able to support analysis of different designs and implementations of navaids facilities by specifying navaids technical characteristics, intended flight path, and surrounding environment.
1.3 The software shall support units for distance measurement including feet, meters, kilometers and nautical miles.
1.4 The software shall support simulation iterations to test and compare multiple parameter values.
1.5 The software shall be able to provide graphical and numerical display and representations of the simulation and modelling results.
1.6 The software shall be able to export simulation and modeling results in both text and graphic formats.
1.7 The software shall be licensed permanently and will not require any additional fee.
1.8 The software shall be able to provide simulation results that are consistent with the actual signal measurements from the flight inspection aircraft of the Aeronautical Radio of Thailand Ltd. (AEROTHAI).
a. The proposer shall submit the signal simulation report of the LOC, GP, and VOR equipment according to the specifying navaids technical characteristics, intended flight path, and surrounding environment as specified in Appendix A. b. The simulation results from the software shall be consistent with the actual signal measurements from the flight inspection aircraft before and after the construction of the specified environment.

2. Navaids Modelling and Analysis

The software shall provide predefined antenna arrays for LOC, GP, VOR and allow for the creation of additional user-defined antenna patterns, arrays and characteristics.

2.1 LOC Modelling Requirements

2.1.1 Using the LOC modelling evaluation, the software user will perform analysis of LOC signal along the flight path. This analysis evaluates the course errors along the flight path taking into account the multipath effects caused by the orography and the buildings inside and around the airport.
2.1.2 The LOC modelling module of the software shall support the following functionalities:
a. support user-defined positioning of the LOC within the airport environment model b. support user-defined LOC antenna patterns, arrays and characteristics c. support modeling airport and airspace environment, which enables the software user to simulate the result of LOC flight inspection.

d. capable of analyzing the course error and signal strength analysis at various discrete points along a flight path.
2.1.3 The LOC modelling module of the software shall support customization of the following Runway and LOC parameters:
a. Localizer Width (or distance of the base of the Localizer Mast from the runway threshold) b. Antenna array type c. Antenna element type d. Course/Clearance Frequency e. The offset distance of the base of the localizer mast from the runway centerline (Main Offset) f. The localizer mast height g. The angular rotation of the localizer propagation direction from being parallel to the runway centerline (Array Rotation)

2.2 GP Modelling Requirements

2.2.1 Using the GP modelling evaluation, the software user will perform analysis of GP signal along the flight path. This analysis evaluates the path errors along the flight path taking into account the multipath effects caused by the orography and the buildings inside and around the airport.
2.2.2 The GP modelling module of the software shall support the following functionalities:
a. support user-defined positioning of the GP within the airport environment model b. support user-defined GP antenna patterns, arrays and characteristics c. support modeling airport and airspace environment, which enables the software user to simulate the result of GP flight inspection. d. capable of analyzing the path error and signal strength analysis at various discrete points along a flight path.
2.2.3 The GP modelling module of the software shall support customization of the following GP parameters:
a. Antenna array type b. Antenna element type c. Course/Clearance Frequency d. The setback distance of the base of the Glide Path Mast from the runway threshold (Main Setback) e. The offset distance of the base of the Glide Path mast from the runway centerline (Main Offset) f. Glide Path Width g. Glide Path Angle h. Glide Path Antenna Height i. Glide Path Antenna offset

2.3 VOR Modelling Requirements

2.3.1 The software shall support modelling and analysis of the Doppler VOR (DVOR).
2.3.2 The VOR modelling allows numerical modeling and performance simulation of Doppler VOR (DVOR) equipment in real sites, taking into account elements such as: cartography, physical characteristics of the terrain, artificial obstacle scattering, and the effects of material properties on the radio electrical parameters of site elements.
2.3.3 Using the VOR modelling evaluation, the software user will perform analysis of VOR signal along the flight path. This analysis evaluates the bearing errors along the flight path taking into account the multipath effects caused by the orography and the buildings inside and around the airport.
2.3.4 The VOR modelling module of the software shall support the following functionalities:
a. support user-defined positioning of the VOR within the airport environment model b. support modeling airport and airspace environment, which enables the software user to simulate the result of VOR flight inspection. c. capable of analyzing bearing error and signal strength analysis at various discrete points along a flight path.
2.3.5 The VOR modelling module of the software shall support customization of the following VOR parameters:
a. Frequency b. VOR Position c. Ground Elevation d. Antenna Height e. Counterpoise Height f. Counterpoise Radius

3. Environment Modelling and Analysis

3.1 The environment modeling simulates adverse conditions such as limited reflection planes, high hills, buildings, and metal structures. These elements are likely to cause distortions in the LOC, GP and VOR signals due to reflections or diffractions of the signals along the aircraft path. Environmental modeling involves creating representations of various obstacle profiles based on the physical models of aircraft and hangars.
3.2 The Environment Modelling and Analysis capability of the software shall be as the followings:
a. The software shall be able to compute multipath errors that occurs due to objects and terrain in the vicinity of LOC, GP and VOR. b. The software shall provide a visualization capability for the software user to view the simulation environment. c. The software shall provide a capability for the software user to record the simulation environment.

d. The software shall provide predefined objects within the airport vicinity include aircraft, hangars, wind turbines, and control towers and support analysis of impacts of such objects to LOC, GP and VOR signals. e. The software shall support varying reflectivity indexes based on different object materials. This shall include, at the minimum, steel, aluminum, concrete, brick, vinyl, glass, plexiglass, wood, trees, rock, and soil. f. The software shall support user customization of obstacle profiles. This capability shall support user selection of Plate and Wire Type, Material, Dimension, Base Elevation, Height, and Tilt Angle for each obstacle under consideration. g. The software shall include functions for the user to insert, view, and modify various scatter objects within the simulation environment. h. The software shall support analysis of impacts from forward–sloping and side–sloping terrain on LOC/GP signals. i. The software shall support the analysis of open drainage in any orientation relative to the runway, evaluating its impact on the GP signal.

4. LOC/GP Flight Inspection Profile Modelling and Analysis

4.1 For standard LOC/GP flight inspection profiles, the software shall support the following flight profiles:
4.1.1 Approach Flight Path
1) Shall be specified by the following parameters:
a. Approach Path Angle b. Altitude at Threshold c. Azimuth Angle d. Range at Start e. Range at Stop
2) For the simulation result, a plot showing the distance from the threshold versus LOC/GP parameter values shall be provided.
4.1.2 Level Run Flight Path
1) Shall be specified by the following parameters:
a. Elevation at Start b. Elevation at Stop c. Altitude d. Azimuth Angle
2) For the simulation result, a plot showing the elevation angle versus LOC/GP parameter values shall be provided.
4.1.3 Orbit Flight Path

1) Shall be specified by the following parameters:
a. Azimuth at Start b. Azimuth at Stop c. Range d. Altitude
2) For the simulation result, a plot showing the azimuth angle versus LOC/GP parameter values shall be provided.
4.2 The result of LOC/GP simulations using the flight profiles described above shall include the following LOC/GP parameter values:
a. Course/Path error in μAmps or DDM b. Total Signal Strength
4.3 Output reports of the LOC/GP simulation results shall be generated by inspecting all data points within the simulated flight path and those linearly interpolated between inspected points at the boundary of a zone. Note: The references to inspected points and the boundary of a zone shall comply with the ICAO Annex 10 Volume I standards for LOC/GP Categories I,II and III.
4.4 The output reports for LOC/GP simulation shall include:
a. Alignment error in μAmps or DDM b. For each zone, the highest absolute Course/Path error in that zone c. For each zone, the distance from threshold at the point with the highest absolute Course/Path error in that zone

5. VOR Flight Inspection Profile Modelling and Analysis

5.1 For standard VOR flight inspection profiles, the software shall support the following flight profiles:
5.1.1 Radial Pattern
1) Shall be specified by the following parameters:
a. Start Range b. Stop Range c. Altitude d. Radial
2) For the simulation result, a plot showing the distance versus VOR parameter values shall be provided.
5.1.2 Orbit Pattern
1) Shall be specified by the following parameters:
a. Start Radial b. Stop Radial c. Range

d. Altitude
2) For the simulation result, a plot showing the azimuth angle versus VOR parameter values shall be provided.
5.2 The result of VOR simulations using the flight profiles described above shall include the following VOR parameter values:
a. Bearing Error – Angle in degrees b. Total Signal Strength
5.3 Output reports of the VOR simulation results shall be generated by inspecting all data points within the simulated flight path and those linearly interpolated between inspected points.
5.4 The output reports for VOR simulation shall include:
a. Alignment Error – average value b. Roughness/Scalloping – maximum error value, and location (bearing or distance) c. Maximum Bend – maximum value, and location (bearing or distance)

6. Required List of Deliverables

	Items	Number
6.1	Navigation and Landing Systems Modeling Software	3 software licenses
6.2	Technical Manual and Documentation for the software listed in Item 6.1	1 hard copy and 1 soft copy
6.3	A Maintenance Agreement for the software listed in Item 6.1 covering the period of 2 years	
6.4	Laptop including necessary operating system and software (see Appendix B for details) with the minimum of 12-month warrantee	3 laptops
Note 1: The contractor shall ensure the software listed in 6.1 are successfully installed onto the laptops listed in Item 6.4 above and is fully tested and functional.		
Note 2: In the event that the laptops mentioned in Item 6.4 are damaged, the software listed in 6.1 can be installed onto the new laptops, along with a permanent license, and will not require any additional fees.		

Appendix A:

Examples of LOC, GP and DVOR

Flight Inspection Report

EXAMPLE 1: Localizer at Sakon Nakhon Airport

1. Modelling Description

1.1 Localizer System

- Table 1.1.1 presents the relevant data on the ILS/LOC RWY 23 system.
- Fig. 1.1.1 shows the Commissioning Width and the Position of the Threshold Point.

Latitude and Longitude :	17° 11'07.70" N, 104° 06'30.91"E
Equipment model :	THALES WILCOX MARK20A
Antenna Types :	LOG-Periodic Dipole Antenna
Number of Antenna :	14 Antenna Elements
Frequency :	110.3 MHz
Radiated Power :	15 Watts
Category :	I

Table 1.1.1 – ILS/LOC System for Runway 23 at Sakon Nakhon Airport

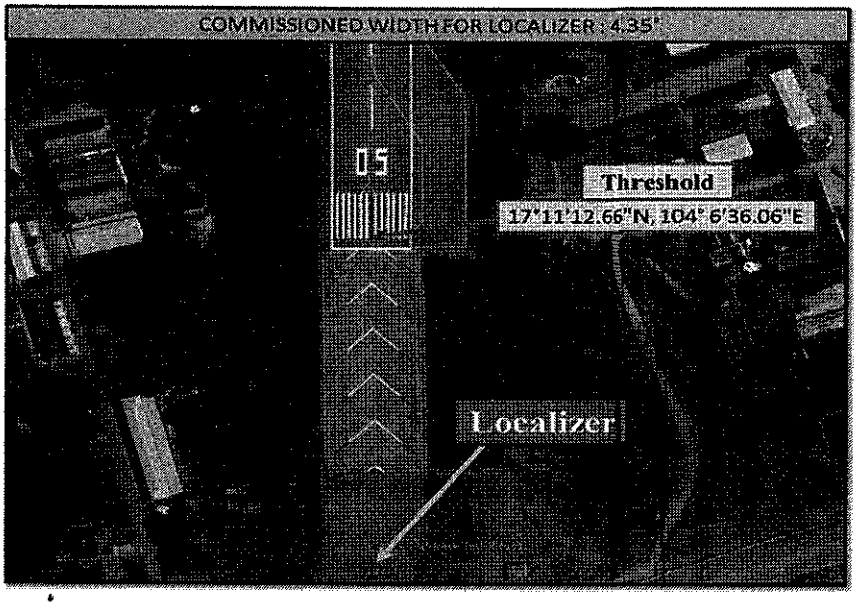


Fig. 1.1.1 – the Commissioned Width and the Position of the Threshold Point.

1.2 Obstacle

The obstacle is a perimeter fence surrounding the airport.

- Fig. 1.2.1 shows the characteristics of the fence.
- Fig. 1.2.2 shows the fence line around the airport.
- Table 1.2.1 shows the position of the fence line.

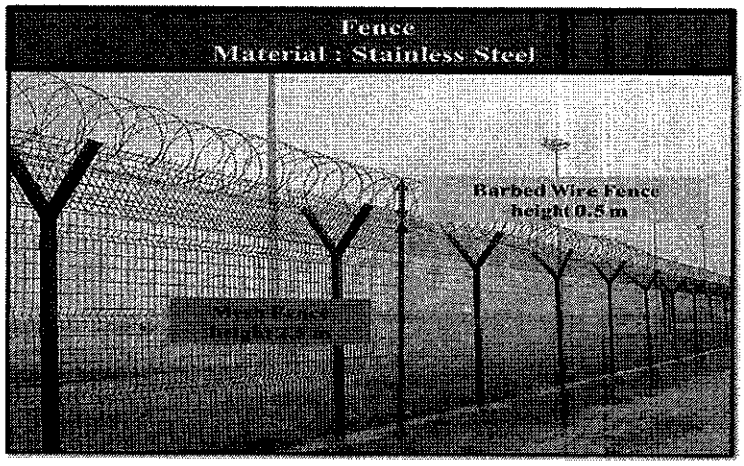


Fig. 1.2.1 – Description of the Characteristics of the Fence

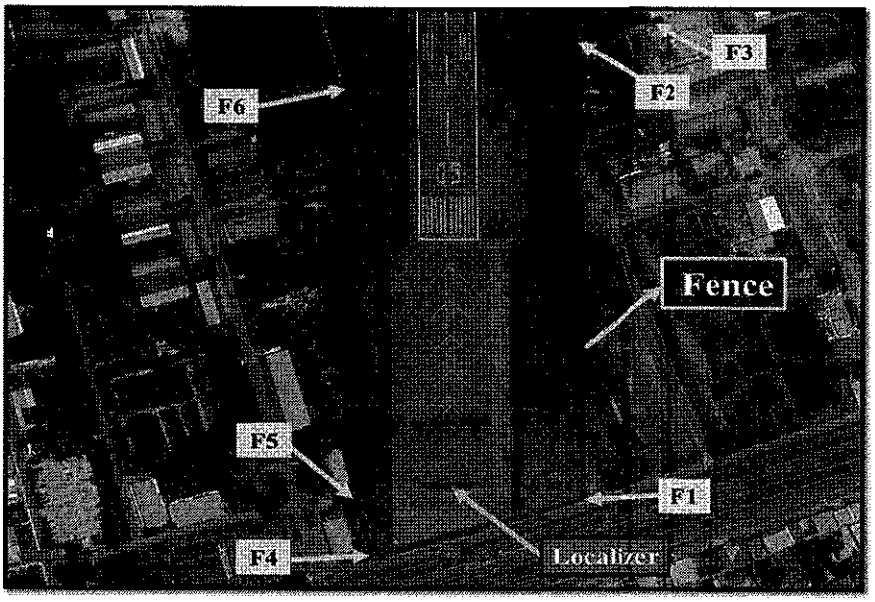


Fig. 1.2.2 – Fence line around the airport

Obstacles - Fence	Latitude and Longitude
F1	17°11'5.25"N, 104° 6'32.99"E
F2	17°11'14.27"N, 104° 6'42.54"E
F3	17°11'13.27"N, 104° 6'44.19"E
F4	17°11'7.78"N, 104° 6'28.06"E
F5	17°11'9.09"N, 104° 6'28.84"E
F6	17°11'17.62"N, 104° 6'37.46"E

Table 1.2.1 – Position of the Fence Line

2. Flight Inspection Report

2.1 CASE I

- Fig. 2.1.1 shows the terrain of Sakon Nakhon Airport in the absence of a perimeter fence.
- Fig. 2.1.2 presents the results of a flight inspection, showing clearance and width with labels, conducted during the LOC partial orbit (8 NM ±40° CW, 2020 ft AMSL, 1500 ft HGT), considering the absence of the fence.

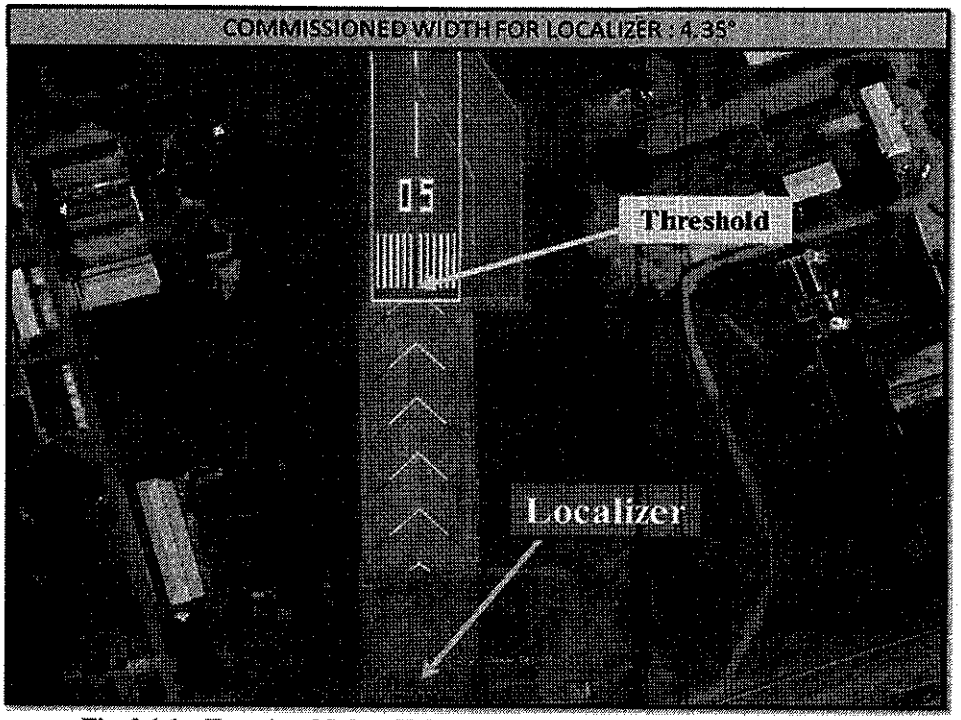


Fig. 2.1.1 – Terrain of Sakon Nakhon Airport without a perimeter fence

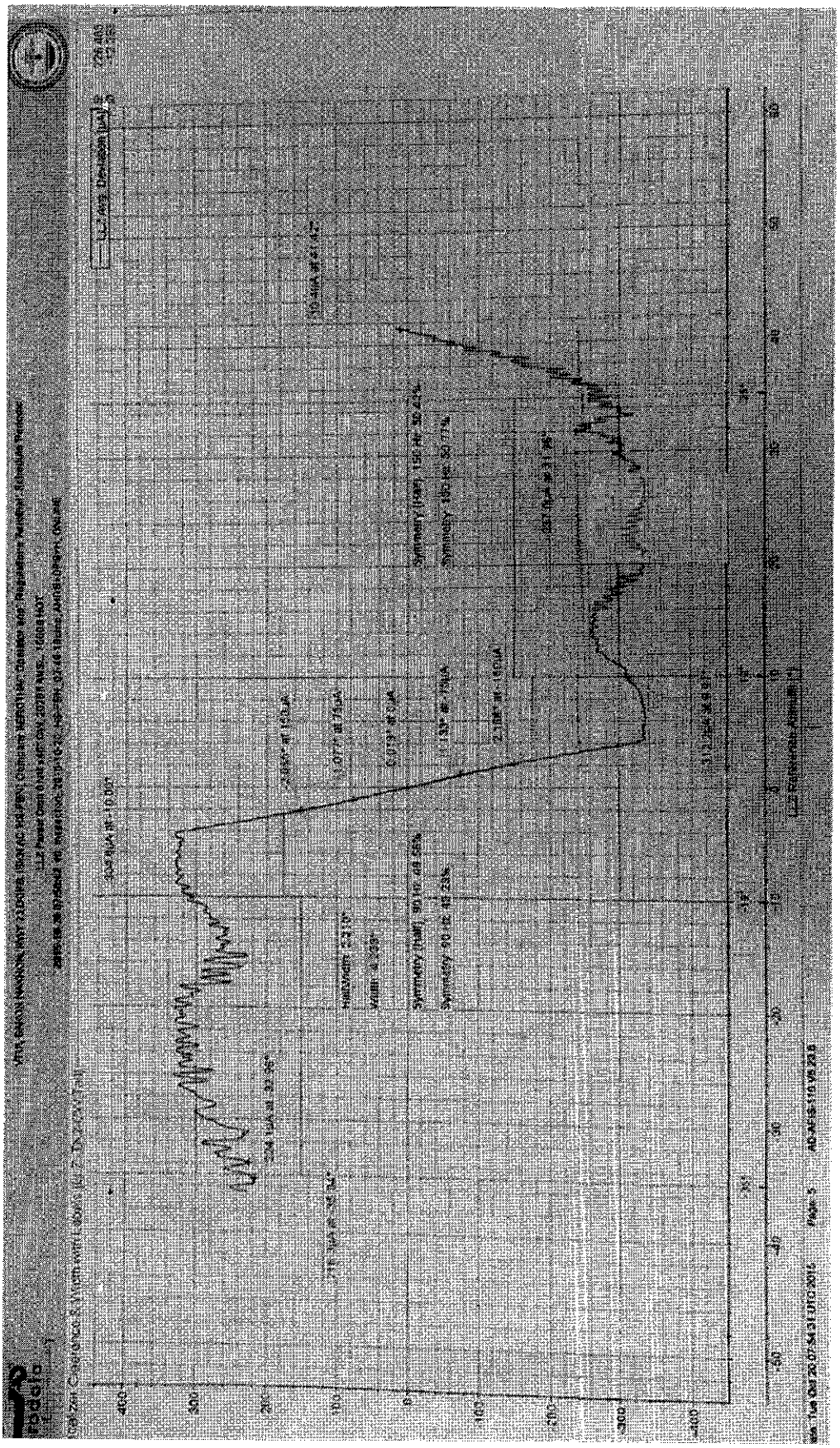


Fig. 2.1.2 – ILS/LOC RWY 23 Partial Orbit 8 NM ±40° CW, 2020ft AMSL / 1500ft HGT, absence of the fence

2.2 CASE II

- Fig. 2.2.1 shows the terrain at Sakon Nakhon Airport, taking into account the presence of the perimeter fence.
- Fig. 2.2.2 presents the results of a flight inspection, showing clearance and width with labels, conducted during the LOC partial orbit (8 NM ±40° CW, 2030 ft AMSL, 1500 ft HGT), considering the existence of the fence.

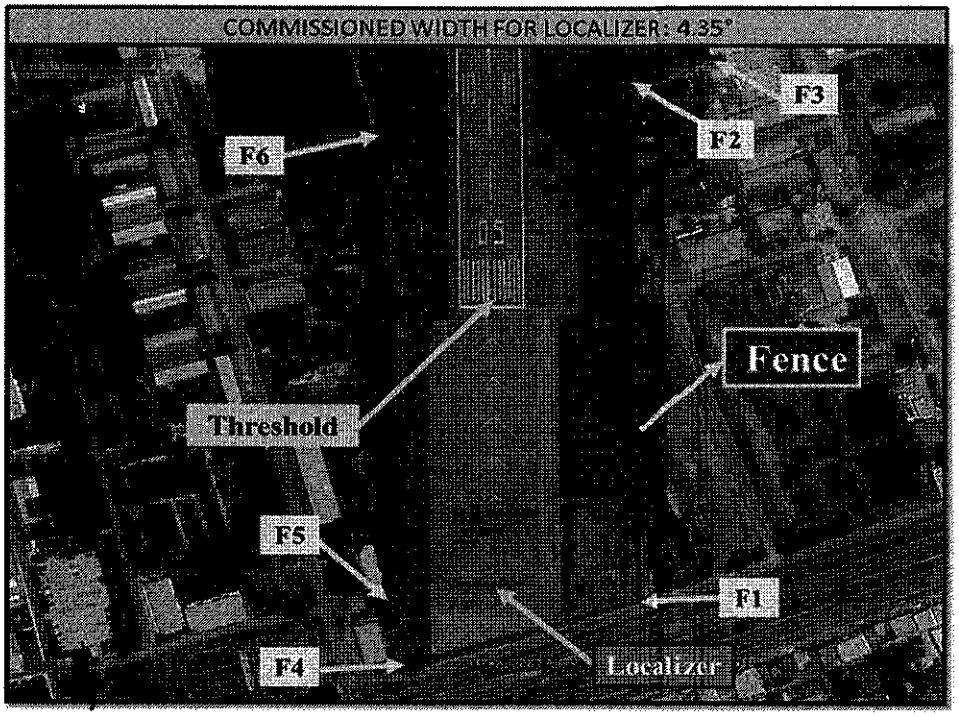


Fig. 2.2.1 - Terrain at Sakon Nakhon Airport, showing the presence of the fence

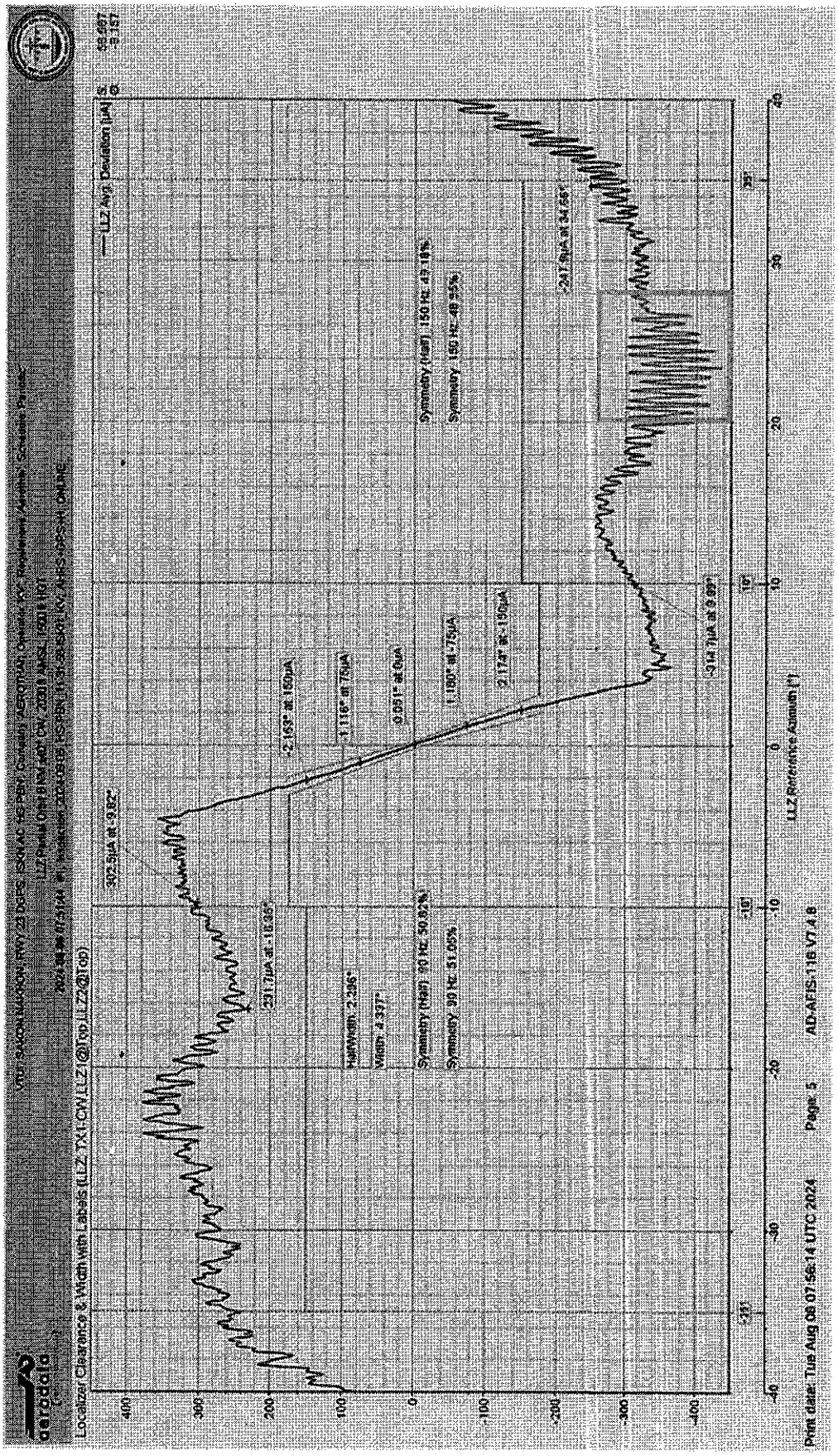
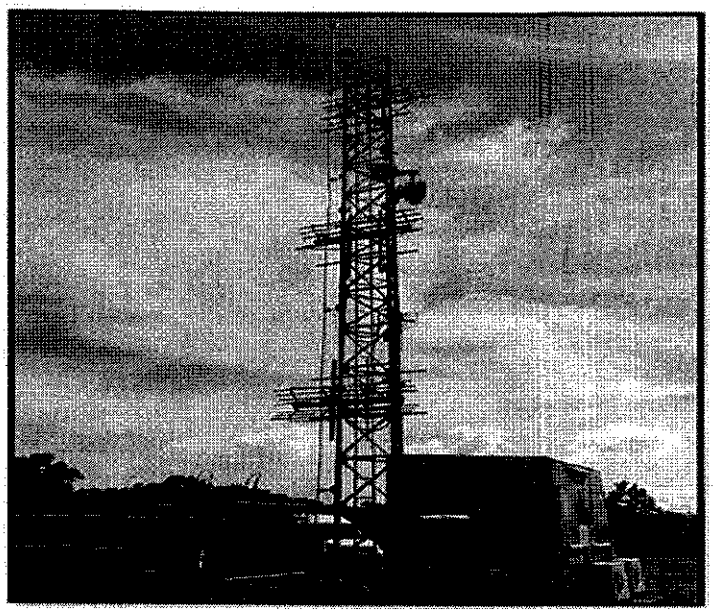


Fig. 2.2.2 – ILS/LOC RWY 23 Partial Orbit 8 NM ±40° CW, 2020ft AMSL / 1500ft HGT, existence of the fence

EXAMPLE 2: Glide Path at Chumphon Airport



1. Modelling Description

1.1 Glide Path System

- Table 1.1.1 presents the relevant data on the ILS/GP RWY 24 system.
- Fig. 1.1.1 shows the Commissioning Angle and the Position of the Threshold Point.

Latitude and Longitude :	10° 42' 49.28" N, 99° 2205.86" E
Equipment model :	THALES WILCOX MARK20A
Antenna Types :	Direction Finding M-Array Capture Effect Method
Number of Antenna :	3 Antenna Elements
Frequency :	333.8 MHz
Radiated Power :	5 Watts
Category :	I

Table 1.1.1 – ILS/GP System for Runway 24 at Chumphon Airport

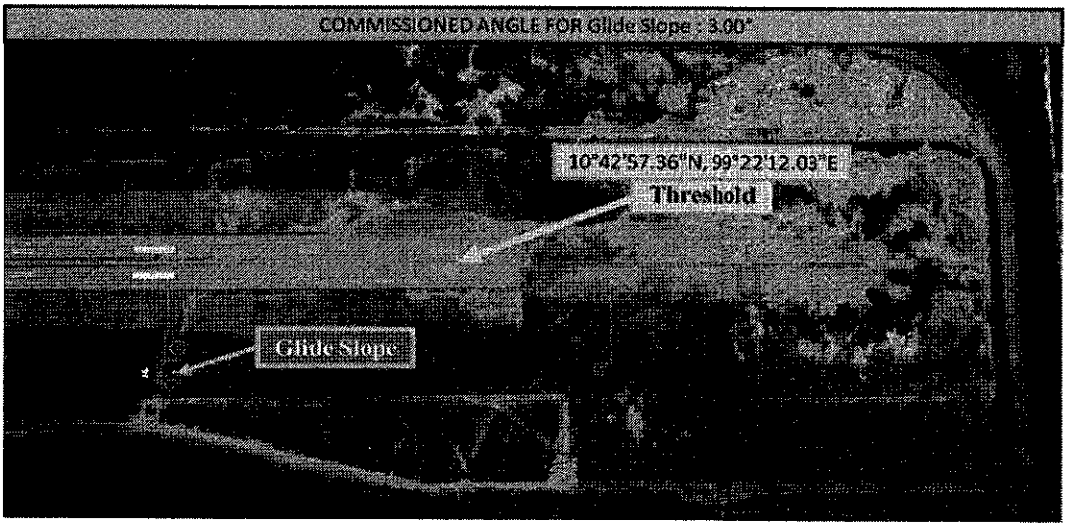


Fig. 1.1.1 – the Commissioned Angle and the Position of the Threshold Point.

1.2 Obstacle

The obstacle is a perimeter fence surrounding the airport.

- Fig. 1.2.1 shows the characteristics of the fence.
- Fig. 1.2.2 shows the fence line around the airport.
- Table 1.2.1 shows the position of the fence line.

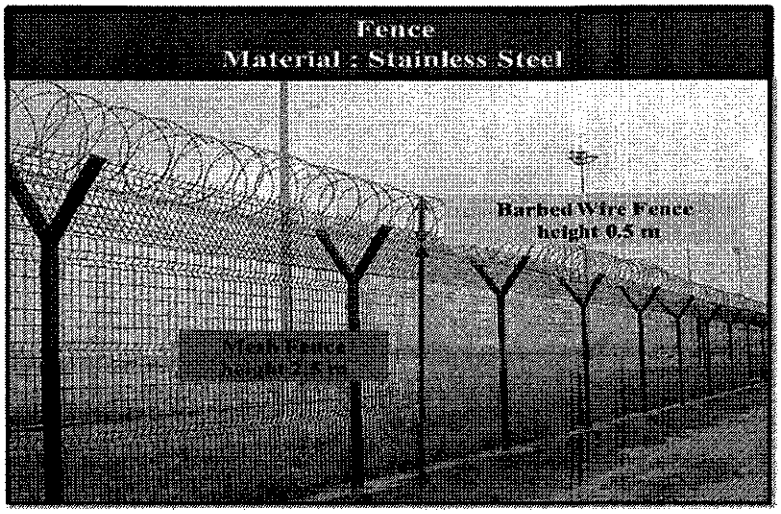


Fig. 1.2.1 – Description of the Characteristics of the Fence

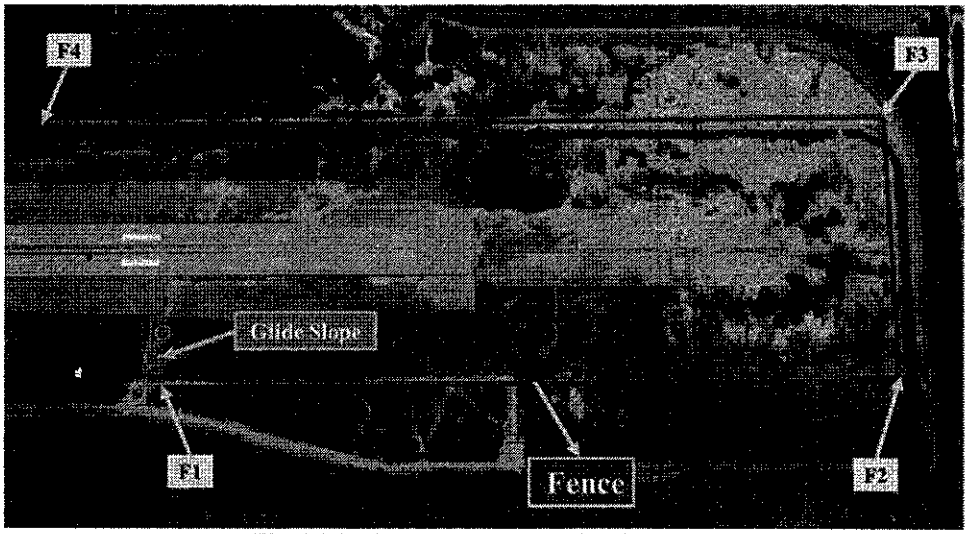


Fig. 1.2.2 – Fence line around the airport

Obstacles : Fence	Latitude and Longitude
F1	10°42'48.41"N, 99°22'6.31"E
F2	10°43'2.10"N, 99°22'30.21"E
F3	10°43'10.59"N, 99°22'25.32"E
F4	10°42'54.37"N, 99°21'56.92"E

Table 1.2.1 – Position of the Fence Line

2. Flight Inspection Report

2.1 CASE I

- Fig. 2.1.1 shows the terrain of Chumphon Airport in the absence of a perimeter fence.
- Fig. 2.1.2 presents the results of the Glide Slope Average Deviation Error [μA] from a flight inspection conducted during the THR Approach procedure, covering the range from 10 NM to Threshold, at 3020 ft AMSL and 3000 ft HGT, considering the absence of the perimeter fence.

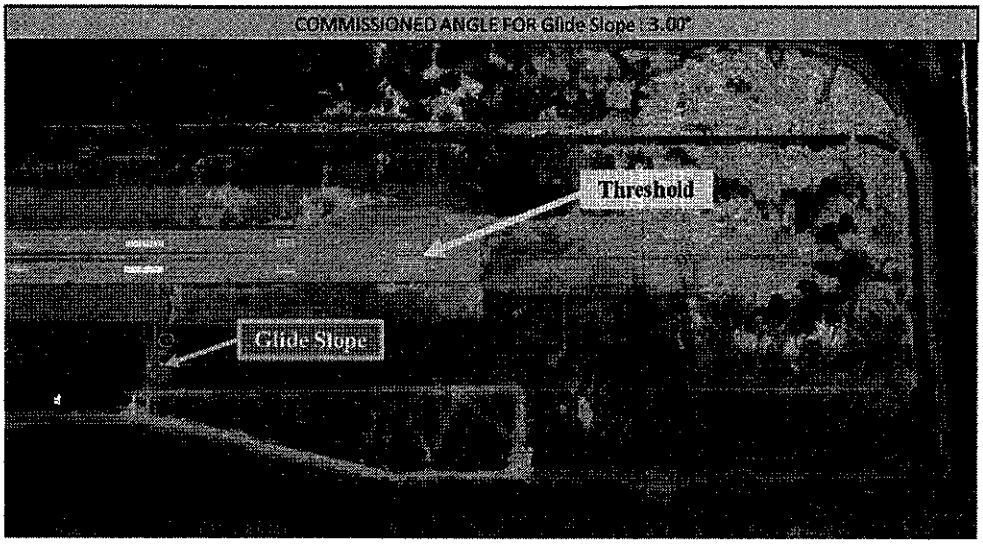


Fig. 2.1.1 – Terrain of Chumphon Airport without a perimeter fence

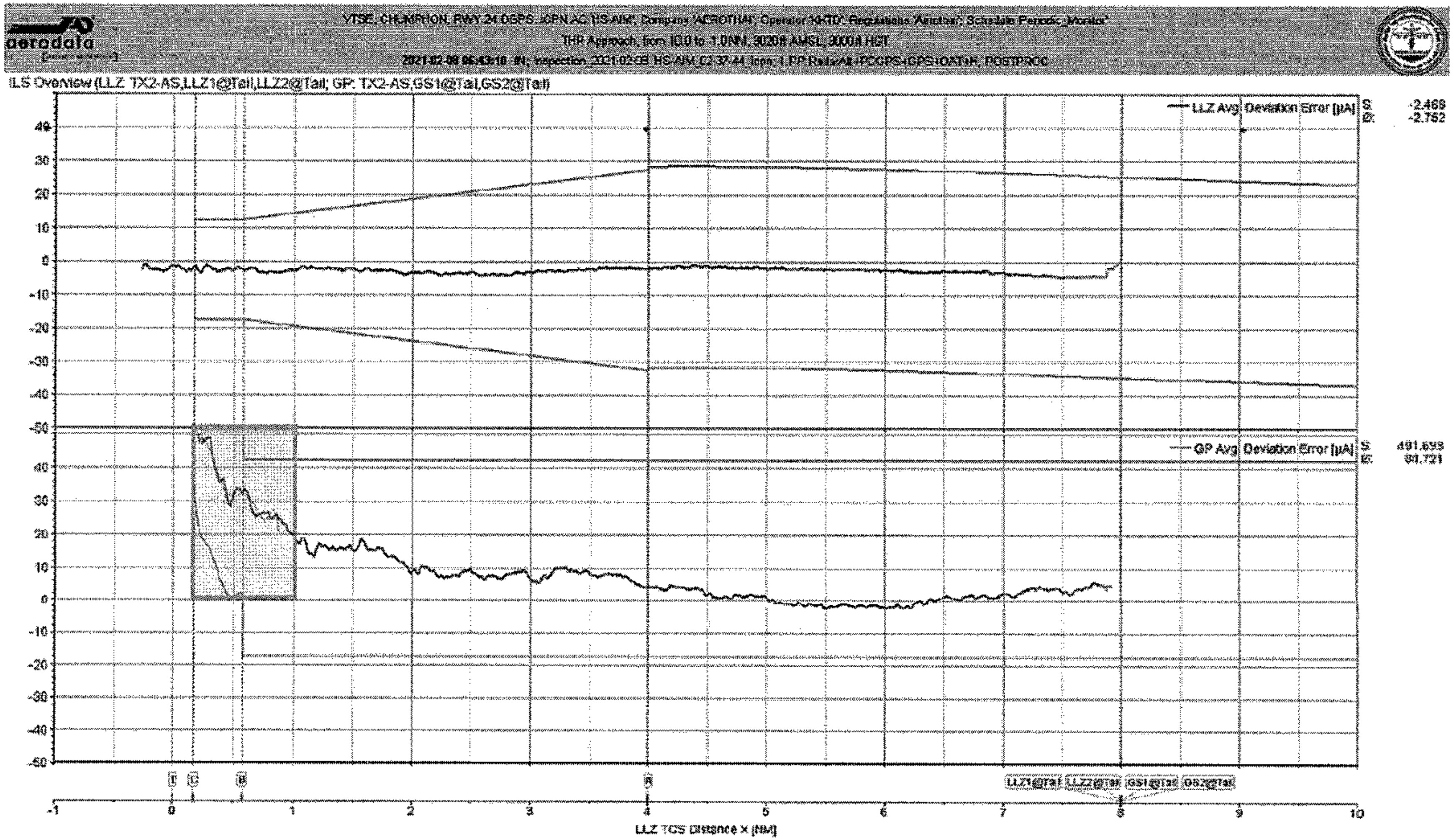


Fig. 2.1.2 – ILS/GP RWY 24 THR APPROACH, FROM 10 NM to THR, 3020ft AMSL / 3000ft HGT, absence of the fence

2.2 CASE II

- Fig. 2.2.1 shows the terrain at Chumphon Airport, taking into account the presence of the perimeter fence.
- Fig. 2.2.2 presents the results of the Glide Slope Average Deviation Error [μA] from a flight inspection conducted during the THR Approach procedure, covering the range from 10 NM to Threshold, at 3020 ft AMSL and 3000 ft HGT, considering the existence of the fence.

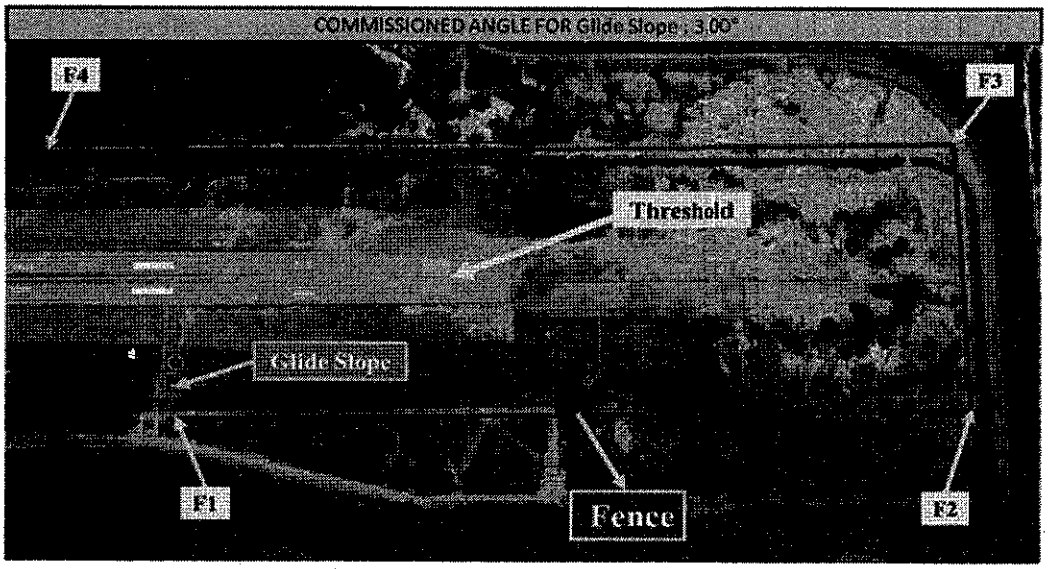


Fig. 2.2.1 - Terrain at Chumphon Airport, showing the presence of the fence.

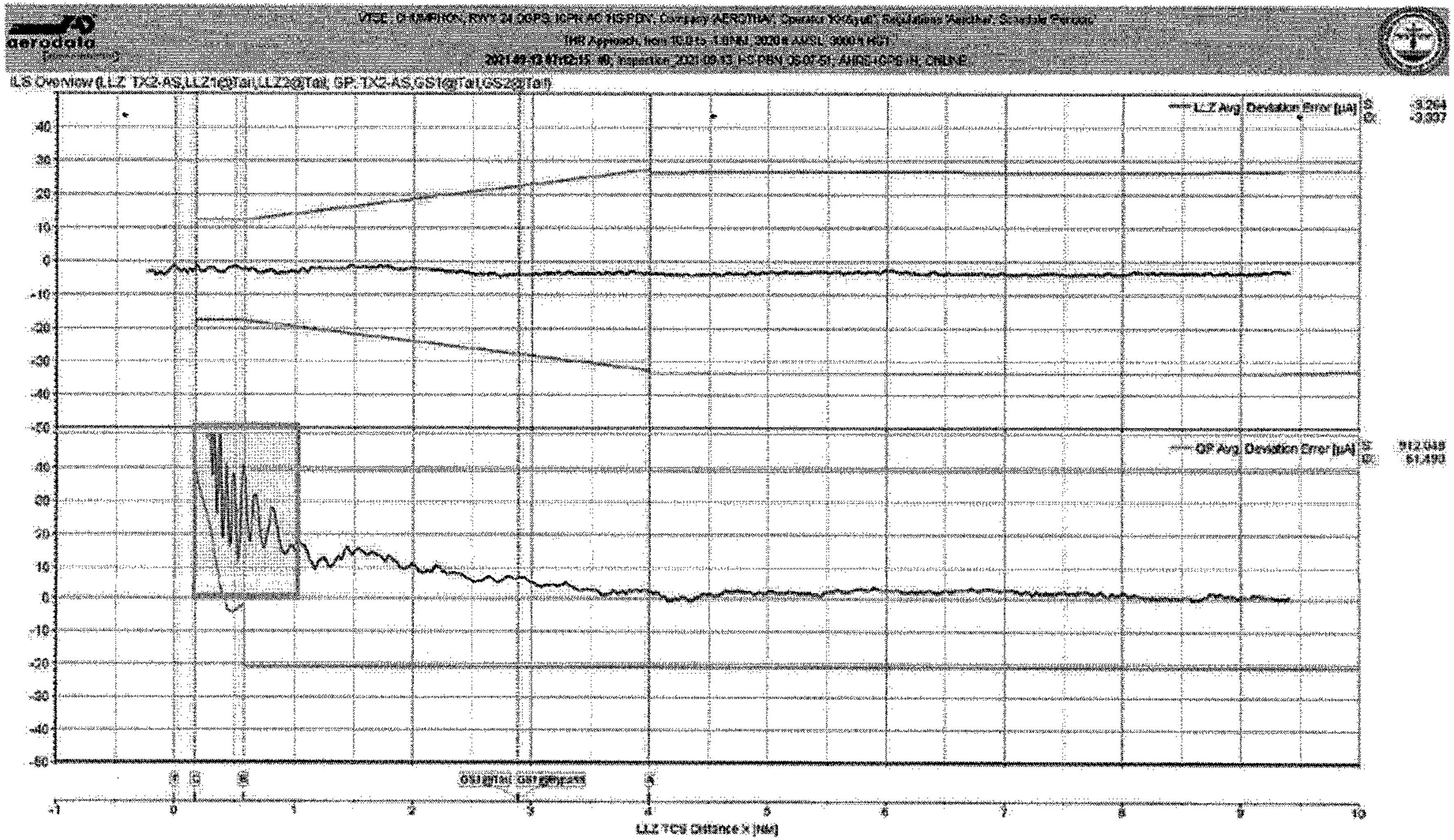
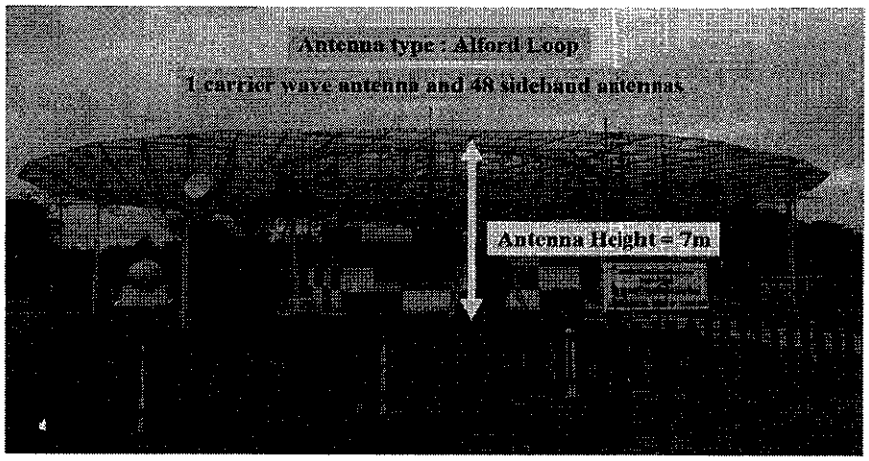


Fig. 2.2.2 – ILS/GP RWY 24 THR APPROACH, FROM 10 NM to THR, 3020ft AMSL / 3000ft HGT, existence of the fence

EXAMPLE 3: DVOR at Udon Thani International Airport



1. Modelling Description

1.1 DVOR System

- Table 1.1.1 presents the relevant data on the DVOR system.

Latitude and Longitude :	17°23'5.16"N, 102°46'29.78"E
Equipment model :	MOPIENS MARU 220
Antenna Types :	Alford Loop
Antenna height :	7 m
Number of Antenna :	Carrier : 1 Antenna Sideband : 48 Antennas
Frequency :	114.3 MHz
Radiated Power :	50 Watts

Table 1.1.1 – DVOR system at Udon Thani International Airport

1.2 Obstacle

The obstacles are water tanks constructed near the DVOR station.

- Fig. 1.2.1 presents the physical characteristics of the water tank.
- Table 1.2.1 shows the position of the water tank located near the DVOR station.

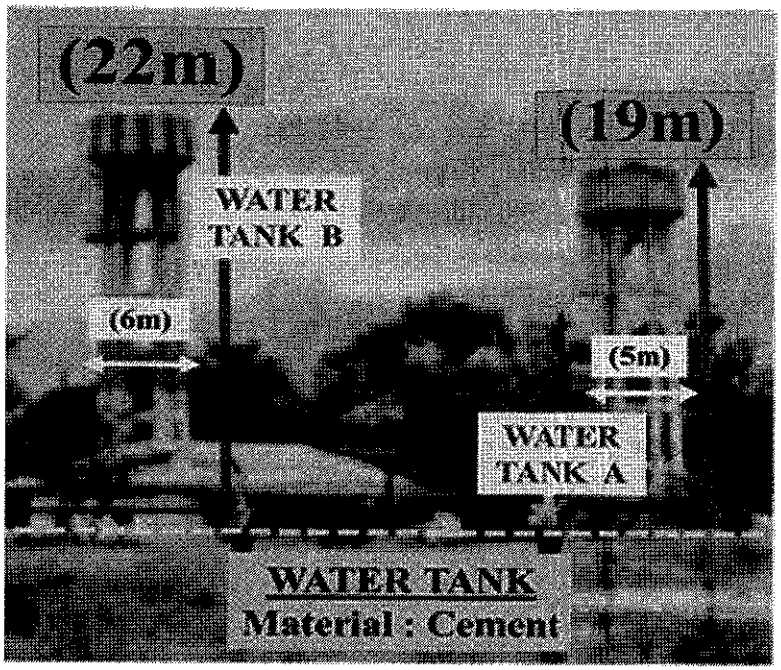


Fig. 1.2.1 – Characteristics of the water tank

Obstacle : Water Tank	Latitude and Longitude
A	17°23'6.31"N, 102°46'24.67"E
B	17°23'5.43"N, 102°46'24.97"E

Table 1.2.1 – Position of the Water Tank

2. Flight Inspection Report

2.1 CASE I

- Figures 2.1.1 and 2.1.2 show the details and the location of Water Tank A in relation to the DVOR station, including distance and orientation.
- Fig. 2.1.3 presents the results of the DVOR azimuth error (in degrees) from a flight inspection conducted during the orbit procedure, covering 8 NM CCW at 3,000 ft AMSL and 2,382 ft HGT, considering the existence of Tank A.

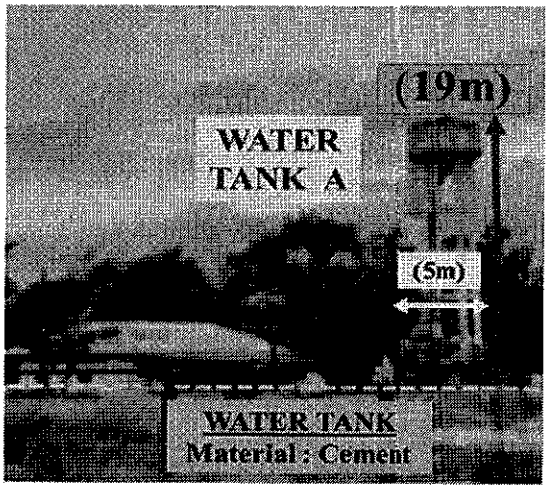


Fig. 2.1.1 - Water Tank A

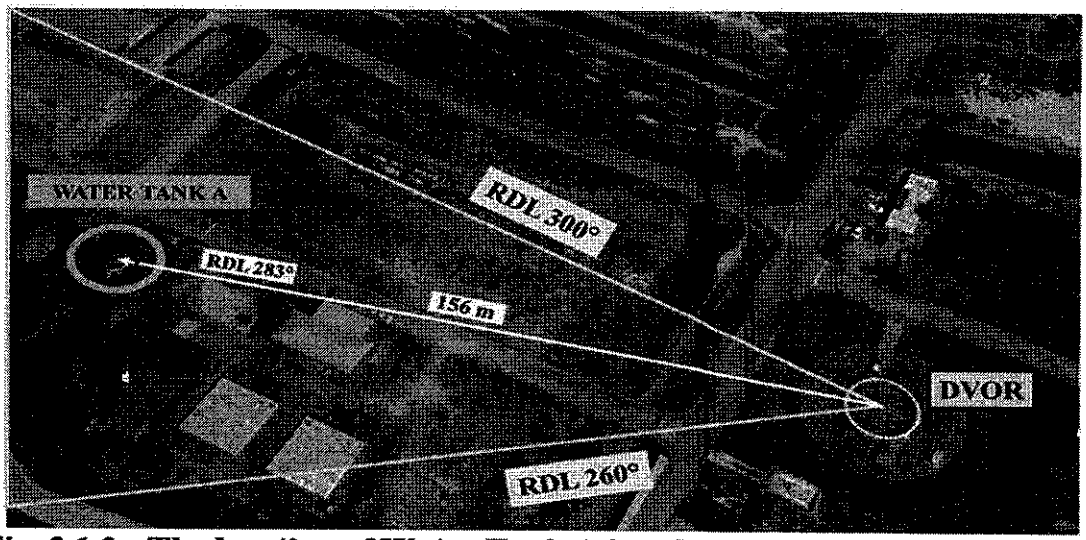


Fig. 2.1.2 - The location of Water Tank A in relation to the DVOR station, including distance and orientation

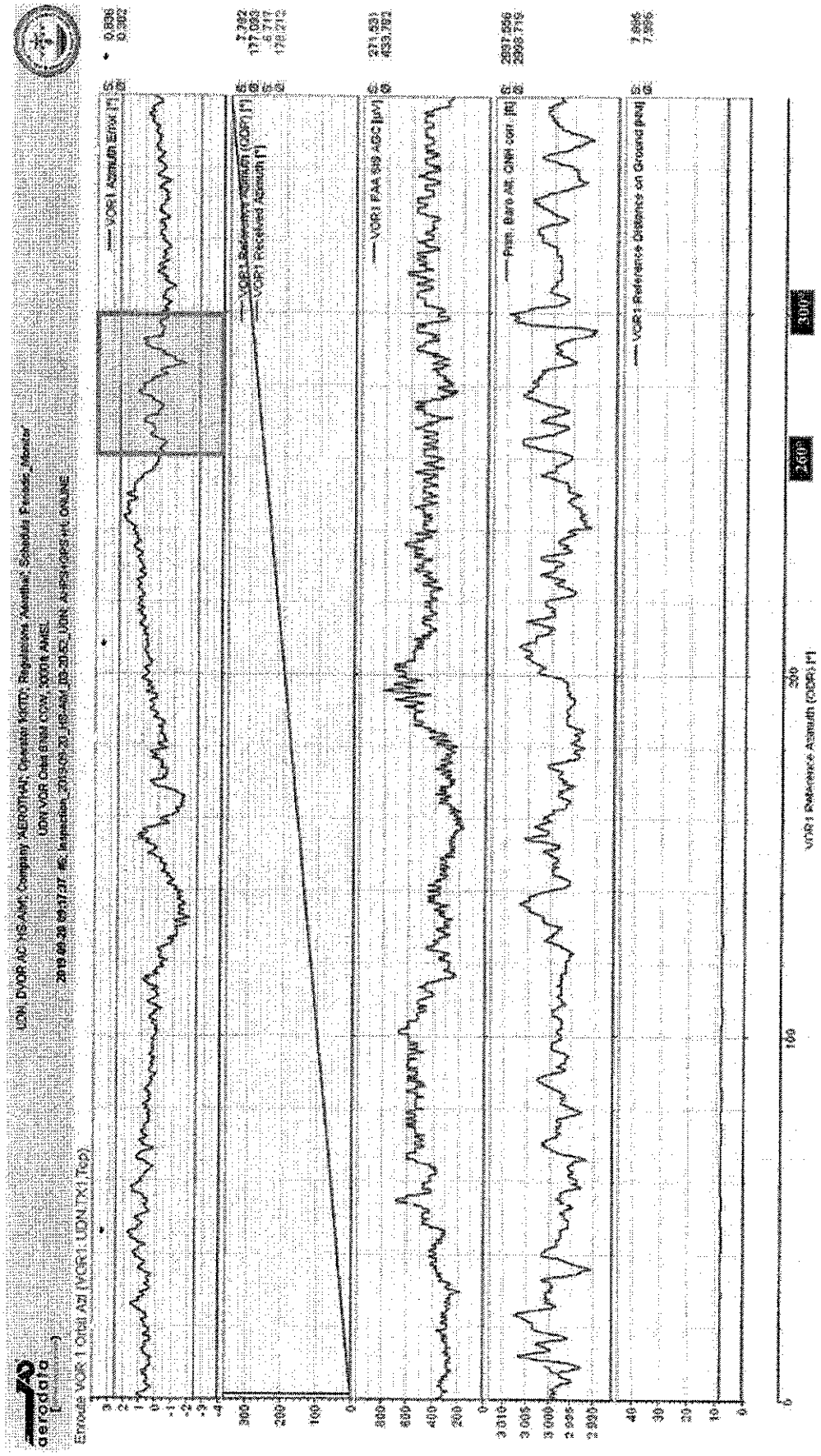


Fig. 2.1.3 – DVOR orbit, 8 NM CCW at 3,000 ft AMSL / 2,382 ft HGT, considering the existence of Water Tank A

2.2 CASE II

- Figures 2.2.1 and 2.2.2 show the details and locations of Water Tanks A and B in relation to the DVOR station, including distances and orientations.
- Fig. 2.2.3 presents the results of the DVOR azimuth error (in degrees) from a flight inspection conducted during the orbit procedure, covering 8 NM CCW at 3,000 ft AMSL and 2,382 ft HGT, considering the existence of Tanks A and B.

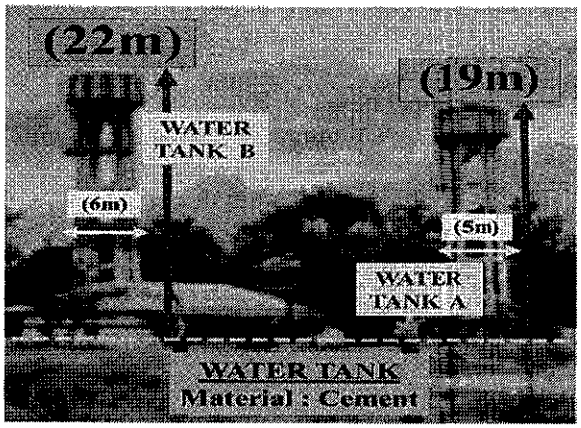


Fig. 2.2.1 - Water Tank A and B

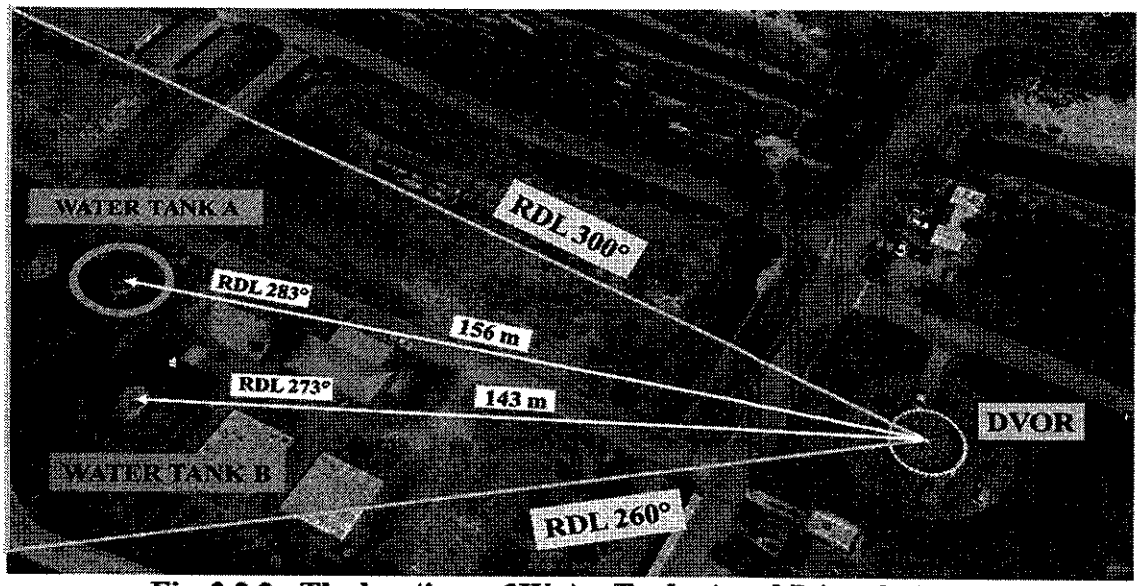


Fig. 2.2.2 - The locations of Water Tanks A and B in relation to the DVOR station, including distances and orientations

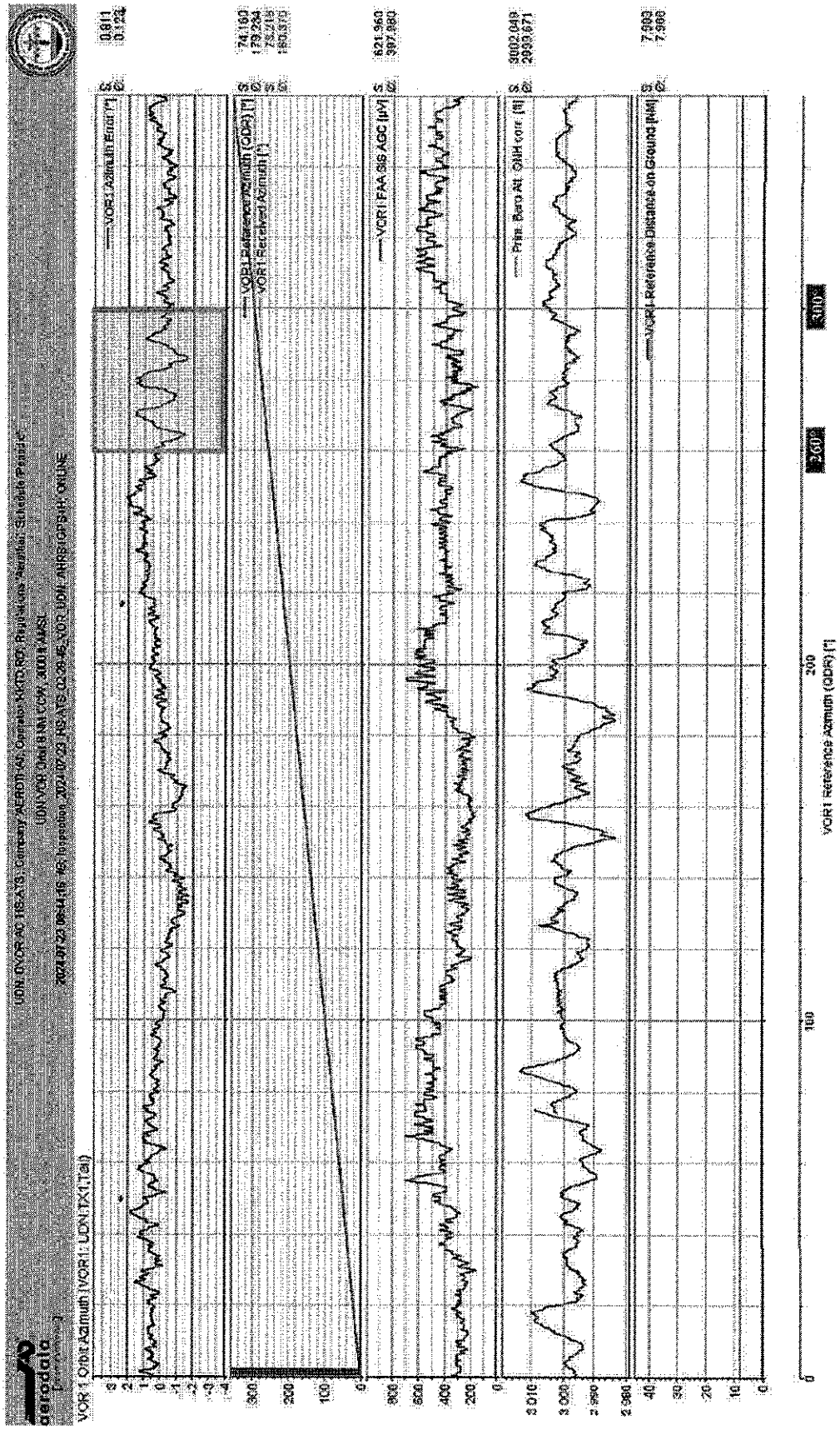


Fig. 2.2.3 – DVOR orbit, 8 NM CCW at 3,000 ft AMSL / 2,382 ft HGT, considering the existence of Water Tanks A and B

Appendix B:

Technical Specifications for Notebook Computer (Laptop)

Minimum Technical Specifications

1. **Central Processing Unit (CPU):**

- The CPU shall have a minimum of 4 physical cores and 8 logical threads.
- The CPU shall include integrated cache memory of at least 8 MB, at the same cache level.

2. **Main Memory (RAM):**

- The main memory (RAM) shall be DDR4 or newer, with a minimum capacity of 8 GB.

3. **Storage Drive:**

The storage device shall be one of the following:

- A SATA hard disk drive (HDD) or better, with a minimum capacity of 1 TB; or
- A Solid-State Drive (SSD) with a minimum capacity of 250 GB.

4. **Display Screen:**

- A display screen shall support a resolution of at least 1,366 x 768 pixels and have a screen size of not less than 12 inches.

5. **Interface Ports:**

- At least three (3) USB ports (version 2.0 or higher).
- At least one (1) HDMI

6. **Network Interface:**

- At least one (1) network interface port supporting 10/100/1000 Base-T or better.
- The device shall support wireless connectivity of no less than Wi-Fi (IEEE 802.11 ax) and Bluetooth.

7. **Additional Conditions:**

- All items must be brand-new, unused, and not refurbished.
- The product must come with a minimum 1-year warranty.