Pre-Flight Check NAV Aids System Using UAV

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ABSTRACT

Flight inspection aircraft perform inspections of airport navigation and visual aid systems are required to perform special procedures that require long flights at low and high levels and perform maneuvers that are specific to flight inspections.

All of these flight procedures have unique features for each navigation or visual aid system, which poses a risk of increased pressure on the aircraft and the globe.

Preparation of airport navigation and visual aid systems for flight inspection by ATSEP & AGL expert personnel are performed using ground measuring devices. This puts the navigation and visual aid systems of the airports in a position where they have the least changes during the flight inspection.

Due to these conditions and the serious need to increase flight safety and reduce potential flight hazards, in addition to the use of past ground check methods, to increase the level of quality and accuracy and standards of measurement, the use of UAVs is recommended, which has been growing for several years. And occasional use in different countries, including Iran.

In this article, we will deal with the method of pre-flight inspection by UAV and compare its results with the results of flight inspection aircraft.

INTRODUCTION

In the name of God.

Flight inspection aircraft perform inspections of airport navigation and visual aid systems are required to perform special procedures that require long flights at low and high levels and perform maneuvers that are specific to flight inspections.

All of these flight procedures have unique features for each navigation or visual aid system, which poses a risk of increased pressure on the aircraft and the globe.

Several different factors that increase the potential hazards to the flight inspection aircraft and the health of the spherical flight include the following:

1. Air Traffic and Fatigue Due to Long Flight (Crash of the Flight Inspection Plane in 2019 in Dubai).

2. Unfavorable weather conditions

3. Special inspection maneuvers at the lowest levels

4- Topographic conditions of flight inspection area

The United States Federal Aviation Administration has been conducting night flight inspection operations since the mid 1960's. Conducting flight inspection missions at night has become necessary due to the increase of commercial air traffic at some of the nation's busiest airports. The stated reason for night flight inspection initiatives is to lessen the congestion at busy airports, and might initially be perceived as an enhancement to safety. However, there is a major negative impact on the flight crews involved, and that impact must be considered. Changes in circadian rhythms lead to sleep deprivation and fatigue. Certain flight inspection operations, which require maneuvering the aircraft in close proximity to the ground, cannot be safely conducted at night and must then be coordinated for daylight conditions. This raises new crew, support, and equipment concerns. [1]

All of these and other factors can, at a specific time and place, create conditions that seriously jeopardize flight safety and the health of the flight inspection sphere. Most of these potential flight hazards during flight inspection operations, pose a serious risk to the safety and health of the flight inspection sphere, in addition to the many factors and solutions available to minimize these potential hazards, the preparation of navigation assistance systems and Visual airports are in the best condition before flight inspection operations.

Preparation of airport navigation and visual aid systems for flight inspection by ATSEP & AGL expert personnel are performed using ground measuring devices. This puts the navigation and visual aid systems of the airports in a position where they have the least changes during the flight inspection.

However, due to the propagation of navigation and visual signals in space and the impossibility of measuring them properly, this method can have little effect on reducing flight inspection operations.

Factors that can be mentioned in reducing the impact of ground measurement at close range can be asphalt runway - runway slope - ground and topographic conditions - how to install equipment - physical conditions of the land and installation site, etc. that can be They cause undesirable propagation of signals of navigation and visual assistance systems and are not visible and measurable.

Due to these conditions and the serious need to increase flight safety and reduce potential flight hazards, in addition to the use of past ground check methods, to increase the level of quality and accuracy and standards of measurement, the use of UAVs is recommended, which has been growing for several years. And occasional use in different countries, including Iran.

Due to its special sensitivities, this new method can be used by a trained flight inspection sphere as a flight inspection unit to place airport navigation and visual assistance systems in the best conditions to reduce flight inspection operations and reduce potential hazards.

In this article, we will discuss the method and tests performed by the UAV and compare its results with the results of the inspection aircraft.

UAVs with their unique features can help a lot in navigation and visual aid systems in space to conduct inspection operations.

Preparation of the drone for pre-inspection of the navigation and visual assistance systems of the airports was done by purchasing the necessary equipment, measuring and programming the software for analyzing the signals for the navigation aid systems, and lighting for the PAPI lights in space according to the flight inspection results. And caused us to test this method at different airports and compare it with the results of the inspection aircraft, which we will discuss below.

UAVs are divided into two categories: fixed wings and multi-rotor. In this method, we used a multi-rotor or vertical flight drone due to its special features, such as staying fixed anywhere in space, which makes it non-interfering. In airport air traffic and special UAV flight coordination, flight pre-inspection operations have the shortest time to make possible adjustments to airport navigation and visual assistance systems.

UAV EQUIPMENT

This drone is equipped with a signal receiver analyzer for ILS / DVOR navigation aid systems from KAVICS South Korea, whose user software has been programmed by an Iranian team.

In all tests performed by the UAV, the RTK (Base & Rover) system has been used to generate reference data.

Figure (1) shows the accuracy of the coordinates and measurement references of the method using UAV and RTK and Analyzer were verified using a theodolite camera and the obtained values were equal.

Figure 1. RTK Method Test by Theodolite

All the output values of the analyzer are sent by radio data link to the receiver connected to the operator’s computer to analyze the received data and display the graph of the values.

In the flight pre-inspection software, the reference points of each airport must be defined, which are the same reference points listed in the panel of the inspection aircraft.

MEASUREMENT METHODS

First, we measure by the vertical flight drone, and then we compare the results of the flight pre-inspection using the drone and the flight inspection results by the aircraft. Due to the many challenges of the ILS system and PAPI lights, we will address these issues in this article.

GP Width measurement method:

Flight Inspection aircraft: Fly level run from a distance of 12nm at an altitude of 1000 ft to the runway and cut width and obtain Low / Hi Width & Angle values.

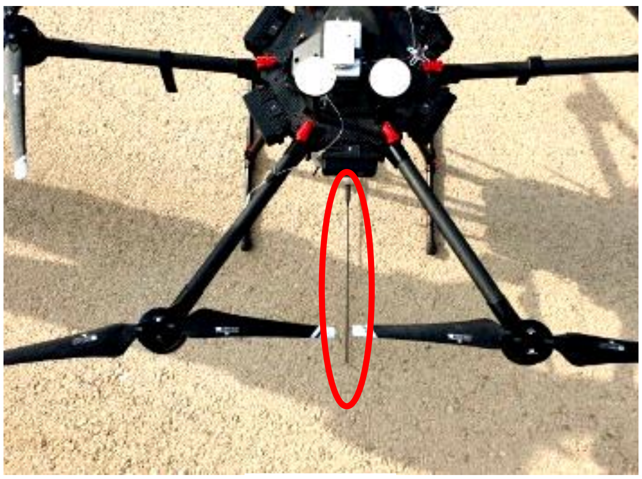
Pre-inspection UAV: Fly vertically further away from the Inner Marker and cut Width and obtain Low / Hi Width & Angle values.

<u>GP measurement method:</u>

Flight Inspection aircraft: Flight on the GP slope from a distance of 8 nm from an altitude of 2500 ft and intercept the route from point A to point THR and obtain the GP slope angle.

Pre-inspection UAV: Fly vertically further away from the Inner Marker and stay at RAW DDM = 0.00 for a few minutes to intercept and obtain the GP tilt angle.

A particular challenge is to separate the desired ILS/VOR signal-in-space from near field effects generated by the UAS itself. [2]. In measuring the signal of the GP navigation aid system by the UAV, due to the 90Hz noises of the engine propellers [3], the graph obtained from the values was very cluttered and unreliable. For LOC navigation has no effect and does not cause a problem. One way to eliminate this noise in the GP navigation aid system is to use wooden propellers. Another way to remove this noise is to use the antenna positioning method, in Figure1, by installing the antenna between the two propellers, the amount of DDM fluctuations reached its lowest value, and in Figure2, by installing the antenna under the propellers, severe DDM fluctuations you see that it is caused by 90Hz noise.



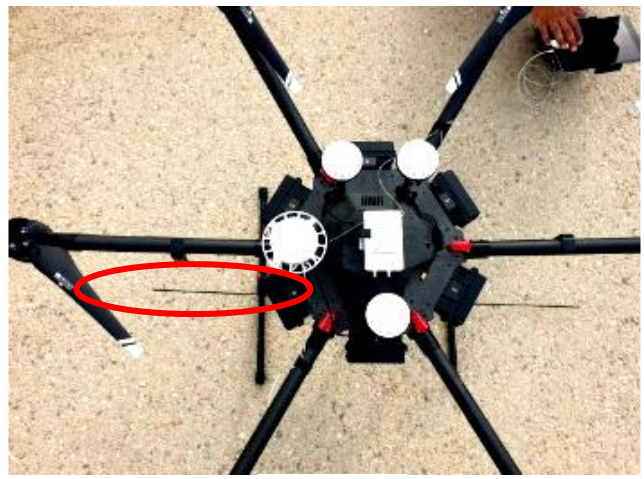


Figure1 **Figure2**

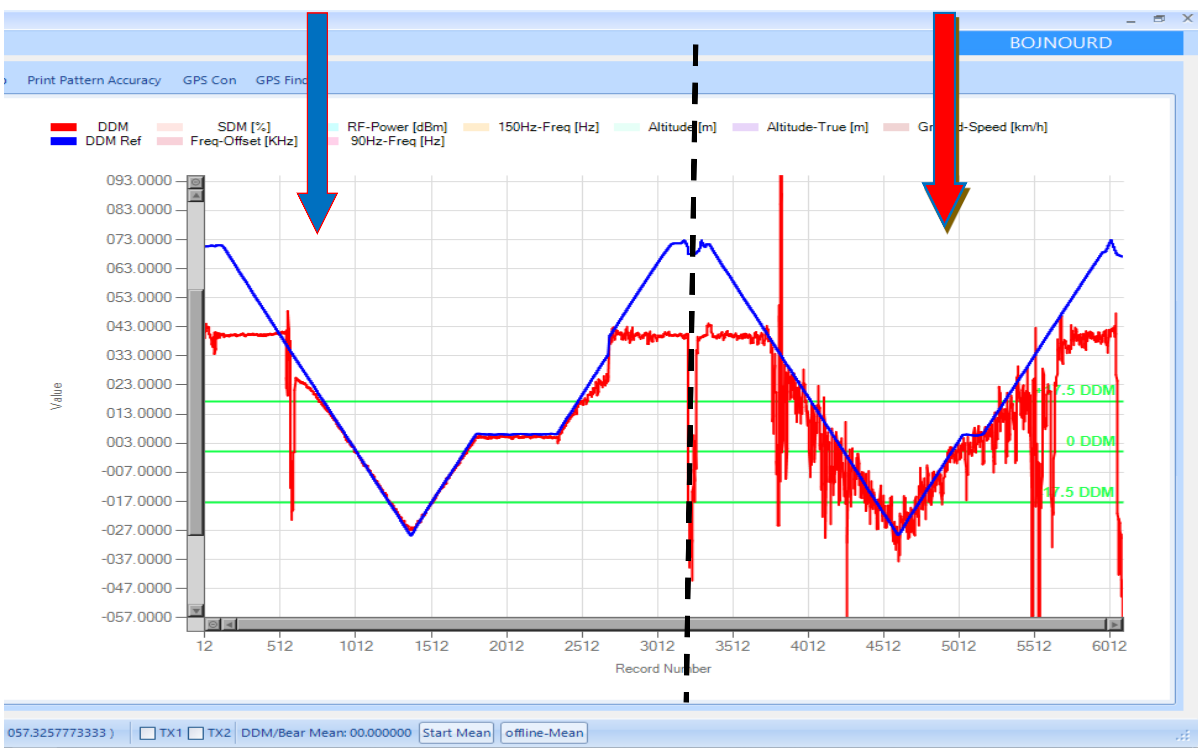


Figure 3. Red Line is RAW DDM – Blue Line is Reference DDM

LOC Width measurement method:

Flight Inspection aircraft: 40 degrees Arc flight at an altitude of 1500 ft at a distance of about 6nm from the LOC antennas and cut Width and obtain Left / Right Width & Center Line values.

Pre-inspection UAV: Transverse flight at an altitude of more than 50 m in the THR range and cut Width and obtain Left / Right Width & Center Line values.

LOC Center measurement method:

Flight Inspection aircraft: Flying from a distance of about 8nm at an altitude of 2500 ft in the center of LOC antennas and obtaining the average Center error value.

Pre-inspection UAV: Flying at an altitude of 50m from the THR range and staying at Reference DDM = 0.00 for a few minutes to intercept and obtain the Center error.

Bearing DVOR measurement method:

Pre-inspection UAV: Circular flight from the center of DVOR at a distance of 500m and a height of 50m and obtaining Bearing error.

Tilt measurement of PAPI lights:

Flight Inspection aircraft:
1- Flying from a distance of 4nm and being on the slope of each PAPI light and obtaining the average slope of a light.
2- Flying from a distance of 5nm at an altitude 1000ft as a level run and getting the slope of all the lights.

Pre-inspection UAV:
Vertical flight at a distance of more than 400m from PAPI lights and check the slope of each light and adjust them by the camera and image processing online.

UAV TESTS AND COMPARISON WITH THE RESULTS OF THE INSPECTION AIRCRAFT:

PAPI lights:

In tests performed by the UAV, it was found that the measuring equipment of AGL specialists is not enough to perform the initial settings of PAPI lights, and various factors affect the angle of each light. All steps of measuring the angle of PAPI lights are done automatically and manually by image processing software.

Consider the two different airports below:

1- **Shohadaye Bojnourd Airport:**

Figure (4) the final image of measuring and adjusting PAPI lights by AGL experts using a clinometer before inspecting the UAV.

Figure (5) the final image of measuring and adjusting PAPI lights using a UAV.

3- **Payam Airport:**

Figure (6) the final image of measuring and adjusting PAPI lights by AGL experts using a clinometer before inspecting the UAV.

Figure (7) the final image of measuring and adjusting PAPI lights using a UAV.

Figure 4. Calibration by Clinometer before FLC

Figure 5. Calibration by Drone before FLC

Figure 6. Calibration by Clinometer before FLC

Figure 7. Calibration by Drone before FLC

In checking the papal lights of Chabahar airport, we noticed another problem that the pilot can't see of the inspection plane due to the long-distance during the inspection by the aircraft and also the predominance of white or red light, and that is the inconsistency of the internal lenses of each unit UAVs cause this problem due to the closer and zooming of the image on PAPI lights by the camera installed on the UAV can detect the difference between the lenses of each unit figure 8&9 and possible defects and angular settings of each PAPI light and Take the necessary measures to eliminate them before the flight inspection by the aircraft so that there is no problem in issuing a confirmation of the correct operation of the device.

Figure 8. PAPI A Light Error

Figure 9. PAPI B Light Error

MEASUREMENT ILS System by UAV & Aircraft

GP System:

Left Runway Tabriz Airport:

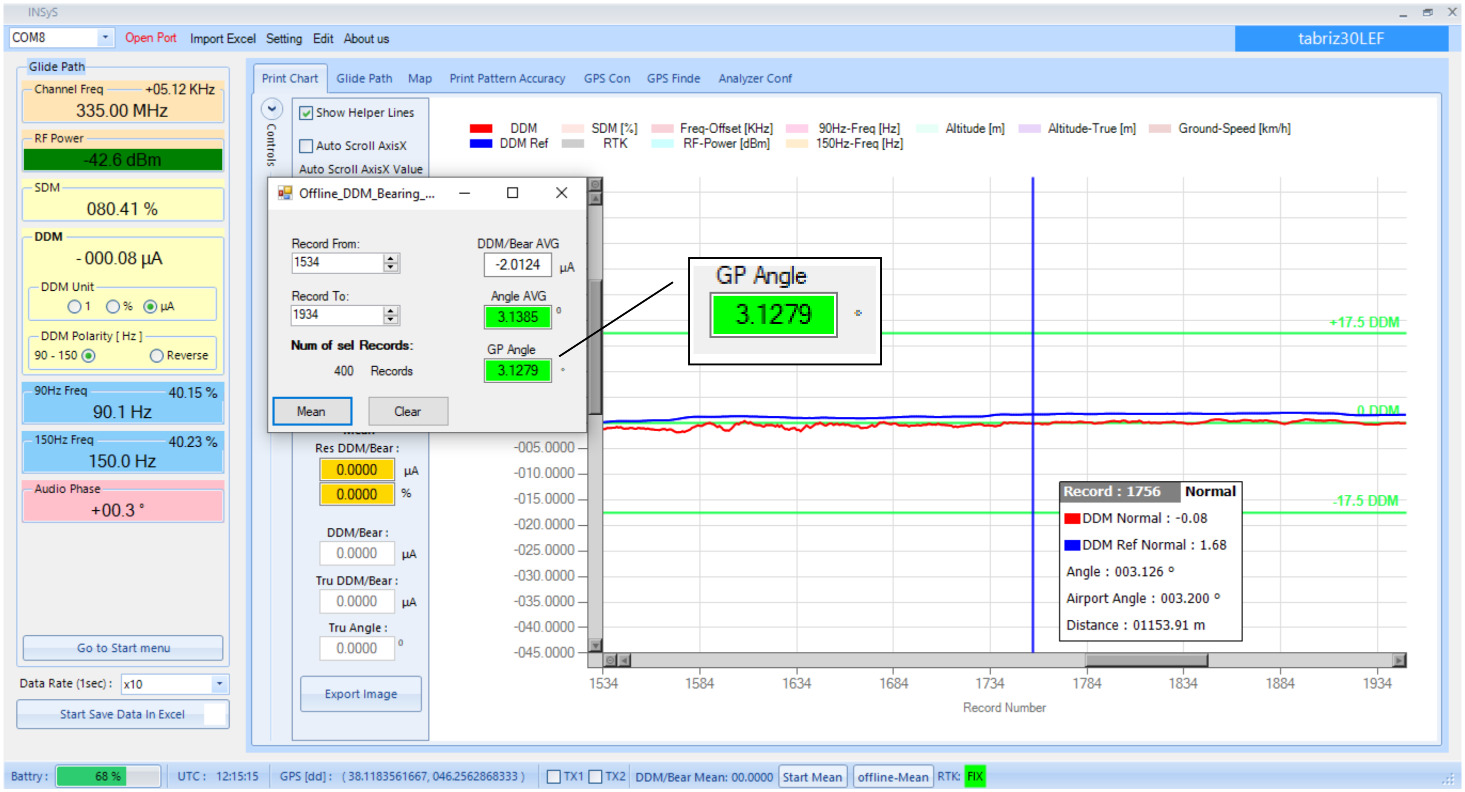


Figure 10. Left Runway Tabriz Airport – GP Angle AVG by Drone / Angle = 3.127°

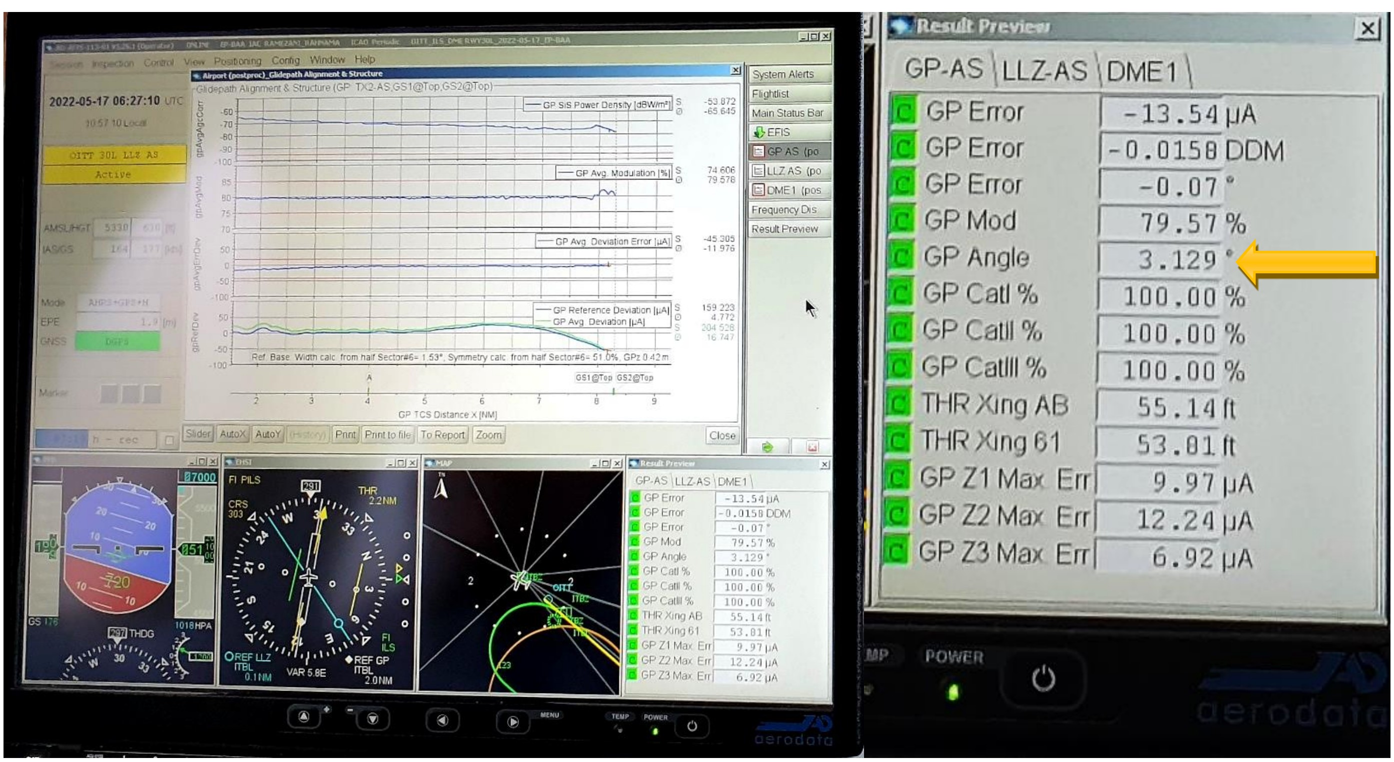


Figure 11. Left Runway Tabriz Airport – GP Angle AVG by Aircraft / Angle = 3.129°

Right Runway Tabriz Airport:

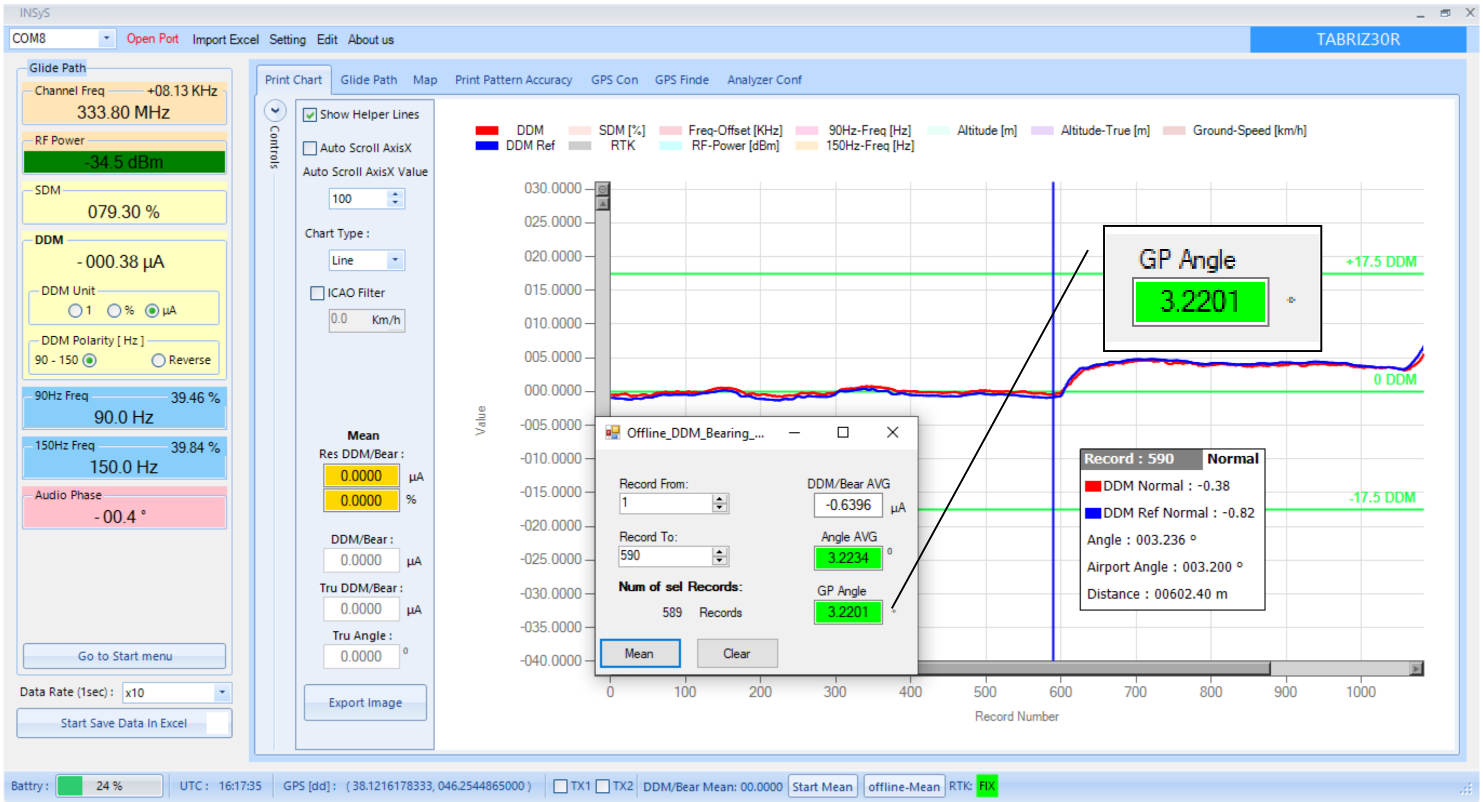


Figure 12. Right Runway Tabriz Airport – GP Angle AVG by Drone / Angle = 3.220°

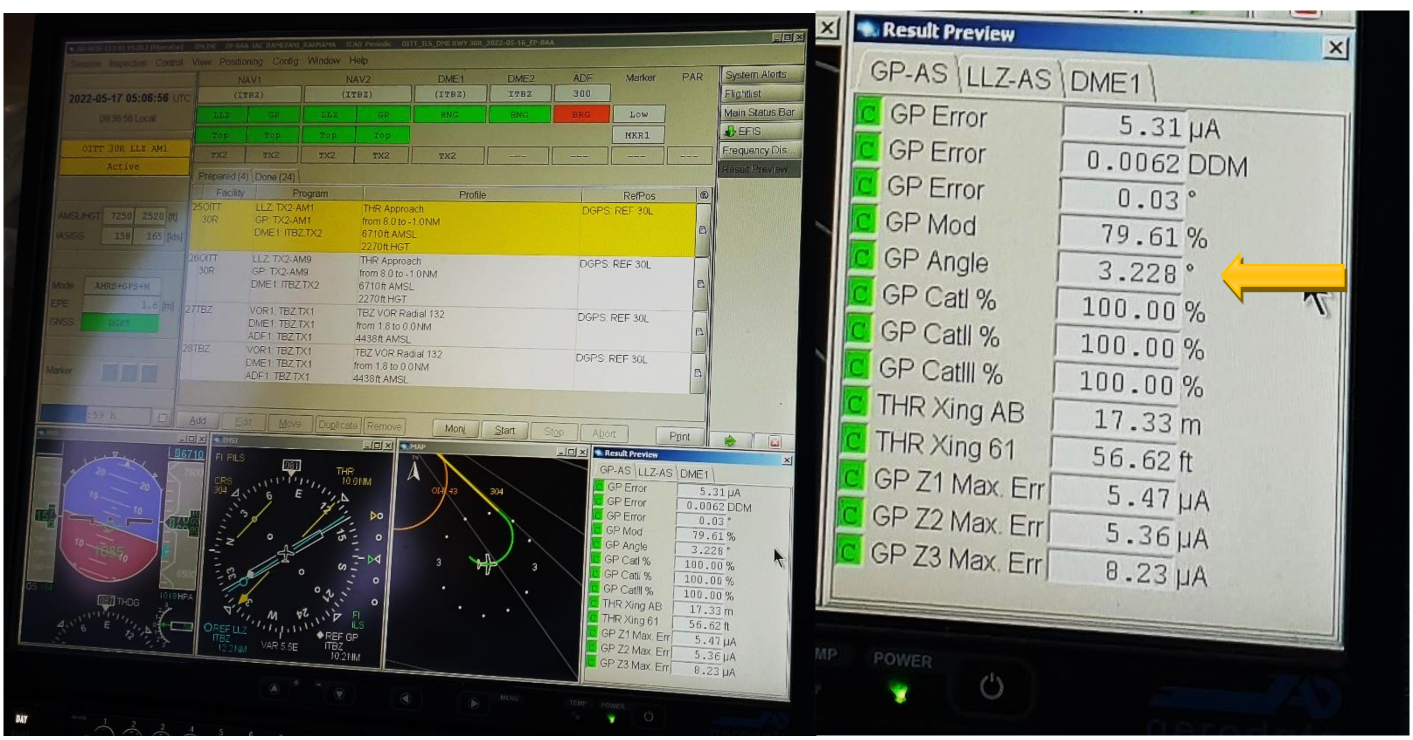


Figure 13. Right Runway Tabriz Airport – GP Angle AVG by Aircraft / Angle = 3.228°

LOC system:

Left Runway Tabriz Airport:

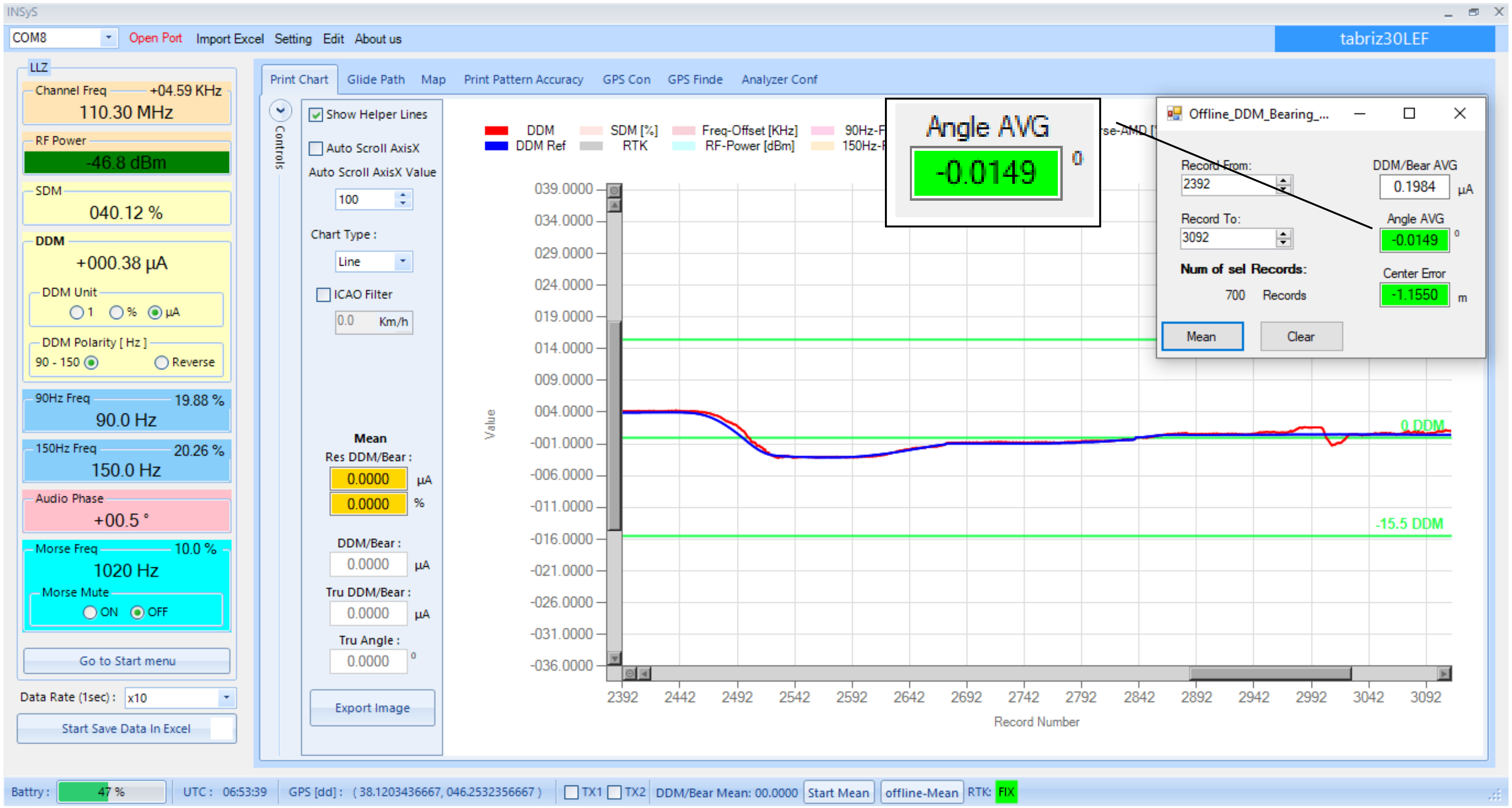


Figure 14. Left Runway Tabriz Airport – LOC Center AVG by Drone / Angle = -0.0149°

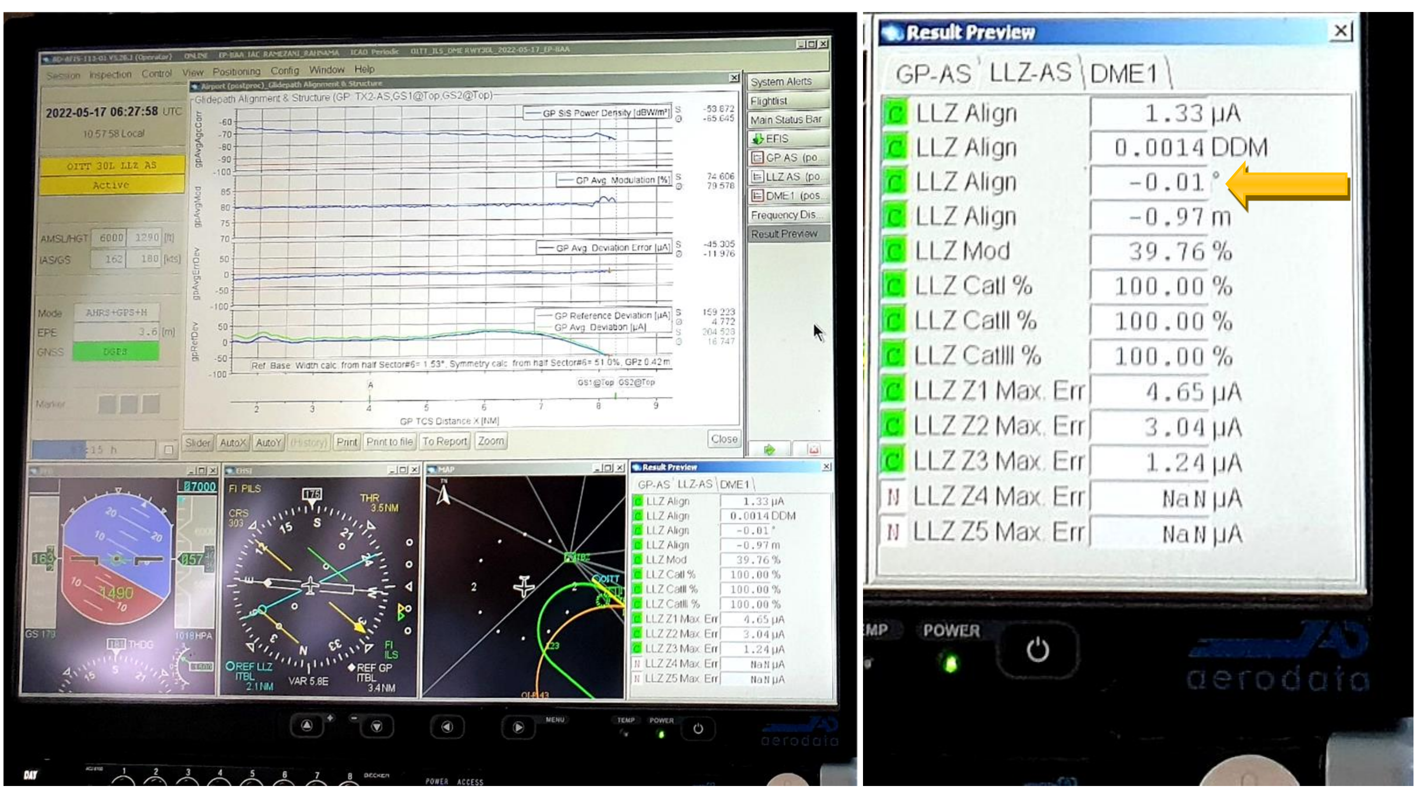


Figure 15. Left Runway Tabriz Airport – LOC Center AVG by Aircraft / Angle = -0.01°

Left Runway Tabriz Airport:

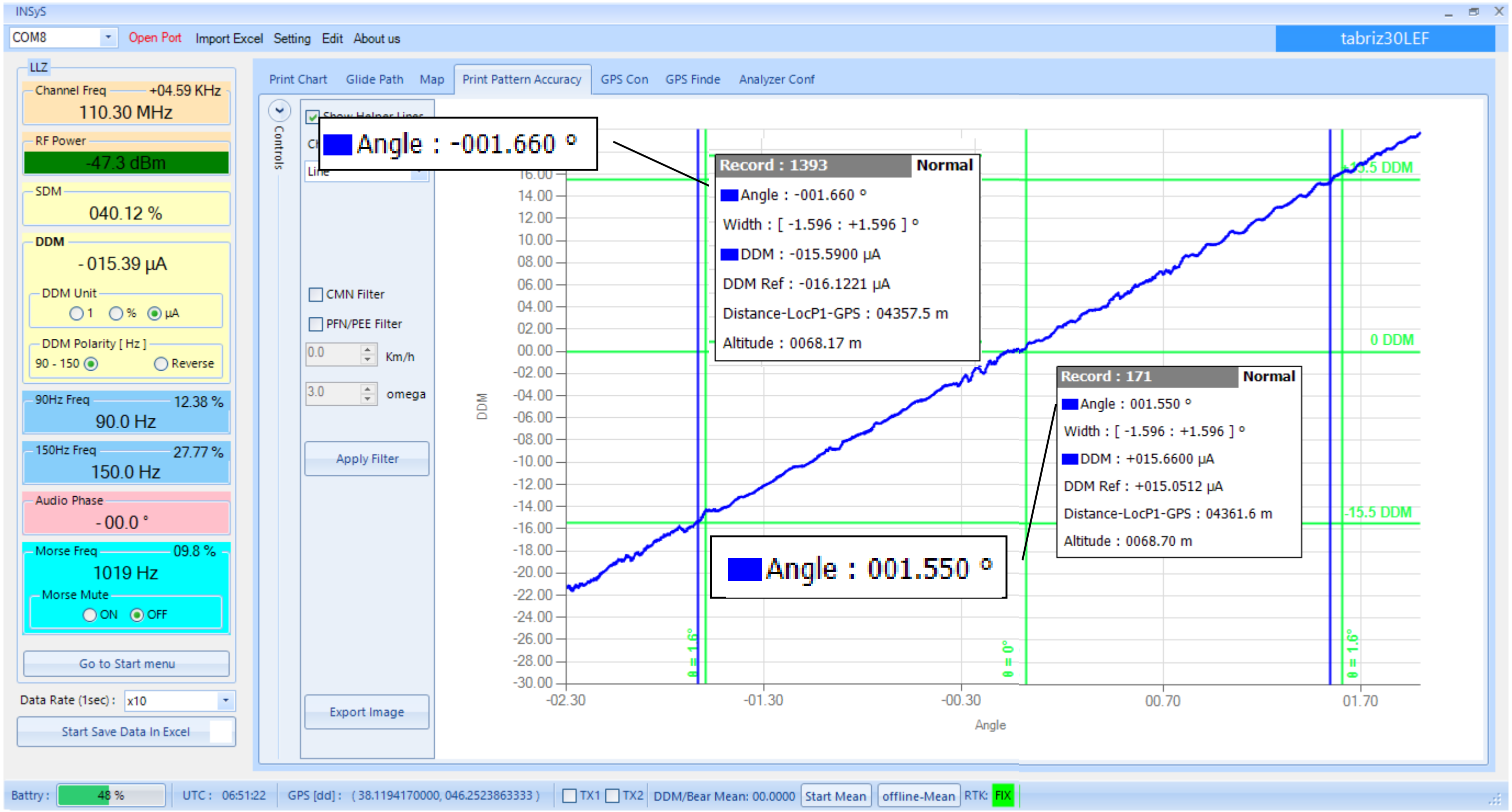


Figure 16. Left Runway Tabriz Airport – LOC Width by Drone / Width = 3.21°

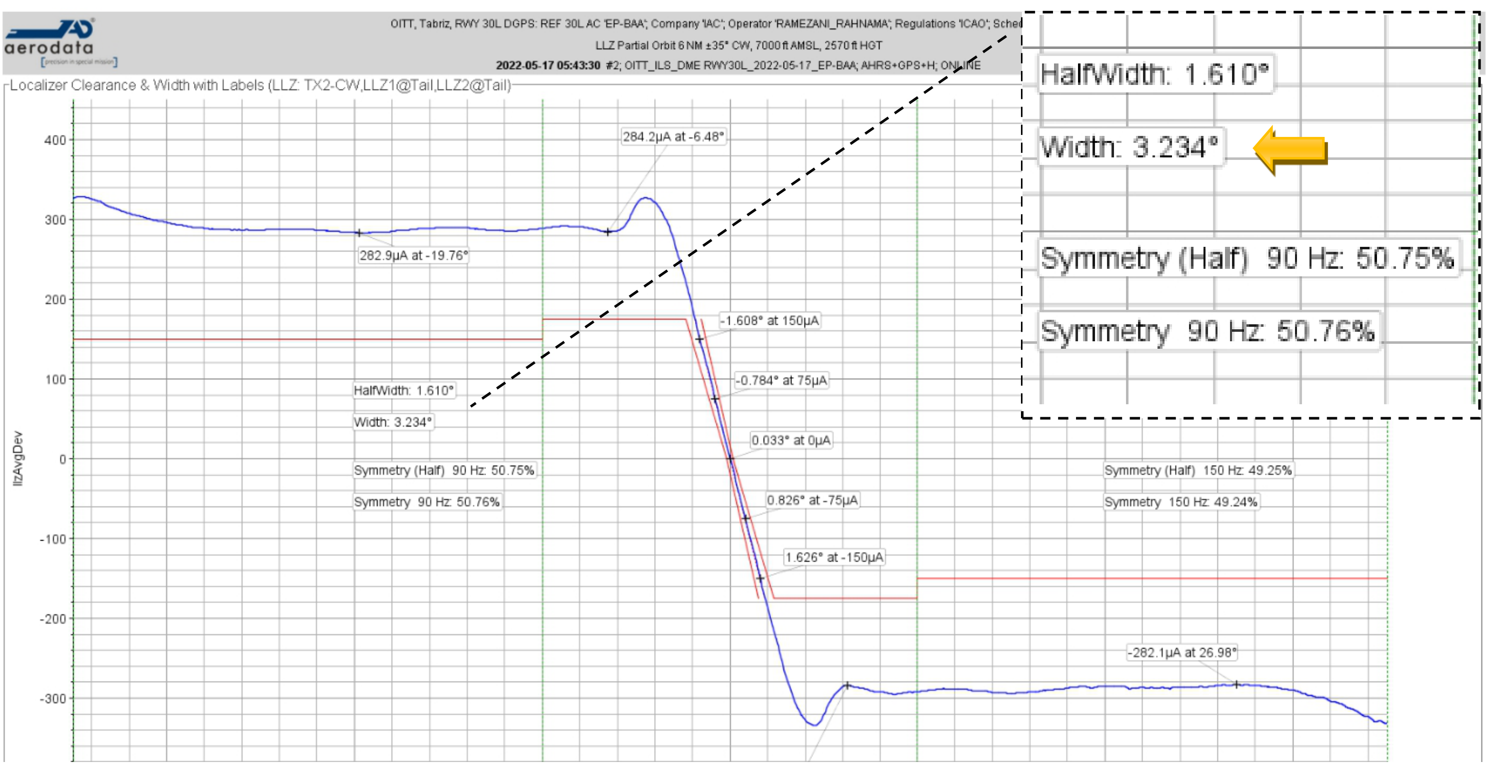


Figure 17. Left Runway Tabriz Airport – LOC Width by Aircraft / Width = 3.23°

CONCLUSIONS

All the results of the tests show that the accuracy of the UAV operation at close range is very close to the overall result measured by the inspection aircraft. Due to the growing use of UAVs, the flight inspection sphere can use UAVs to increase the Reference point accuracy

One of the things to consider in checking navigation aids and PAPI lights is to accurately measure the reference points of the navigation aids such as the exact coordinates of the center of the LLZ antennas or the exact coordinates of the GP point as well as the exact height in centimeters to calculate the GP or PAPI lights slope.

Because most checks are done with DRONE at close range and any small measurement error will cause the incorrect calculation of angles if such errors are completely negligible by flight inspection aircraft because most checks are performed at longer distances. And errors of a few tens of centimeters do not have a significant effect on the calculation of angles.

For example, in one case, a mistake of 80 cm in giving the antenna offset (antenna height) to the software caused a tenth of a degree in calculating the slope of the GP at a distance of 550 meters.

It can be seen that the check with the UAV at close range has subtleties that should not be overlooked. number of flight inspection courses for airports Nav aids systems in addition to aircraft flight inspections.

FUTURE WORK

Then, using fixed-wing drones, signal check of airport navigation assistance systems over long distances, and flight inspection aircraft procedures use this method to issue special approvals when necessary.

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