

A Decade of Operational Excellence in CNS Drone Inspection

From Multi-CNS and Radar Expansion to GNSS-Independent Operational Resilience

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BIOGRAPHIES

Hervé Demule, navigation engineer and senior project leader at Skyguide, is an engineering graduate of SUPAERO (Ecole Nationale Supérieure de l'Aéronautique et de l'Espace, Toulouse/France) and has accumulated extensive experience with ILS troubleshooting, commissioning and optimization. As project manager of many navaid replacements as well as with development and commercialization of a mobile bench for ILS measurements (ground and air) he has proven his great expert skill in these fields. On the educational side, he is also a certified instructor and a technical speaker. The Skyguide CNS Drone SkyRF® is one of his innovations.

Domien De Ruyck graduated from the Royal Military Academy in Brussels with an M.Sc. in Telecommunications. As Managing Director of Intersoft Electronics Services, channeling 40 years of experience in developing RF measurement equipment and Radar Analysis Support Systems (RASS), he is committed to provide the best support to their partners worldwide – to make the sky safer.

ABSTRACT

Ten years after its first successful tests and eight years after operational deployment for ILS inspection, the CNS Drone SkyRF® has evolved into a mature, autonomous and resilient multi-CNS inspection platform. Co-developed by Skyguide and Intersoft Electronics Services, the system now supports an expanded range of civil and military drone check use cases, building on a decade of operational experience.

At the core of the platform is the SkyRF® transceiver, enabling simultaneous, high-resolution measurements of ILS (LOC and GP), DME and Radar. The system has been extended to VOR/DME and TACAN, with TACAN fully integrated into Skyguide's DroneChecker software, enabling harmonized civil–military inspection workflows. Automated reporting is available for ILS/DME, VOR/DME, TACAN and PAPI measurements, delivering immediate, standardized outputs aligned with ICAO requirements.

In response to increasing GNSS vulnerability, the platform has been extended with optional GNSS-independent positioning capabilities, including terrestrial ultra-wideband-based solutions, aimed at improving operational robustness and continuity in constrained environments.

PAPI inspection has been added as a fully automated capability using optical sensing and image processing. All inspections are executed through predefined autonomous flight profiles with onboard data acquisition. From a system perspective, the platform is BVLOS-ready, enabling extended-range operations once regulatory approval is granted

CNS DRONE SKYRF

A 10 year system maturity

Co-developed by Skyguide and Intersoft Electronics Services, the system profits from both experiences in the domain of measurement techniques.

Skyguide: A 10 year experience in drone check

Following the first successful trials in 2015, Skyguide started using the CNS Drone for testing purposes in 2016 and deployed it operationally from 2018 onwards for routine ILS preventive maintenance. Over the past decade, the system has reached a high level of maturity and has evolved into a second-generation platform.

This operational experience has enabled continuous optimization of measurement methods, procedures, and system handling, with a strong focus on usability and versatility. The solution has been developed by users (Skyguide ANSP) for users (ANSPs, airports, and CNS maintenance organizations), directly benefiting from the day-to-day experience of navigation engineers and maintenance teams. Today, the system is routinely used (typically once or twice per week) by Skyguide maintenance teams across Switzerland.

Intersoft experience in RF measurement techniques

Intersoft Electronics brings more than 35 years of experience in RF measurement technologies, primarily through the development and global deployment of Radar Analysis Support Systems (RASS). These solutions are used by most major radar manufacturers worldwide.

In addition to RASS, Intersoft has extensive experience in CNS modernization projects, including PAR, PSR, and SSR systems, as well as in radar technology development. Although drone-based measurement solutions have emerged more recently, they build directly on this long-standing RF expertise. The same fundamental principles applied in ground-based RF transceivers are leveraged in the SkyRF airborne platform, ensuring high accuracy and reliability in drone-based measurements.

Business development

The ILS drone check concept has evolved from a national innovation into an internationally adopted operational solution. In addition to Switzerland, operational deployments have been realized in Belgium (Skeyes, from 2022 ; Belgian Air Force, from 2025), Germany (IE Luftfahrt und Service GmbH, from 2024), Latvia (LGS, from 2025), Bosnia and Herzegovina (BHANSA, from 2025), Poland (PANSA, from 2025), and Dubai (DANS, from 2025).

Beyond these operational implementations, numerous demonstrations and proof-of-concept activities have been successfully conducted worldwide. These include campaigns in Portugal (NAV), the United States (FAA and US Air Force), Spain (ENAIRES), Turkey (DHMI), Italy, France, Germany (DFS Academy and German Air Force), Belgium (Belgian Air Force), and Australia. The system has also been showcased at major international events such as Airspace World (Geneva 2023 and 2024, Lisbon 2025), demonstrating capabilities across ILS/DME, VOR/DME, and other CNS domains.

This growing international footprint confirms both the maturity of the technology and its relevance for a wide range of civil and military CNS stakeholders.

BVLOS ready (Behind visual line of sight)

Automatic Flights (Waypoint to Waypoint)

The selected drones are navigating automatically, based on a preconfigured waypoint flight that precisely follows a programmed path. While it is always possible for the pilot to take on manual control at any moment of the operation, the automation concerns all the phases of the flight, including take-off and landing. This makes the measurements process much easier and precise as repeatability is not affected by the human factor. Each specific navigation needs to be configured once and then stored in order to be loaded and repeated at will.

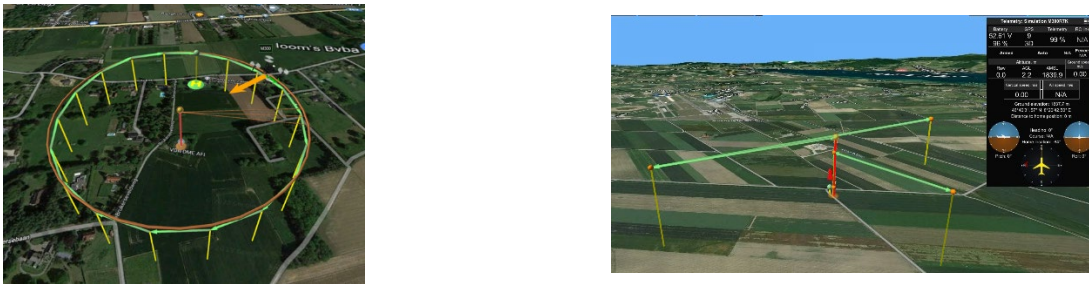


Figure 1. Illustrations of preconfigured waypoints in a general mission planning software

Autonomous measurements

The measurements are fully autonomous with autostart and stop function. Based on the location of the drone, the software automatically starts and stops the data measurement. As the ILS/DME and VOR/DME Drone Checker software are running on the processing PC aboard the drone, the system is fully autonomous and does not require any measurement datalink to the ground PC. The ground PC "only" enables to follow the sequence of measurements.

Live monitoring of measured data is available on the ground station (laptop or tablet) via a Wi-Fi or cellular data connection. The SkyRF device records the data, ensuring no data is lost if the connection to the ground station is interrupted. When the connection is restored, live streaming resumes seamlessly. This is a major technical evolution which would already enable to conduct BVLOS (Beyond Visual Line of Sight) flights. The limiting factor is no more the technical capability, it is currently the flight authorization. Technically, the CNS Drone SkyRF® is BVLOS ready.

Entering more and more into the flight check domain

Similar methods for ILS sector width measurements

In order to improve correlation with flight check, it is crucial to use the same measurement methods and to fly similar trajectories. For example, if the assessments of LOC sector widths are conducted during flight check orbits, then the same method of lateral orbits should be used by drone checks. This systematic correlation using these orbits has systematically been since 2018 in Switzerland. However, as illustrated below by Figure 2, if the assessments of the LOC and GP sector widths are conducted during flight check offset approaches, then one of the latest innovations consists in drone checking offset approaches as well:

- For the LOC sector widths: left and right offset approaches (offset by the value of the $\frac{1}{4}$ sector width)
- For the GP sector widths: below (at an elevation angle of 2.64°) and above (at 3.36°) for a 3° GP angle

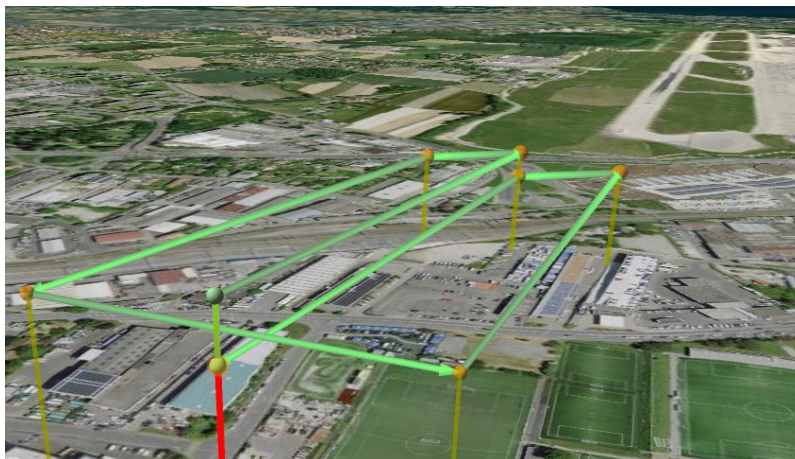


Figure 2. Illustration of offset approaches (below, above, left and right) for the assessments of the sector widths

Thanks to averaging calculations along the offset approaches, the quality and the repeatability of the assessments of the sector widths is of course better than "slice" measurements such as lateral orbits, vertical profiles or even level run for flight checks. Both figures 3 and 4 illustrate the offset approached measurements and their averaged results (nominally +/- 75 uA) for LOC and GP. These averaged drone check results can be compared and correlated with the corresponding ones from flight check.

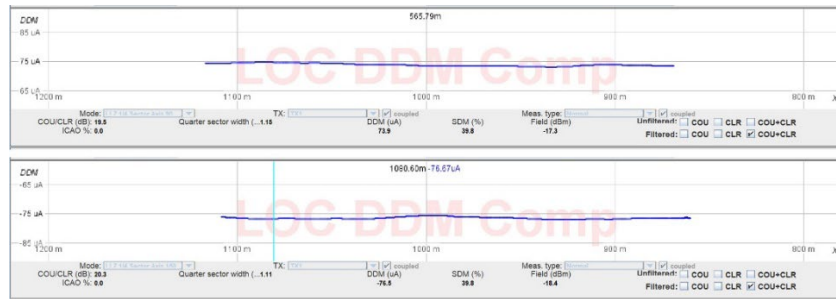


Figure 3. LOC ¼ sector widths measurements during left and right offset approaches (nominally +/- 75 uA)



Figure 4. GP ¼ sector widths measurements during below and above offset approaches (nominally +/- 75 uA)

Automatic reporting

The ILS DME Drone Checker and VOR DME Checker SW enable to automatically produce standard reports based on selected measurement campaigns: either a single one or several ones (the displayed results will be the averages of all selected measurement campaigns). As illustrated below by Figures 5 and 6, one of the innovations is that every parameter can be measured and assessed by one, two or even three different methods:

- Lateral Orbit, Mini Approach and Offset Mini Approach for Localizer
- Vertical Profile, Mini Approach and Offset Mini Approach for Glide Path
- Lateral Orbit, Vertical Profile and Mini Approach for DME

For every parameter, this new feature enables to compare the results produced by different drone check methods. Moreover, it also enables to specifically compare and establish correlation between similar methods of drone and flight checks, for example:

- LOC displacement error and sector widths measured either by drone check lateral orbit or flight check orbit
- GP displacement error and sector widths measured either by drone check vertical profile or flight check level run
- LOC and GP displacement errors measured either by drone check mini-approach or flight check approach
- LOC and GP sector widths measured either by drone check offset mini-approach or flight check offset approach

DME LSME22								
	PARAMETERS	TX	Vertical Profile	Lateral Orbit	Mini Approach	OPS Tolerances		
DME	DME ERROR	TX1	NM	NM	NM	-0.04 NM	0.04 NM	
	DME ERROR	TX2	0.00 NM	0.01 NM	0.00 NM	-0.04 NM	0.04 NM	
	DME REPLY RATE	TX1	%	%	%	70 %	100 %	
	DME REPLY RATE	TX2	86.9 %	77.0 %	72.9 %	70 %	100 %	

Figure 5. Illustration of automatic standard DME drone check reports (Comparison of three different methods)

LOCALIZER LSME22						
PARAMETERS	TX	Lateral Orbit	Mini App Relative	OPS Tolerances		
CENTRELINE	LOC COURSE STRUCTURE	TX1	NA %	100 %	95 %	100 %
		TX2	NA %	100 %	95 %	100 %
	DISPLACEMENT ERROR	TX1	0.1 uA	-0.5 uA	5.4 uA	-5.4 uA
		TX2	-2.1 uA	-0.7 uA	5.4 uA	-5.4 uA
	SDM	TX1	NA %	39.8 %	37.0 %	43.0 %
		TX2	NA %	39.8 %	37.0 %	43.0 %
	COURSE / CLERANCE RATIO ON CENTERLINE	TX1	NA dB	22.3 dB	10 dB	40 dB
		TX2	NA dB	22.3 dB	10 dB	40 dB
COURSE ALARM 90 Hz	TX2	uA	7.2 uA	10.9 uA	-10.9 uA	
COURSE ALARM 150 Hz	TX2	uA	-6.5 uA	10.9 uA	-10.9 uA	
WIDTH SECTOR 90 Hz (+)	1/4 WIDTH SECTOR 90 Hz	TX1	73.7 uA	74.6 uA	65.4 uA	84.6 uA
		TX2	74.1 uA	74.5 uA	65.4 uA	84.6 uA
	SYMMETRY 90 Hz	TX1	51.0 %	NA %	40 %	60 %
		TX2	50.5 %	NA %	40 %	60 %
1/4 WIDTH SECTOR ALARM 90 Hz WIDE	TX2	69.6 uA	69.4 uA	65.4 uA	75.0 uA	
1/4 WIDTH SECTOR ALARM 90 Hz NARROW	TX2	82.1 uA	82.5 uA	84.6 uA	75.0 uA	
WIDTH SECTOR 150 Hz (-)	1/4 WIDTH SECTOR 150 Hz	TX1	-76.8 uA	-75.6 uA	-65.4 uA	-84.6 uA
		TX2	-75.6 uA	-75.7 uA	-65.4 uA	-84.6 uA
	SYMMETRY 150 Hz	TX1	49.0 %	NA %	40 %	60 %
		TX2	49.5 %	NA %	40 %	60 %
1/4 WIDTH SECTOR ALARM 150 Hz WIDE	TX2	-69.8 uA	-69.1 uA	-65.4 uA	-75.0 uA	
1/4 WIDTH SECTOR ALARM 150 Hz NARROW	TX2	-82.9 uA	-82.1 uA	-84.6 uA	-75.0 uA	
FREQUENCIES	COURSE	TX1	5.2 kHz	5.2 kHz	-10.0 kHz	10.0 kHz
		TX2	4.9 kHz	4.9 kHz	-10.0 kHz	10.0 kHz
	CLEARANCE	TX1	-4.9 kHz	-4.9 kHz	-10.0 kHz	10.0 kHz
		TX2	-5.1 kHz	-5.1 kHz	-10.0 kHz	10.0 kHz

GLIDE PATH LSME22						
PARAMETERS	TX	Vertical Profile	Mini App Relative	OPS Tolerances		
GLIDE PATH AXIS	PATH ANGLE	TX1	3.49 deg	3.50 deg	3.36 deg	3.64 deg
		TX2	3.52 deg	3.50 deg	3.36 deg	3.64 deg
	GP COURSE STRUCTURE	TX1	NA %	100 %	95 %	100 %
		TX2	NA %	100 %	95 %	100 %
	DISPLACEMENT ERROR	TX1	1.1 uA	-0.8 uA	35.2 uA	-35.2 uA
		TX2	-4.6 uA	0.2 uA	35.2 uA	-35.2 uA
	SDM	TX1	79.7 %	79.7 %	76.3 %	83.7 %
		TX2	79.7 %	79.6 %	76.3 %	83.7 %
	COURSE / CLERANCE RATIO ON CENTERLINE	TX1	NA dB	32.0 dB	10.0 dB	50.0 dB
		TX2	NA dB	32.0 dB	10.0 dB	50.0 dB
HEIGHT OF ILS REFERENCE DATUM	TX1	NA m	15.1 m	15 m	18 m	
	TX2	NA m	15.1 m	15 m	18 m	
COURSE ALARM 90 Hz (HIGH)	TX2	24.7 uA	24.3 uA	46.9 uA	0.0 uA	
COURSE ALARM 150 Hz (LOW)	TX2	-28.4 uA	-27.6 uA	-35.2 uA	0.0 uA	
WIDTH SECTOR 90 Hz (+)	1/4 WIDTH SECTOR 90 Hz	TX1	74.2 uA	78.0 uA	60.0 uA	87.5 uA
		TX2	75.7 uA	77.3 uA	60.0 uA	87.5 uA
	SYMMETRY 90 Hz	TX1	52.6 %	NA %	40.0 %	60.0 %
		TX2	51.3 %	NA %	40.0 %	60.0 %
1/4 WIDTH SECTOR ALARM 90 Hz WIDE	TX2	66.1 uA	66.3 uA	60.9 uA	75.0 uA	
1/4 WIDTH SECTOR ALARM 90 Hz NARROW	TX2	80.9 uA	82.0 uA	97.7 uA	75.0 uA	
WIDTH SECTOR 150 Hz (-)	1/4 WIDTH SECTOR 150 Hz	TX1	-82.5 uA	-80.3 uA	-60.0 uA	-87.5 uA
		TX2	-79.9 uA	-81.8 uA	-60.0 uA	-87.5 uA
	SYMMETRY 150 Hz	TX1	47.4 %	NA %	40.0 %	60.0 %
		TX2	48.7 %	NA %	40.0 %	60.0 %
1/4 WIDTH SECTOR ALARM 150 Hz WIDE	TX2	-67.4 uA	-65.9 uA	-60.9 uA	-75.0 uA	
1/4 WIDTH SECTOR ALARM 150 Hz NARROW	TX2	-81.3 uA	-82.2 uA	-97.7 uA	-75.0 uA	
FREQUENCIES	COURSE	TX1	7.6 kHz	7.6 kHz	-15.0 kHz	15.0 kHz
		TX2	6.8 kHz	6.8 kHz	-15.0 kHz	15.0 kHz
	CLEARANCE	TX1	-7.4 kHz	-7.4 kHz	-15.0 kHz	15.0 kHz
		TX2	-8.1 kHz	-8.1 kHz	-15.0 kHz	15.0 kHz

Figure 6. Illustrations of automatic LOC and GP drone check reports (Comparison of two different methods)

Full Control of the ILS frequency offset

As also illustrated by Figures 6 and 7 (bottom part of the figure), one of the latest innovations of the automatic reporting is that the averaged values of the Course and Clearance frequency offset are systematically calculated and displayed. This new feature offers the possibility to have a full control of all ILS parameters: not only on the main parameters such as DDM, SDM and RF level for the displacement error, course structure and sector widths, but also the crucial frequency settings.



Figure 7. Frequency offset measurement during LOC mini approach (averaged values: +4.7 kHz for the Course, -5.2 kHz for the Clearance)

GNSS INDEPENDENT POSITIONING

Introduction

Unmanned aerial systems have become an established tool for the inspection and validation of Communication, Navigation, and Surveillance (CNS) infrastructure. Over the past decade, the SkyRF® platform has progressed from early demonstrations of drone-based ILS inspection to a fully operational multi-CNS measurement system used by civil aviation authorities and military organisations.

While GNSS-based positioning has enabled high-accuracy geo-referenced measurements, recent operational experience has demonstrated that reliance on GNSS alone represents a critical vulnerability. GNSS interference, spoofing, and denial can disrupt autonomous flight and invalidate CNS measurement data, even though the RF measurement payload itself remains functional.

GNSS-Independent Positioning Architecture Based on UWB APNT

To mitigate GNSS dependency, the SkyRF® platform has been extended with an Alternative Positioning, Navigation and Timing (APNT) capability based on terrestrial Ultra-Wideband (UWB) radio technology. The objective of this integration is to provide a positioning solution that is functionally equivalent to GNSS for autonomous flight and CNS data geo-referencing.

The APNT system consists of multiple UWB anchor nodes deployed within the operational area and a compact UWB tag mounted onboard the UAV. The anchors transmit time-synchronized ranging messages using a time-division multiple access scheme. By measuring the time of arrival of these signals, the onboard tag computes pseudo-ranges to multiple anchors and determines its three-dimensional position through multilateration.

UWB's large signal bandwidth enables high temporal resolution and strong resilience to multipath propagation, making the system well suited for operation near reflective structures, terrain, and metallic installations.

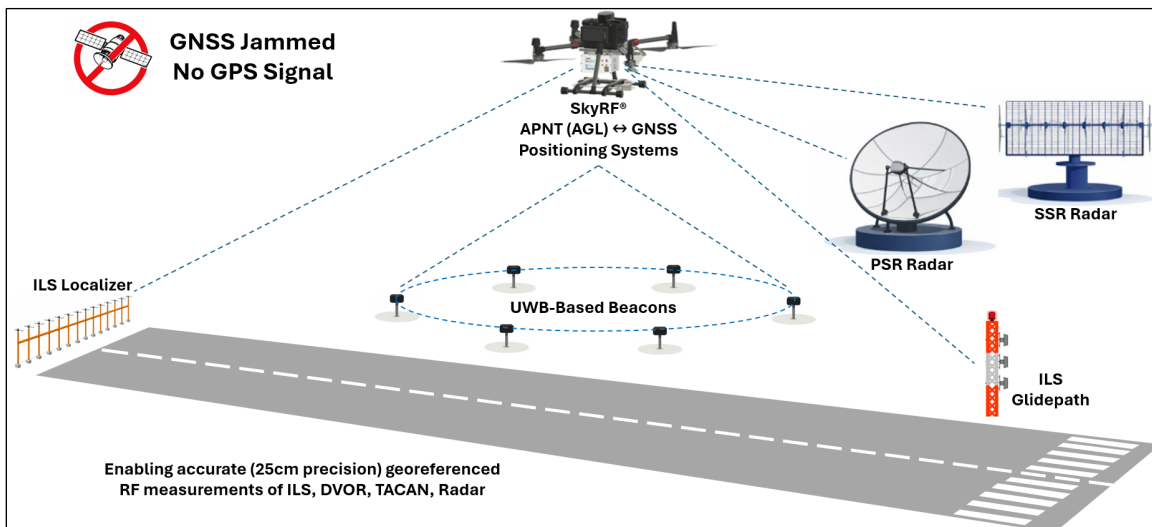


Figure 8: General GNSS-independent CNS inspection concept

Operational Coverage and Deployment Geometry

The APNT anchor network is designed to define a three-dimensional operational volume rather than a single point of interest. Anchors are typically deployed around the broader inspection area, such as along runway edges or nearby infrastructure, and do not need to be co-located with the CNS asset under test.

A typical deployment supports an operational volume of approximately 100 m by 100 m horizontally and up to 200 m vertically. Within this volume, the system achieves horizontal positioning accuracy below 40 cm RMS and a vertical

accuracy less than 25 cm RMS. This level of performance is sufficient to maintain CNS measurement accuracy comparable to RTK GNSS-based operations.

Integration with Autonomous Flight and CNS Measurement

From an integration perspective, the APNT-derived position solution is treated equivalently to GNSS by the UAV flight controller and the SkyRF® transceiver. Autonomous flight profiles, including vertical profiles, lateral scans, and approach trajectories, can be executed without modification.

The SkyRF® transceiver receives the same position stream for time-aligned fusion with RF measurement data. Seamless transition between GNSS-based and APNT-based positioning is supported, allowing uninterrupted mission execution when GNSS becomes unavailable.

Extension to Moving Reference Frames and Maritime Operations

Beyond static airport environments, the APNT positioning concept can be extended to moving reference frames such as maritime vessels. In this configuration, the UWB anchors are installed on a ship or offshore platform, maintaining a fixed relative geometry.

The UAV operates within this local reference frame, enabling stable autonomous flight and reliable CNS measurements despite vessel motion. When GNSS is intermittently available, global geo-referencing can be recovered without disrupting measurement continuity.

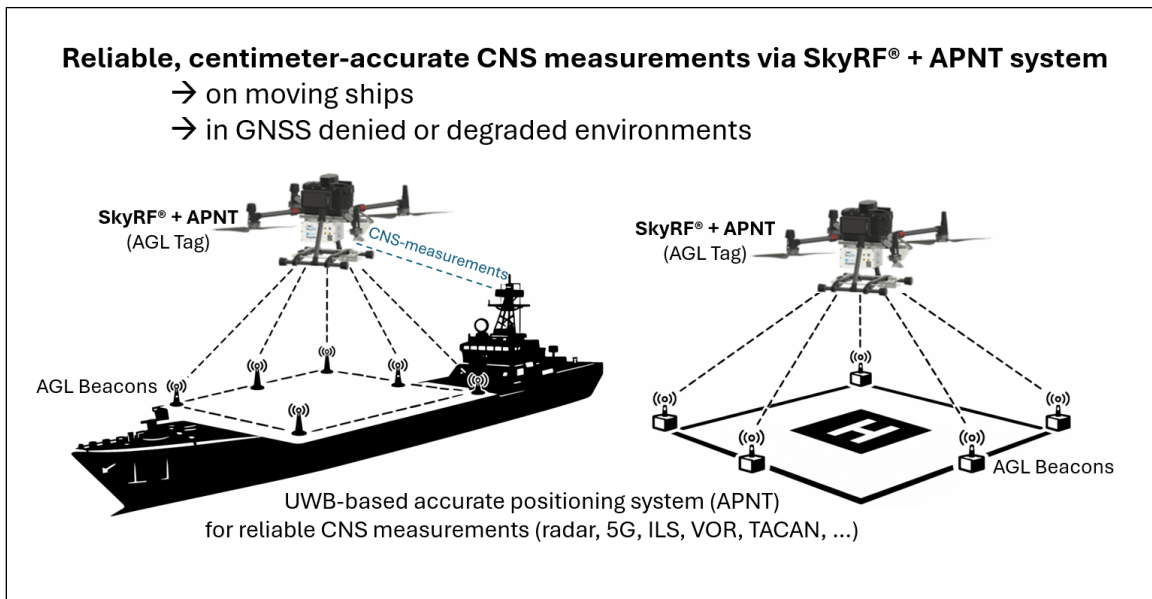


Figure 9: APNT operation on moving vessel

Impact on CNS Inspection Operations

The integration of GNSS-independent positioning significantly extends the operational envelope of drone-based CNS inspection. It enables mission continuity during GNSS outages, supports military and high-security operations, and reduces dependency on costly manned inspection flights.

This capability is particularly relevant for contingency inspections, military exercises, and maritime CNS validation scenarios where GNSS availability cannot be assumed.

Conclusion on GNSS independent positioning

By integrating a UWB-based APNT capability, the SkyRF® platform evolves from a GNSS-dependent inspection drone into a resilient CNS measurement system capable of operating in degraded and denied environments. This development supports emerging requirements for robust, autonomous, and future-proof CNS inspection across civil and military aviation domains.

DRONE-BASED PAPI INSPECTION USING IMAGE PROCESSING

Principle of Operation

Precision Approach Path Indicator (PAPI) systems provide visual glide path guidance to pilots during final approach by displaying a combination of red and white lights. Each PAPI installation typically consists of four light units arranged perpendicular to the runway, with each unit emitting a sharp transition between white and red light at a specific elevation angle relative to the runway threshold.

The SkyRF® platform extends its CNS inspection capability with a dedicated PAPI inspection module, enabling automated verification of PAPI geometry and optical characteristics using a UAV-mounted camera and image processing algorithms. The objective of this capability is to measure the angular alignment, transition boundaries, and horizontal coverage of the PAPI lights in accordance with ICAO Annex 14 requirements.

The system performs these measurements by capturing a sequence of high-resolution images of the PAPI installation while the drone follows predefined trajectories. The captured images are subsequently processed to determine the color state (red or white) and relative intensity of each PAPI lamp, allowing the calculation of the angular transition boundaries between the different glide path indications.

This approach enables objective and repeatable PAPI inspections without the need for manned aircraft flight checks.

Measurement Geometry and Flight Profiles

The SkyRF PAPI inspection workflow consists of two complementary measurement trajectories:

1. Vertical trajectory measurements, used to determine the elevation angles of the red-white transition for each PAPI unit.
2. Horizontal trajectory measurements, used to verify the lateral coverage and alignment of the PAPI installation.

Both trajectories are executed using automated UAV flight planning software such as UGCS.

Vertical Measurement

For vertical inspection, the UAV is positioned at a defined distance from the PAPI installation and performs a vertical ascent or descent while continuously capturing images of the lights.

The measurement is typically performed at distances between 300 m and 1 km from the PAPI system, with distances of approximately 500 m commonly used for inspection flights.

During the measurement:

- The UAV maintains a constant horizontal distance from the PAPI installation.
- The drone ascends through a vertical range that spans the expected glide path angles.
- Images are captured at fixed time intervals while the drone moves slowly (typically around 0.1 m/s) to maximize angular resolution.

This vertical trajectory ensures that the camera observes all possible PAPI light states (four white, three white/one red, two white/two red, etc.), enabling the detection of the precise elevation angle at which each light transitions between white and red.

Horizontal Measurement

In addition to the vertical inspection, the drone performs a horizontal scan in front of the PAPI installation.

This trajectory evaluates the lateral visibility and alignment of the PAPI lights relative to the runway centerline.

According to ICAO specifications, the PAPI system must provide adequate guidance within a horizontal sector of approximately $\pm 8^\circ$ from the runway centerline. To ensure full coverage, the SkyRF inspection trajectory typically spans at least $\pm 9^\circ$, with $\pm 11^\circ$ recommended to provide additional margin.

The horizontal measurement is conducted at a fixed distance from the PAPI installation, typically 300 m, while the UAV moves laterally across the observation sector.

This flight profile allows the system to determine the angular extent over which each light remains visible and correctly colored.

Optical Data Acquisition

The PAPI measurement system uses a stabilized camera mounted on the UAV, such as the DJI Zenmuse H30, to acquire high-resolution images of the PAPI lights during the flight mission.

To ensure consistent photometric measurements, camera parameters are configured to minimize noise and maintain stable exposure conditions. Typical configuration parameters include:

- ISO sensitivity set to a low value (e.g. ISO 100) to reduce sensor noise,
- controlled shutter speeds (e.g. 1/60–1/100 s) to maintain sufficient brightness detection,
- manual focus configuration to maintain sharp lamp imaging.

The camera operates in interval capture mode, typically recording images every two seconds, which provides sufficient spatial sampling along the UAV trajectory.

To ensure optimal image quality and consistent photometric response, the PAPI light intensity is typically configured at approximately 30% of maximum brightness during inspection flights.

Image Processing and Angle Determination

After completion of the flight mission, the captured images are processed using the Intersoft PAPI analysis software.

The processing workflow consists of several steps:

1. **Image Import and Metadata Extraction**
All captured images are imported into the analysis tool, which extracts image timestamps and metadata for correlation with the UAV trajectory.
2. **Lamp Identification**
The operator defines bounding boxes around each of the four PAPI light units in the first image frame. These regions are then tracked across the full image sequence.
3. **Color and Intensity Classification**
For each frame and each lamp, the algorithm evaluates the relative brightness and color components to determine whether the lamp is observed as red or white.
4. **Transition Detection**
By correlating the UAV position with the detected color state, the software identifies the exact elevation angle at which each lamp transitions from white to red.
5. **Angular Deviation Calculation**
The measured transition angles are compared with the nominal design angles of the PAPI installation to determine alignment deviations.

In addition to elevation measurements, the software also evaluates the relative brightness and intensity distribution of the lamps to identify potential optical or mechanical misalignments.

Results and Reporting

The results of the inspection are presented within the PAPI analysis interface as both tabulated data and graphical plots.

The analysis outputs include:

- elevation transition angles for each PAPI light unit,
- horizontal coverage limits of the installation,
- deviation from nominal glide path geometry,
- relative intensity characteristics of each lamp.

The software automatically generates a structured inspection report summarizing the results and highlighting any deviations from ICAO specifications.

Integration with Multi-CNS Inspection Operations

The PAPI module is integrated within the broader SkyRF inspection ecosystem and can be executed as part of combined inspection missions. In practice, this enables harmonized inspection workflows, where RF-based measurements (ILS, DME, radar) and optical inspections (PAPI and airfield lighting) are performed during the same operational deployment.

This integrated approach reduces operational cost and allows infrastructure owners to perform comprehensive approach guidance verification using a single UAV-based measurement platform.

CONCLUSION

With a decade of system maturity and five years of demonstrated reduction in ILS flight checks in Switzerland, the CNS Drone SkyRF® has evolved into a proven and internationally deployed solution.

Recent advancements, including fully autonomous measurements, extended operational range and endurance, automated reporting, and precise control of frequency offsets, mark a significant step forward in CNS maintenance capabilities. These developments not only enhance efficiency and accuracy but also expand the operational envelope towards extended-range and BVLOS missions.

By progressively bridging the gap between ground-based measurements and traditional flight inspection, the CNS Drone SkyRF® is reshaping inspection methodologies and setting a new standard for the future of navaid calibration.

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