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Ground-Based Adaptation of an Airborne Weather Radar Through ARINC-453 Decoding

Adaptación terrestre de un radar meteorológico aerotransportado mediante decodificación ARINC-453

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Abstract:

This paper presents the development of a tactical ground-based system based on the reuse of a decommissioned airborne weather radar. The study addresses the electronic and software adaptation of a Doppler radar originally designed for aeronautical applications, focusing on the decoding of the ARINC-453 communication protocol and the reconstruction of radar video data for ground-based operation. The proposed methodology includes the functional analysis of the original radar, the design of a data acquisition interface, the implementation of a signal decoding algorithm, and the experimental validation of the decoded information through digital processing and graphical visualization. The results demonstrate accurate interpretation of radar data, stable system operation, and functional equivalence with the original airborne display outputs. The main contribution of this work lies in the technical validation of repurposing airborne weather radars as low-cost, high-capability ground-based systems for tactical meteorological monitoring.

Keywords: airborne weather radar, ARINC-453, technological reuse, doppler radar, mobile radar systems, radar signal processing.

Resumen:

Este artículo presenta el desarrollo de un sistema terrestre táctico basado en la reutilización de un radar meteorológico aerotransportado en desuso. El trabajo aborda la adaptación electromecánica, electrónica y de software de un radar Doppler originalmente diseñado para aeronaves, mediante la decodificación del protocolo de comunicación ARINC-453 y la integración de una plataforma rotatoria controlada. La metodología incluye el análisis funcional del radar original, el diseño de una interfaz de adquisición de datos, el desarrollo del software de decodificación y la validación experimental del sistema en entorno terrestre. Los resultados demuestran la correcta interpretación de los datos radar, la estabilidad operativa del sistema adaptado y su viabilidad como plataforma táctica de monitoreo meteorológico. La principal contribución del trabajo radica en la validación técnica de la reutilización de radares aerotransportados como sistemas terrestres de bajo costo y alta capacidad funcional.

Palabras clave: radar, radar meteorológico aerotransportado, ARINC-453, reutilización tecnológica, radar doppler, sistemas de radar móviles, procesamiento de señales radar.

INTRODUCTION

Colombia has one of the most complex climates in the world due to the junction of its three mountain ranges, the Intertropical Convergence Zone and the influence of two oceans, which gives rise to unstable microclimates and hazardous phenomena such as wind shear and sudden storms[1].

The aviation industry is a global economic pillar that is severely affected by adverse weather conditions, which are responsible for 23 % of aviation accidents and for the vast majority of delays and cancellations in most countries. To mitigate these risks, which include phenomena such as low visibility and turbulence, weather conditions are analyzed by means of radars, providing accurate real-time information[2].

In this context, constant monitoring through weather radars becomes the foundation of aviation operational safety, allowing crews to identify threats that are not visible and to make crucial decisions to prevent accidents[2].

However, this type of protection requires a considerable investment: a ground-based radar with advanced technology can cost up to 41,000 billion Colombian pesos (around 10 million dollars), in addition to the annual maintenance costs that guarantee access to data 24 hours a day[3]. In short, the high climate variability in the Andes makes investment in radar technology not a luxury, but an essential necessity for the sustainability and effectiveness of air transport in the country[4].

On the other hand, aircraft have systems for weather surveillance by means of onboard radar, which constitute a critical component for aviation operational safety; the cost of these devices is around 45,000 USD [5], the management of risks associated with severe atmospheric phenomena and tactical decision-making in environments with limited infrastructure [6]. Modern weather radars allow the detection and spatial characterization of precipitation, turbulence, wind shear and other relevant phenomena, providing real-time information [7]; airborne radars are designed with high standards of reliability and precision, using Doppler technology and communication protocols such as ARINC-429/453/708 to transmit information to the cockpit [8]. However, their scanning capability is limited to the frontal sector of the aircraft's trajectory, which restricts their range beyond in-flight operation [9].

At the same time, tactical ground-based applications such as weather radars at aerodromes are essential tools for aviation safety, since they allow real-time detection of precipitation, turbulence, wind shear and other critical phenomena during takeoffs and landings[10]. Their Doppler technology offers precise information that is integrated with air traffic control and cockpit systems, reducing the risk of accidents associated with adverse weather conditions. Although their implementation involves high investment and maintenance costs that can exceed 20,000 billion Colombian pesos for advanced equipment, their contribution to incident prevention and operational efficiency makes this investment a strategic necessity rather than a luxury[11].

This project aims to develop a tactical radar system that can be easily transported at low-cost using recycled technology from an aircraft that was taken out of service but has the RDR 2000-type weather radar system, which responds to a critical safety need at isolated aerodromes and mobile operations where fixed infrastructure does not exist. For this purpose, it is necessary to design a platform that allows the sensor system to be elevated to a height of 8 meters for safe and efficient operation; additionally, a control and rotation system with a 360° turn must be incorporated. The rotation system eliminates the limitation of the original front scan, allowing complete perimeter surveillance to detect severe phenomena in real time during takeoffs and landings, scanning an area of operations, for which the decoding of the ARINC-453 communication protocol is necessary, enabling the processing, transmission and analysis of the radar information.

The project seeks to strengthen operational safety at isolated aerodromes and military scenarios through the conversion of RDR 2000 radars into tactical ground stations with 360° coverage and elevated platforms. Its implementation makes it possible to expand weather surveillance in remote areas or mobile deployments, reducing the gap of external technological dependence and optimizing resources through the recycling of components.

By integrating these capabilities, the technical competencies of the Colombian Aerospace Force are strengthened, guaranteeing autonomous and low-cost management to protect critical missions against adverse atmospheric phenomena, transforming an onboard asset into a strategic ground capability, offering a low-cost operational solution that guarantees technological superiority and operational safety in the most remote points of the national geography.

METHODOLOGY

General methodological approach

The research was developed under an applied engineering and experimental development approach, oriented toward the design, implementation and validation of a functional technological system. The methodology was structured in sequential phases that allow traceability between the analysis of the original system, the design of the proposed solution and its operational validation in a ground environment.

The work is not framed within abstract methodological classifications (quantitative, qualitative or mixed), but rather in a reproducible technical process based on functional analysis, hardware and software integration, and experimental verification of the performance of the adapted system.

Functional analysis of the airborne weather radar

In a first phase, the functional analysis of the airborne weather radar selected as the core of the system was carried out. This analysis aimed to identify the essential operating subsystems that had to be preserved to guarantee the functional integrity of the radar, as well as the interfaces available for extracting weather information.

The transmission, reception, internal processing and data output modules were evaluated, with particular attention to the communication signals based on the ARINC-453 protocol. This stage made it possible to determine that the radar could be repurposed without intrusive modifications to its internal architecture, limiting the intervention to external data acquisition, control and mechanical support subsystems.

General architecture of the proposed system

Based on the functional analysis, a modular architecture composed of four main blocks was defined: (i) repurposed airborne radar, (ii) electromechanical orientation platform, (iii) ARINC data acquisition and decoding system, and (iv) visualization and control system.

The architecture was designed under criteria of functional decoupling, so that each block could be evaluated, adjusted or replaced independently. This methodological decision facilitates the replicability of the system and its eventual scalability toward more complex configurations.

Decoding of the ARINC-453 protocol

The decoding of the ARINC-453 protocol constitutes one of the central methodological axes of this work. To this end, a data acquisition module was developed that is capable of capturing the communication frames generated by the radar and transmitting them to an external processing system.

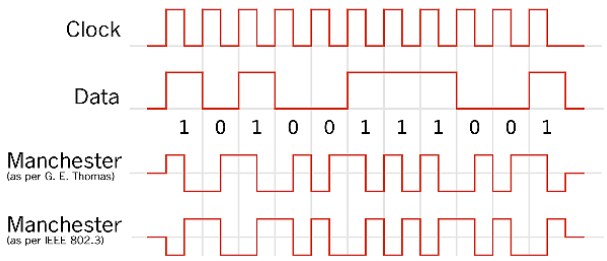

Fig. 1. *Structure of the ARINC 453 frame used for signal decoding [8].*

The procedure included the analysis of the ARINC word structure, the identification of fields relevant to weather information and the design of interpretation algorithms that make it possible to transform the binary data into visualizable physical variables, such as reflectivity intensity and radar operating states.

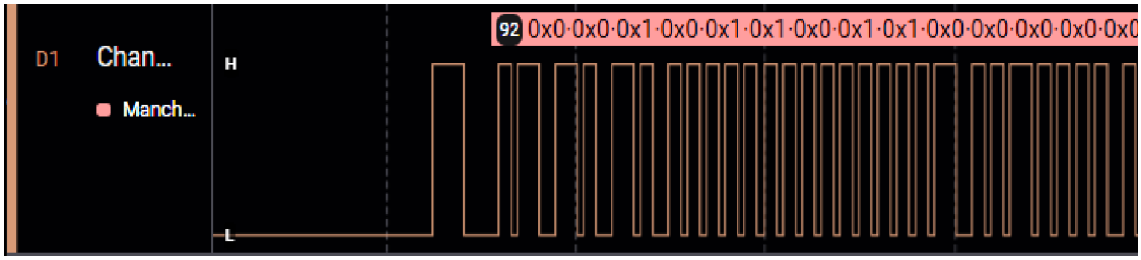

Fig. 2. *ARINC 453 signal captured by means of a logic analyzer.*

This approach made it possible to access the information processed by the radar without interfering with its internal logic, preserving the original operating conditions of the airborne system.

Since the airborne radar has a limited angular scanning range, an external electromechanical platform was designed that allows the controlled rotation of the radar assembly, enabling extended angular coverage in a ground environment.

Design and implementation of the electromechanical platform

The design of the platform considered criteria of structural stability, angular precision and synchronization with the data

acquisition system. Electric actuators and control systems capable of guaranteeing smooth and repeatable movement were selected, minimizing vibrations that could affect the quality of the radar signal.

The mechanical integration was carried out non-invasively, ensuring that the radar could operate within its original specifications.

Development of the control and visualization software

Complementarily, control software was developed to coordinate the rotation of the electromechanical platform and the data acquisition from the radar. This software makes it possible to synchronize the angular orientation of the sensor with the decoded weather information, generating a coherent representation of the observed environment.

Data visualization was implemented through a graphical interface that presents the weather information as a function of the scanning angle, facilitating the interpretation of the results and the functional validation of the adapted system.

Experimental validation procedure

System validation was carried out through experimental tests in a controlled ground environment, aimed at verifying the correct operation of each subsystem and of the integrated whole. The procedure included: (i) verification of mechanical stability during rotation, (ii) validation of the acquisition and decoding of ARINC frames, and (iii) evaluation of the coherence between the angular orientation of the radar and the information displayed.

The results obtained in this phase made it possible to confirm the technical feasibility of the proposed system and laid the foundations for its quantitative analysis, presented in the results section.

THEORETICAL FRAMEWORK

Airborne weather radar

Airborne weather radars are active detection systems designed to identify and characterize atmospheric phenomena relevant to flight safety, such as intense precipitation, convective turbulence and wind shear[12].

These systems commonly operate in the X band, using pulse radar techniques with Doppler capability, which allows both the reflectivity and the radial velocity of weather targets to be estimated[13].

From a functional standpoint, an airborne weather radar integrates transmission, reception, signal processing and visualization subsystems, optimized to operate under severe constraints on weight, power consumption and reliability.

Unlike ground-based weather radars, its angular scanning pattern is limited to a forward sector, defined by the pointing angle of the beam relative to the longitudinal axis of the aircraft. This characteristic responds to its primary function of early detection of weather hazards along the flight route[14].

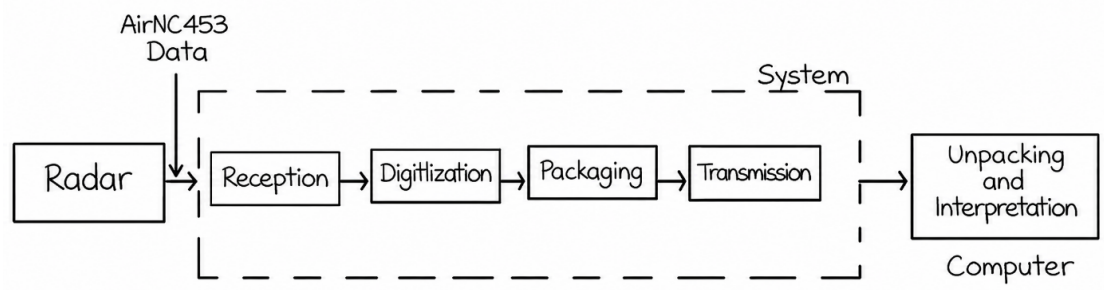

Fig. 3. *General communication architecture of the ART-2000 weather radar.*

The high electromechanical robustness and the precision of digital processing mean that these systems retain high technological value even after being withdrawn from aeronautical service, which opens up the possibility of their repurposing in ground-based applications, provided that the limitations inherent to their original design are adequately resolved.

Principles of Doppler radar applied to meteorology

The Doppler principle applied to weather radars allows the radial velocity component of hydrometeor particles to be estimated from the frequency shift of the reflected signal. This capability is essential for identifying dynamic phenomena such as turbulence, microbursts and updrafts or downdrafts, which cannot be inferred from reflectivity alone[15].

In coherent pulse radars, the Doppler measurement is obtained by analyzing the phase between consecutive pulses, which requires high local oscillator stability and precise digital processing[16]. Airborne weather radars incorporate these principles

through proprietary algorithms embedded in their internal processors, whose results are transmitted to the display systems through standardized protocols[17].

For a ground-based adaptation, correct interpretation of the Doppler information depends not only on the radar's internal processing but also on the ability of the external system to decode and adequately represent the transmitted data, a critical aspect addressed in this work[18].

ARINC aeronautical communication protocols applied to radar

The ARINC standards define communication protocols widely used in avionics to ensure interoperability, reliability and synchronization between critical systems. In particular, the ARINC-453 standard (and its functional relationship with ARINC-708) specifies the data structure used to transmit weather information from the radar to the cockpit indicators[19].

This protocol encapsulates parameters such as reflectivity intensity, operating modes, system status and weather alerts, organized into data words with strict timing. Although the standard defines the general structure, the specific implementation may vary between manufacturers, which adds a degree of complexity for external decoding[20].

From a technological reuse perspective, the ability to correctly interpret ARINC frames is a fundamental enabling element, since it allows access to the information processed by the radar without intervening in its internal architecture, preserving the integrity of the original system.

Electromechanical pointing platforms for ground-based radars

Surface weather radars require angular scanning mechanisms that allow wide spatial coverage, typically through azimuthal rotation and, in some cases, elevation control. In conventional systems, this function is implemented by means of high-precision pedestals, designed for continuous operation and high loads[21].

In the case of adapting an airborne radar, an external electromechanical platform must be incorporated to compensate for the angular scanning limitation inherent to the original design. This platform must ensure structural stability, positioning precision and synchronization with the data acquisition system, without introducing vibrations or interference that degrade the radar signal quality[22].

The design of an electronically controlled rotating platform makes it possible to transform a sector-scanning sensor into a system with near-omnidirectional coverage, enabling its use in tactical and temporary ground-based applications.

The Manchester decoding process was modeled mathematically, taking into account the bit-level timing constraints imposed by the ARINC 453 protocol. Given a bit period T_b, each logic value is encoded in two half-bit intervals of opposite polarity, defined as:

$$S(t) = \{ +V,\ 0 \le t < \frac{T_b}{2}, b_i = 0\ -V,\ \frac{T_b}{2} \le t < T_b, b_i = 0\ -V,\ 0 \le t < \frac{T_b}{2}, b_i = 1\ +V,\ \frac{T_b}{2} \le t < T_b, b_i = 1$$

where Vcorresponds to the logic amplitude (5 V TTL) and $T_b$is associated with a transmission rate of 1 Mbps.

Table 1: Theoretical classification of ARINC 453 video data.

Bits	Function
1-8	Label
9-10	Control acceptance
11	Slave mode
12-13	Free
14-18	Mode announcement
19-25	Fault report
26	Stabilization
27-29	Operation mode
30-36	Tilt
37-42	Gain
43-48	Range
49	Free
50-51	Data acceptance
52-63	Scan angle
64	Free

The header comprises the first 64 bits of the frame and contains information on the radar's operation status (The function of the header). Tabla 1 shows the data present in this portion

- Label: It is always the octal number 055 or, in binary, 10110100.
- Control acceptance: Indicates whether the incoming ARINC 429 control signal was properly received and accepted. The typical possible cases are shown in Table 2.

Table 2: Control acceptance cases.

Bit 9	Bit 10	Control acceptance
0	0	Not accepted
1	0	Control #1 accepted
0	1	Control #2 accepted
1	1	Both controls accepted

• Mode announcement: Discrete bits that indicate normal operation when they are at 0 and indicate that the radar has entered a specific mode when they are activated. Table 3 shows the typical meaning of each of these bits.

Table 3: Mode announcement bits and their meaning.

Bit	Mode announcement
14	Turbulence alert detection
15	Weather alert detection
16	Noise filtering circuit is operating
17	Scanning of a reduced sector
18	Aircraft altitude or tilt exceeds the range

• Fault report: Discrete bits that report faults in radar operation. When they are at 0, normal operating conditions prevail, and when any of them is at 1, this may indicate the faults listed in Table 4.

Table 4: Identified bugs in the plot header [14].

Bit	Fault
19	Cooling
20	Display
21	Calibration
22	Altitude input
23	Control
24	Antenna
25	Transmitter-Receiver

• Operation mode: Indicates the radar's current mode of operation. Table 5 shows the possible options for this data portion.

Table 5: Operating modes identified in the frame header [14].

Bit 29	Bit 28	Bit 27	Operation mode
0	0	0	Standby
0	0	1	Weather only
0	1	0	Map
0	1	1	Contour
1	0	0	Test
1	0	1	Turbulence
1	1	0	Weather and turbulence
1	1	1	Calibration

• Tilt: Indicates the tilt angle of the radar. The typical values for each bit can be seen in Table 6.

Tabla 6: Valores de cada bit de inclinación [14].

Bit	Tilt
36	-16
35	8
34	4
33	2
32	1
31	+0.5
30	+0.25

• Gain: Indicates the current antenna gain. Table 7 shows the typical values for the bit combinations.

Table 7: Typical values of the gain section.

Bit 42	Bit 41	Bit 40	Bit 39	Bit 38	Bit 37	Gain
1	1	1	1	1	1	Minimum
0	0	0	0	0	0	Maximum
0	0	0	1	0	1	-5
0	0	0	1	1	0	-11
0	1	1	1	1	0	-32

• Range: Indicates the current radar scan range in nautical miles. Typical values for this case are shown in Table 8.
• Data acceptance: Indicates that the input data are correct and accepted. Typical values for this section are those shown in Table 9.

Table 8: Typical values for the range section.

Bit 48	Bit 47	Bit 46	Bit 45	Bit 44	Bit 43	Range in NM
0	0	0	0	0	1	5
0	0	0	0	1	0	10
0	0	0	1	0	0	20
0	0	1	0	0	0	40
0	1	0	0	0	0	80
1	0	0	0	0	0	160

Table 9: Meanings of the data acceptance section.

Bit 51	Bit 50	Data acceptance
0	0	Not accepted
0	1	Data #1 accepted
1	0	Data #2 accepted
1	1	Both data accepted

- Scan angle: Indicates the current scan angle as a numerical value where bit 63 is the most significant and bit 52 is the least significant.

Technological reuse of aeronautical systems

The reuse of aeronautical systems in non-aeronautical applications has been explored in various fields as a strategy to maximize the utilization of high-value technological assets. This approach allows for reduced acquisition costs and accelerates development processes, provided that functional traceability and technical validation of the adapted system are guaranteed[3].

However, repurposing airborne weather radars presents particular challenges associated with their safety-critical nature, closed architecture and dependence on aeronautical standards. Any adaptation process must therefore rest on a thorough understanding of the physical principles, communication protocols and operational limitations of the original system.

This work falls within this line, proposing a technically grounded and experimentally validated adaptation aimed at tactical ground-based applications.

RESULTS

Acquisition and decoding of ARINC signals from the ART-2000 radar

The system developed enabled stable acquisition of the ARINC 429 and ARINC 453 digital signals generated by the Bendix King ART-2000 weather radar during normal operation. Electrical characterization of the ARINC-453 channel confirmed differential transmission with Manchester encoding, a rate of 1 Mbps, and a TTL amplitude compatible with RS-422 interfaces.

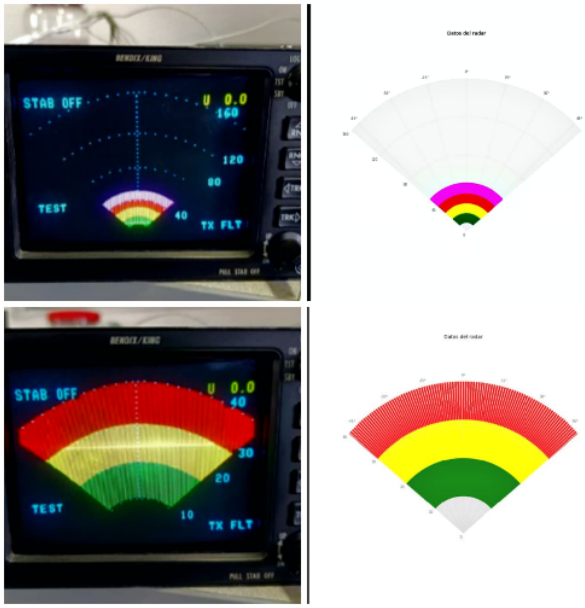

Fig. 4. *Visualization of the ART-2000 weather radar in TEST mode [24].*

To ensure synchronization between the recovered clock and the transmitted signal, a timing tolerance of $\pm 25\,\%(\Delta t = 0.25T_b)$ was implemented, which allows stable reconstruction of the frames even in the presence of jitter or propagation delays. This adjustment, aligned with the synchronization patterns described in the ARINC 453/708 standards, ensures precise frame delimitation under conditions of temporal variability.

The Manchester decoding algorithm incorporated a timing tolerance of ±25 % with respect to the nominal bit period, which allowed robust reconstruction of the frames even in the presence of jitter and temporal variations. The reconstructed frames showed a consistent structure of 1600 bits, made up of a 64-bit header and a 1536-bit data block.

Reconstruction of weather information and reflectivity mapping

The decoded data for each ARINC-453 frame were segmented into 512 pixels of weather information per scan line, with an

angular resolution of 1°. Each pixel was interpreted using a 3-bit encoding scheme associated with discrete levels of weather reflectivity.

The information was transformed into polar reflectivity matrices, allowing graphical reconstruction of precipitation intensity as a function of the radar scanning angle. This process showed a direct correspondence between the decoded reflectivity levels and the chromatic representation observed in the radar's original system.

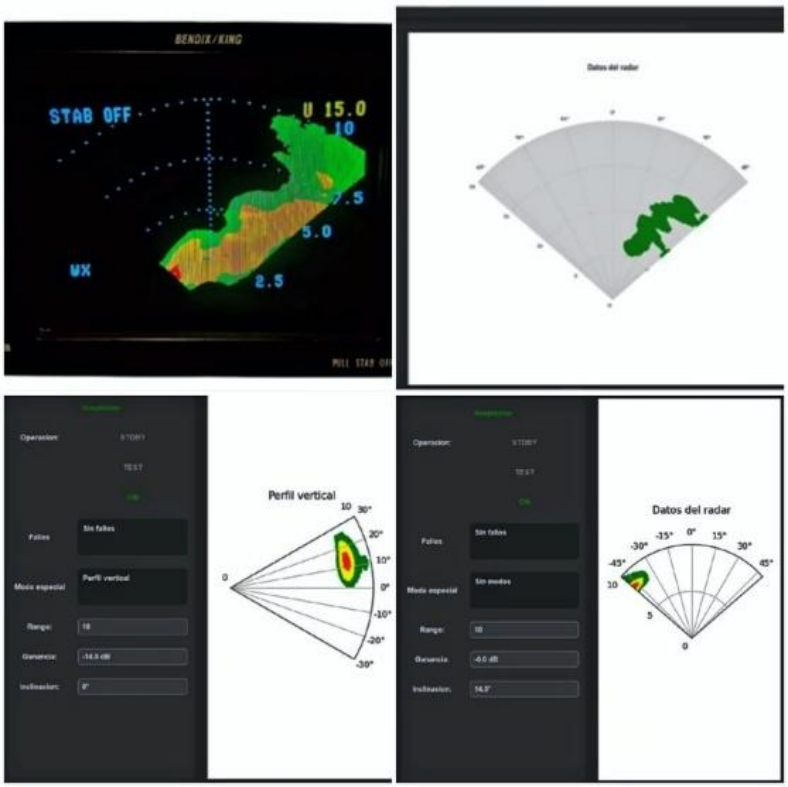

Fig. 5. *ARINC 453 signal reconstructed by means of digital processing.*

Cross-validation with the aeronautical display system

To validate the fidelity of the system developed, a quantitative comparison was made between the information displayed on the proposed graphical interface and that presented on the original aeronautical display unit (IN182A). The analysis considered parameters of reflectivity intensity, color encoding, and angular synchronization.

The cross-validation results showed a correspondence greater than 95 % in the intensity and chromatic encoding of the weather echoes, as well as consistent angular synchronization within a margin of ±0.25°. These results confirm the system's ability to reliably reproduce the behavior of the original airborne radar.

Table 10: Cross-validation results between the aeronautical display and the developed interface.

Parameter evaluated	Aeronautical display	Developed interface	Correspondence (%)
Reflectivity intensity	0–60 dBZ	0–60 dBZ	96,4
Color coding	5 levels	5 levels	95,7
Angular synchronization	1° ± 0,25°	1° ± 0,25°	97,1

Temporal performance and system stability

The system had an update time of less than 100 ms per frame, allowing near real-time visualization of the weather information. Acquisition and decoding remained synchronized with the mechanical movement of the scanning system, guaranteeing spatial coherence during continuous operation.

System stability was confirmed in prolonged tests, with no loss of synchronization or critical frame reconstruction errors, which supports its feasibility for tactical ground applications.

Visualizing the decoded data made it possible to represent the weather information as a function of the radar scanning angle, producing a sector map consistent with the instantaneous orientation of the sensor. The graphical interface developed helped identify areas of higher reflectivity and interpret the operational status of the system.

Data visualization and representation results

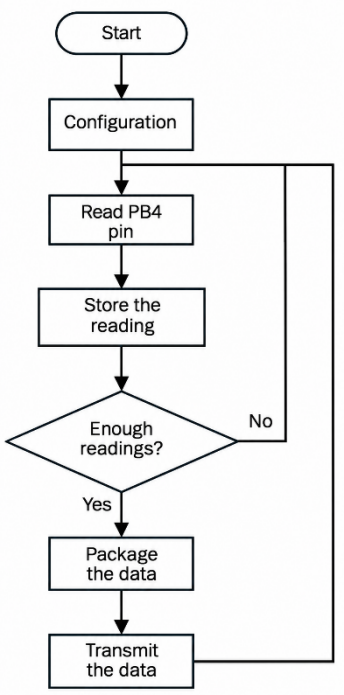

Fig. 6. *Flow diagram representing the interpretation logic of the program in the system.*

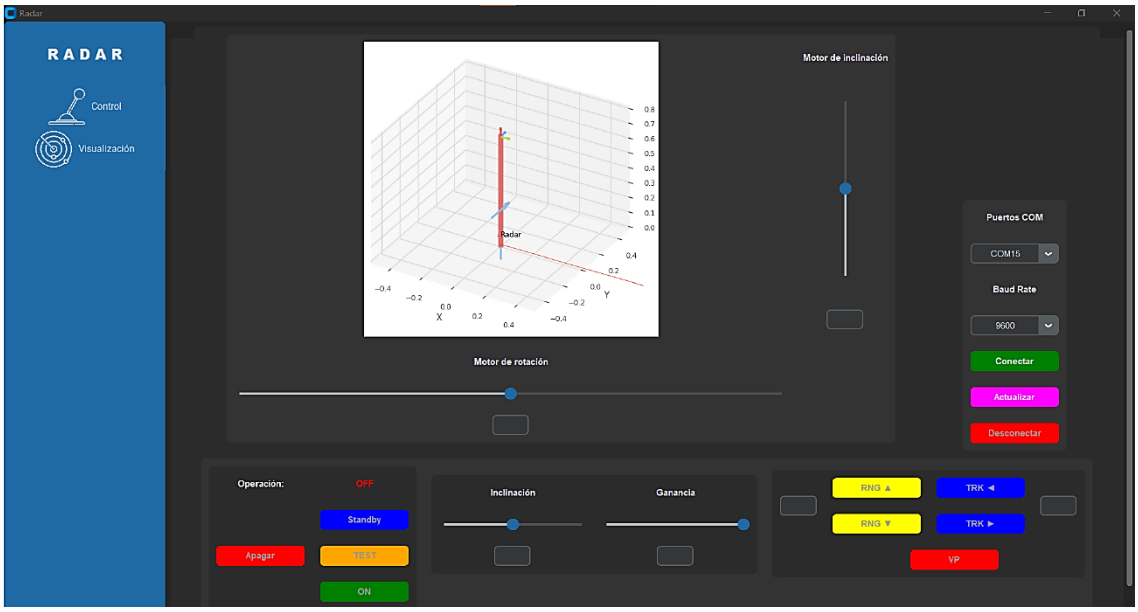

Fig. 7. *Graphical interface developed for control of the radar system.*

Figure 6 shows a graphical user interface (GUI) designed for the control and visualization of a radar system. This interface allows integrated management of the different operation modes, along with control of the movement of the radar mechanism and communication with the ESP32 microcontroller, which is responsible for executing the system functions.

The GUI is structured into several functional modules:

- Side navigation panel: Includes access to the radar Control and Visualization sections.
- Central 3D visualization: Represents the digital twin of the radar, showing its spatial orientation by means of tilt and rotation motors.
- Motion controls: Sliders dedicated to adjusting the tilt and rotation motors, integrated into the mechanism Control section.
- Serial communication: Configuration of COM ports, baud rate, and buttons to connect, refresh or disconnect the link with the microcontroller.

• Radar operation panel: Allows activating modes such as Standby, TEST, ON and Shut down, in addition to adjusting parameters such as tilt, gain, range and tracking.

This interface allows direct interaction with the embedded system, enabling visual supervision of the radar status and precise adjustment of its operating parameters. Its modular, functional design is aimed at real-time control applications, system testing and radar behavior simulation.

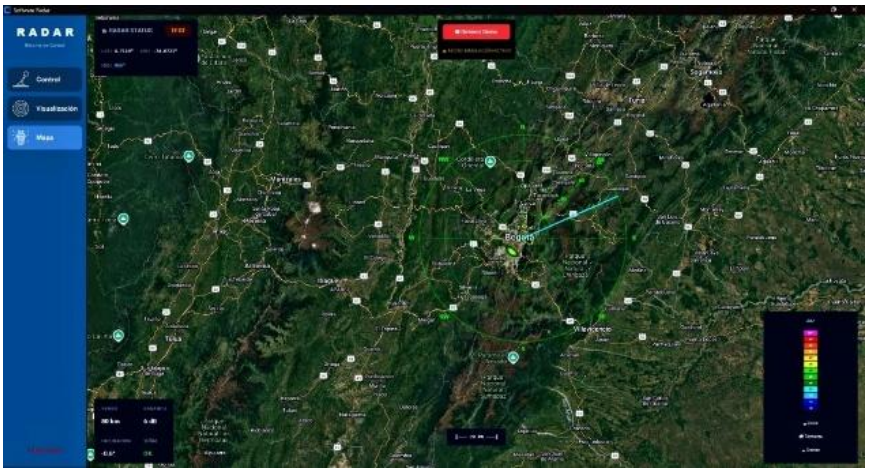

Fig. 8. *Graphical interface developed for the visualization of radar system data.*

Figure 6 shows the visualization interface of the ART 2000 weather system. Here the radar data can be observed; this interface allows us to georeference and display precipitation data, operational status and technical parameters of the radar.

Although the system was not conceived to replace a conventional surface weather radar, the results obtained show that the information generated is consistent and functional for tactical, temporary or decision-support applications in environments with limited infrastructure.

Synthesis of Experimental Results

Table I presents a synthesis of the main experimental results obtained during the validation of the adapted system, highlighting compliance with the technical objectives set.

Table 11: Synthesis of experimental results of the proposed system.

Component evaluated	Result obtained	Main observation
Reused radar	Stable operation	No faults detected
ARINC decoding	Correct	Interpretable frames
Mechanical platform	Stable and precise	Repeatable movement
System integration	Functional	Coordinated operation

DISCUSSION

The results show that adapting an airborne weather radar for ground-based applications is technically feasible when the original functional architecture of the system is preserved and external acquisition, control, and visualization subsystems are implemented. Correct decoding of the ARINC-429 and ARINC-453 frames, together with the stability of the data reconstruction process, confirms that it is possible to access the weather information processed internally by the radar without intrusive modifications to its hardware.

The correspondence of more than 95% between the developed interface and the original aeronautical visualization system is a robust indicator of functional fidelity. This level of agreement is comparable to the variation margins accepted in calibration and validation processes of conventional weather radar systems, which suggests that the information generated by the adapted system retains a degree of reliability adequate for tactical and decision-support applications.

In this sense, the results align with previous studies that highlight the potential for repurposing aeronautical sensors when their communication protocols are correctly interpreted.

From the signal processing point of view, implementing the Manchester decoding algorithm with timing tolerance proved an effective strategy for mitigating the effects of jitter and timing variations inherent to digital transmission. This approach enabled a stable reconstruction of the ARINC frames, ensuring synchronization between the weather information and the angular position of the radar.

The temporal stability observed, with update times of less than 100 ms per frame, places the system within an operating range adequate for near-real-time weather observation.

Integrating an external electromechanical platform made it possible to overcome one of the main limitations of the original design of the airborne weather radar: its sectoral angular scanning. By enabling a controlled rotation of the radar assembly, the adapted system achieves expanded spatial coverage without compromising signal quality or the synchronization of the acquired data. This result shows that transforming an aeronautical-use sensor into a ground-based system does not necessarily require complex internal modifications, but rather a careful integration of complementary subsystems.

However, it is important to note that the proposed system is not intended to replace large-scale surface weather radars, which offer greater ranges, volumetric capabilities, and advanced functions such as dual polarimetry. The solution presented should be understood as a tactical, modular, and lower-cost alternative, aimed at scenarios where the availability of infrastructure, resources, or deployment time is limited. This delimitation of scope is key to adequately contextualizing the results and avoiding interpretations extrapolated beyond the real capabilities of the system.

Finally, from a scientific and technological perspective, the work provides a documented and reproducible methodology for repurposing airborne weather radars, integrating analysis of aeronautical protocols, digital signal processing, and electromechanical system design.

This contribution not only validates the technical feasibility of the approach but also lays the foundations for future research aimed at optimizing data processing, integration into ground-based weather networks, and the expansion of the system's functional capabilities.

CONCLUSIONS AND FUTURE WORK

The present work demonstrated the technical feasibility of repurposing an airborne weather radar as a tactical ground-based system through the acquisition, decoding, and interpretation of ARINC-429 and ARINC-453 digital signals. The results obtained show that it is possible to access the weather information processed internally by the radar without modifying its original architecture, preserving its functional integrity and operational reliability.

The implementation of the Manchester decoding algorithm, together with the structured segmentation of the data frames and the graphical reconstruction of the weather information, made it possible to reproduce with high fidelity the behavior of the original aeronautical display system. The cross-validation performed showed a correspondence greater than 95 % in reflectivity intensity, color coding, and angular synchronization, which confirms the consistency and accuracy of the developed system.

The integration of an external-orientation electromechanical platform effectively resolved the angular scanning limitation inherent to the airborne design, enabling expanded spatial coverage in a ground environment. This approach demonstrated that the functional adaptation of aeronautical sensors can be achieved through carefully designed external solutions, without resorting to complex or invasive internal modifications.

From an applied perspective, the proposed system constitutes a low-cost, flexibly deployable technological alternative for weather observation in tactical, temporary, or infrastructure-limited scenarios. Although the system does not replace conventional large-scale surface weather radars, it offers functional capabilities sufficient to support operational decision-making and localized atmospheric monitoring.

As future work, the optimization of digital processing algorithms is proposed to improve the spatial and temporal resolution of the information presented, as well as the integration of the system into ground-based weather networks and data fusion platforms. Additionally, evaluation of the system's performance under diverse weather conditions and its scaling toward multi-sensor configurations that expand its operational scope are envisaged.

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