ISSN: 1692-7257 - Volume 1 – Number 47 - 2026

RCTA
Revista Colombiana de Tecnologías de Avanzada
UNIPAMPLONA

Digital Object Identifier: 10.24054/rcta.v1i47.4308

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

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

Ing. Carlos Daniel Guerrero Hernández[1], **Ing. Paula Rocío Macías Castillo**[1], **Ing. Miguel Ángel Rincón Otalora**[1], **Ing. Ingrid Carolina Oyaga Padilla**[1], **Tec. Jhon Alexander Cárdenas Puentes**[1]

[1] ***Fuerza Aérea Colombiana,*** *Centro de Investigación y Desarrollo Tecnológico de Innovación Aeronáutica, Madrid, Cundinamarca Colombia.*

Correspondence: *carlos.guerreroh@fac.mil.co*

Received: *October 20, 2025.* ***Accepted:*** *December 20, 2025.* ***Published:*** *January 01, 2026.*

How to cite: *C. D. Guerrero Hernández, P. R. Macías Castillo, M. Á. Rincón Otalora, I. C. Oyaga Padilla y J. A. Cárdenas Puentes, "Ground-Based Adaptation of an Airborne Weather Radar Through ARINC-453 Decoding", RCTA, vol. 1, n.°. 47, pp. 125-136, Jan. 2026. Recovered from https://ojs.unipamplona.edu.co/index.php/rcta/article/view/4308*

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.

1. INTRODUCTION

Colombia has one of the most complicated climates in the world due to the convergence of its three mountain ranges, the Intertropical Convergence Zone, and the influence of two oceans, which causes unstable microclimates and dangerous 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 air accidents and most delays and cancellations in most countries. To mitigate these risks, which include phenomena such as low visibility and turbulence, weather conditions are analyzed using radar, providing accurate information in real time [2].

In this context, constant monitoring via weather radars becomes the foundation of aviation safety, allowing crews to identify invisible threats and make crucial decisions to prevent accidents [2].

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

On the other hand, aircraft are equipped with onboard radar weather surveillance systems, which are a critical component for air safety. The cost of this equipment is around USD 45,000 [5], and it is used for managing risks associated with severe weather phenomena and tactical decision-making in environments with limited infrastructure [6]. Modern weather radars enable 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 accuracy, 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 front sector of the aircraft's trajectory, which restricts their range beyond flight operations [9].

At the same time, tactical ground applications such as weather radars at airports are essential tools for aviation safety, as they enable real-time detection of precipitation, turbulence, wind shear, and other critical phenomena during takeoffs and landings [10]. Their Doppler technology provides accurate 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 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 is no longer in service but has an RDR 2000 weather radar system, which responds to a critical safety need at isolated airfields and mobile operations where fixed infrastructure is non-existent. This requires the design of a platform that allows the sensor system to be raised to a height of 8 meters for safe and efficient operation. In addition, a control and rotation system with a 360° rotation must be incorporated. The rotation system eliminates the limitation of the original frontal scan, allowing complete perimeter surveillance to detect severe phenomena in real time during takeoffs and landings, scanning an area of operations for which it is necessary to decode the ARINC-453 communication protocol, which allows the processing, transmission, and analysis of radar information.

The project seeks to strengthen operational safety at isolated aerodromes and military sites by converting RDR 2000 radars into tactical ground stations with 360° coverage and elevated platforms. Its implementation allows for expanded weather surveillance in remote areas or mobile deployments, reducing the gap in 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, ensuring autonomous and low-cost management to protect critical missions from adverse atmospheric phenomena, transforming an onboard asset into a strategic ground capability, and offering a low-operating-cost solution that guarantees technological superiority and operational safety in the most remote parts of the country.

2. METHODOLOGY

2.1 General methodological approach

The research was carried out using an applied engineering and experimental development approach, focused on 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 terrestrial environment.
The work does not fall within abstract methodological classifications (quantitative, qualitative, or mixed), but rather within a reproducible technical process based on functional analysis, hardware and software integration, and experimental verification of the adapted system's performance.

2.2 Functional analysis of the airborne weather radar

In the first phase, a functional analysis was performed on the airborne weather radar selected as the core of the system. The objective of this analysis was to identify the essential operational subsystems that had to be preserved to ensure the functional integrity of the radar, as well as the interfaces available for extracting meteorological information.

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

2.3 General architecture of the proposed system

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

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

2.4 Decoding of the ARINC-453 protocol

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

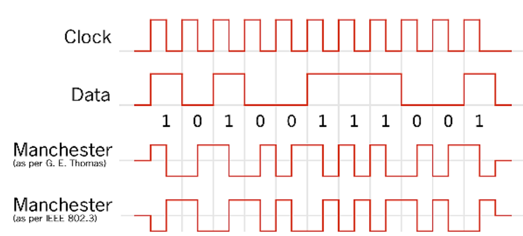

Fig. 1. *Structure of the ARINC 453 frame used for signal decoding [8].*

The procedure included analyzing the structure of ARINC words, identifying fields relevant to meteorological information, and designing interpretation algorithms that enable binary data to be transformed into viewable physical variables, such as reflectivity intensity and radar operating states.

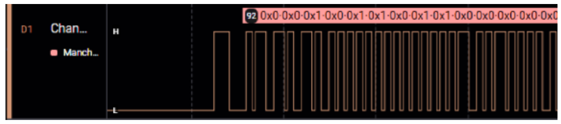

Fig. 2. *ARINC 453 signal captured using a logic analyzer.*

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

2.5 Design and implementation of the electromechanical platform

Given that airborne radar has limited angular scanning, an external electromechanical platform was designed to allow controlled rotation of the radar assembly, enabling extended angular coverage in a terrestrial environment.

The platform design considered criteria such as structural stability, angular precision, and synchronization with the data acquisition system. Electric actuators and control systems capable of ensuring smooth and repeatable movement were selected, minimizing vibrations that could affect the quality of the radar signal.

Mechanical integration was performed in a non-invasive manner, ensuring that the radar could operate within its original specifications.

2.6 Development of control and visualization software

In addition, control software was developed to coordinate the rotation of the electromechanical platform and the acquisition of data from the radar. This software synchronizes the angular orientation of the sensor with the decoded meteorological information, generating a coherent representation of the observed environment.

Data visualization was implemented using a graphical interface that displays meteorological information based on the angle of exploration, facilitating the interpretation of results and functional validation of the adapted system.

2.7 Experimental validation procedure

The system was validated through experimental tests in a controlled terrestrial environment, aimed at verifying the correct operation of each subsystem and the integrated assembly. The procedure included: (i) verification of mechanical stability during rotation, (ii) validation of ARINC frame acquisition and decoding, and (iii) evaluation of the consistency between the angular orientation of the radar and the information displayed.

The results obtained in this phase confirmed the technical feasibility of the proposed system and laid the foundations for its quantitative analysis, presented in the results section.

3. THEORETICAL FRAMEWORK

3.1 Airborne weather radar

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

These systems commonly operate in the X-band, using Doppler-capable pulse radar techniques, which allow both the reflectivity and radial velocity of meteorological targets to be estimated [13].

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

Unlike ground-based weather radars, its angular scan pattern is limited to a frontal sector, defined by the beam's angle of elevation relative to the aircraft's longitudinal axis. This feature responds to its primary function of early detection of weather threats in flight path [14].

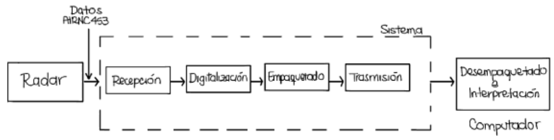

Fig. 3. General communication architecture of the ART-2000 weather radar.

The high electromechanical robustness and precision of digital processing mean that these systems retain a high technological value even after being withdrawn from aeronautical service, opening the possibility of their reuse in terrestrial applications, provided that the limitations inherent in their original design are adequately resolved.

3.2 Principles of Doppler radar applied to meteorology

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

In coherent pulse radars, Doppler measurement is obtained by analyzing the phase between consecutive pulses, which requires high stability of the local oscillator and precise digital processing [16]. Airborne weather radars incorporate these principles through proprietary algorithms embedded in their internal processors, whose results are transmitted to display systems via standardized protocols [17].

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

3.3 ARINC aeronautical communication protocols applied to radar

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 meteorological information from the radar to the cockpit displays [19].

This protocol encapsulates parameters such as reflectivity intensity, operating modes, system status, and weather alerts, organized into strictly timed data words. Although the standard defines the general structure, the specific implementation may vary between manufacturers, introducing an additional degree of complexity for external decoding [20].

From a technological reuse perspective, the ability to correctly interpret ARINC frames is a fundamental enabler, as it allows access to the information processed by the radar without interfering with its internal architecture, preserving the integrity of the original system.

3.4 Electromechanical guidance platforms for ground-based radars

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

In the case of adapting an airborne radar, it is necessary to incorporate an external electromechanical platform that compensates for the angular scanning limitation inherent in the original design. Such a platform must ensure structural stability, positioning accuracy, and synchronization with the data acquisition system, without introducing vibrations or interference that degrade the quality of the radar signal [22].

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

The Manchester decoding process was mathematically modeled considering the bit-level timing constraints imposed by the ARINC 453 protocol. Given a bit period T_b, each logical value is encoded in two half-bit intervals with 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 Vc corresponds 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	Función
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	Operating 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 about the radar's operating status (the header function). Table 1 shows the data contained in this portion

- Tag: Always the octal number 055 or binary 10110100.
- Control acceptance: Indicates whether the ARINC 429 control signal input was properly received and

accepted. Typical possible cases can be seen 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 set to 0 and indicate that the radar has entered a specific mode when activated. Table 3 shows the typical meaning for each of these bits.

***Table 3:** Mode announcement bits and their meaning*

Bit	Mode announcement
14	Turbulence alert detected
15	Weather alert detected
16	Noise filtering circuit is operating
17	Small sector scan
18	Aircraft altitude or pitch exceeds range

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

***Table 4:** Faults identified in the frame header [14].*

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

- Operating mode: Indicates the current operating mode of the radar. 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	Operating 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

Elevation: Indicates the angle of elevation of the radar. The typical values for each bit can be seen in Table 6.

***Table 6:** Values for each elevation bit [14].*

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

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

***Table 7:** Typical values for the gain section.*

Bit 42	Bit 41	Bit 40	Bit 39	Bit 38	Bit 37	Gain
1	1	1	1	1	1	Mín
0	0	0	0	0	0	Max
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 scanning range in nautical miles. Table 8 shows typical values for this case.

***Table 8:** Typical values for the range section.*

Bit 48	Bit 47	Bit 46	Bit 45	Bit 44	Bit 43	Rango en 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

- Data acceptance: Indicates that the input data is correct and accepted. The typical values for this section are shown in Table 9.

***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.

3.5 Technological reuse of aeronautical systems

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

However, the reuse of airborne weather radars presents challenges associated with their critical nature, closed architecture, and dependence on aeronautical standards. Therefore, any adaptation process must be based on a thorough understanding of the physical principles, communication protocols, and operational limitations of the original system.
This work follows this line of thinking, proposing a technically sound and experimentally validated adaptation geared toward tactical terrestrial applications.

4. RESULTS

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

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

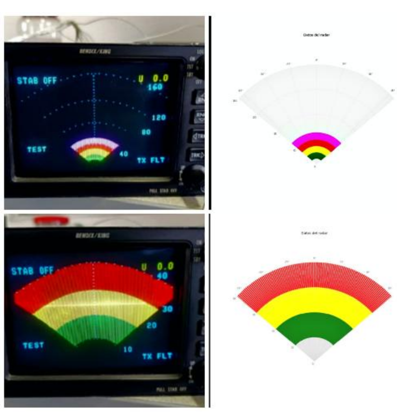

Fig. 4. *Display of the ART-2000 weather radar in TEST mode [24].*

To ensure synchronization between the recovered clock and the transmitted signal, a time tolerance of ±25% (Δt=0.25T_b) was implemented, allowing for stable frame reconstruction even in the presence of jitter or propagation delays. This adjustment, aligned with the synchronization patterns described in the ARINC 453/708 standards, ensures accurate frame delimitation under conditions of temporal variability.

The implementation of the Manchester decoding algorithm incorporated a time tolerance of ±25% with respect to the nominal bit period, allowing for robust frame reconstruction even in the presence of jitter and temporal variations. The reconstructed frames had a consistent 1600-bit structure, consisting of a 64-bit header and a 1536-bit data block.

4.2 Reconstruction of meteorological information and reflectivity mapping

The decoded data corresponding to each ARINC-453 frame were segmented into 512 pixels of meteorological information per scan line, with an angular resolution of 1°. Each pixel was interpreted using a 3-bit coding scheme associated with discrete levels of meteorological reflectivity.

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

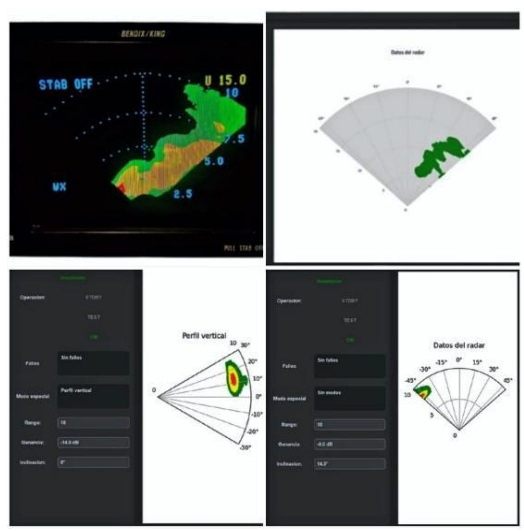

Fig. 5. *ARINC 453 signal reconstructed by digital processing.*

4.3 Cross-validation with the aeronautical display system

To validate the accuracy of the developed system, 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 coding, and angular synchronization.

The cross-validation results showed a correspondence of more than 95% in the intensity and color coding of the meteorological 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	Interface developed	Correspondence (%)
Reflectivity intensity	0–60 dBZ	0–60 dBZ	96,4
Color coding	5 niveles	5 niveles	95,7
Angular synchronization	1° ± 0,25°	1° ± 0,25°	97,1

4.4 Temporary performance and system stability

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

System stability was confirmed during extended testing, with no synchronization losses or critical frame reconstruction errors, validating its viability for tactical ground applications.

4.5 Data visualization and representation results

The visualization of the decoded data allowed the representation of meteorological information based on the radar's scanning angle, generating a sector map according to the instantaneous orientation of the sensor. The developed graphical interface facilitated the identification of areas of higher reflectivity, as well as the interpretation of the system's operational status.

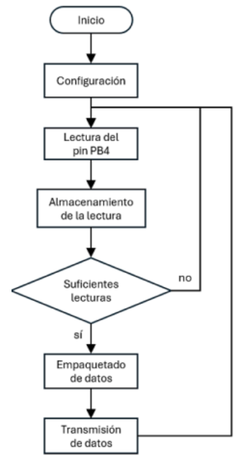

Fig. 6. *Flowchart representing the program's interpretation logic in the system.*

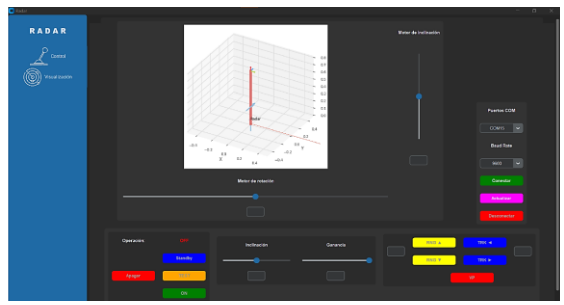

Fig. 7. *Graphical interface developed for radar system control.*

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

The GUI is structured into several functional modules:

- Side navigation panel: Includes access to the radar's Control and Display sections.
- Central 3D display: Represents the digital twin of the radar, showing its spatial orientation using tilt and rotation motors.
- Movement 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, update, or disconnect the link with the microcontroller.
- Radar operation panel: Allows you to activate modes such as Standby, TEST, ON, and Off, as well as adjust parameters such as tilt, gain, range, and tracking.

This interface facilitates direct interaction with the embedded system, allowing visual monitoring of the radar status and precise manipulation of its operating parameters. Its modular and functional design is geared towards real-time control applications, system testing, and radar behavior simulation.

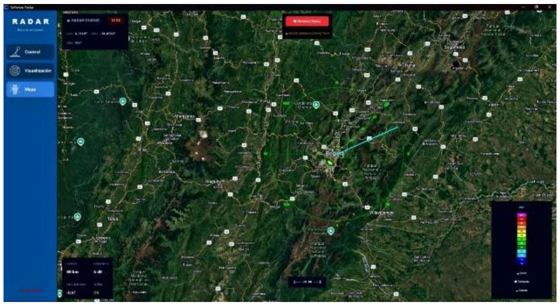

Fig. 8. *Graphical interface developed for radar system data visualization.*

Figure 6 shows the display interface of the ART 2000 weather system. Here you can see the radar data. This interface allows us to georeference and display precipitation data, operational status, and technical parameters of the radar.

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

4.6 Summary of experimental results

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

Table 11. Summary of experimental results for 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 accurate	Repeatable movement
System integration	Functional	Coordinated operation

5. DISCUSSION

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

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

In this sense, the results are in line with previous studies that highlight the potential for reuse of aeronautical sensors when the correct interpretation of their communication protocols is guaranteed.

From a signal processing perspective, the implementation of the Manchester decoding algorithm with time tolerance proved to be an effective strategy for mitigating the effects of jitter and temporal variations inherent in digital transmission. This approach enabled stable reconstruction of ARINC frames, ensuring synchronization between meteorological information and the angular position of the radar.

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

The integration of an external electromechanical platform made it possible to overcome one of the main limitations of the original airborne radar design: its sectoral angular scanning. By enabling controlled rotation of the radar assembly, the adapted system achieves expanded spatial coverage without compromising signal quality or synchronization of the acquired data. This result demonstrates that transforming an aeronautical sensor into a ground-based system does not necessarily require complex internal modifications, but rather 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 range, volumetric capabilities, and advanced features such as dual polarimetry. The solution presented should be understood as a tactical, modular, and lower-cost alternative, geared toward scenarios where infrastructure, resources, or deployment time are limited. This scope limitation is key to properly contextualizing the results and avoiding interpretations that extrapolate beyond the actual capabilities of the system.

Finally, from a scientific and technological perspective, the work provides a documented and reproducible methodology for the reuse of 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 foundation for future research aimed at optimizing data processing, integration into terrestrial meteorological networks, and expanding the functional capabilities of the system.

6. CONCLUSIONS AND FUTURE WORK

This work demonstrated the technical feasibility of reusing an airborne weather radar as a tactical ground 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 meteorological 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 meteorological information, made it possible to reproduce the behavior of the original aeronautical display system with high fidelity. The cross-validation performed showed a correspondence of more than 95% in reflectivity intensity, color coding, and angular synchronization, confirming the consistency and accuracy of the developed system.

The integration of an externally oriented electromechanical platform effectively resolved the angular scanning limitation inherent in the airborne design, enabling expanded spatial coverage in terrestrial environments. 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, flexible-deployment technological alternative for meteorological observation in tactical, temporary, or infrastructure-limited scenarios. While the system does not replace conventional large-scale surface weather radars, it offers sufficient functional capabilities to support operational decision-making and localized atmospheric monitoring.

Future work includes optimizing digital processing algorithms to improve the spatial and temporal resolution of the information presented, as well as integrating the system into terrestrial meteorological networks and data fusion platforms. In addition, the system's performance under various meteorological conditions will be evaluated, and it will be scaled up to multi-sensor configurations that expand its operational range.

7. CONFLICT OF INTEREST

The authors confirm that this work has not been used or published elsewhere. The authors also confirm that there are no conflicts of interest.

8. REFERENCES

[1] IDEAM, "CLIMA - IDEAM". Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: http://archivo.ideam.gov.co/web/tiempo-y-clima/clima

[2] J. C. Daza Rincón, R. E. Ucros Rojas, y L. F. Mónico Muñoz, "Análisis de la influencia de la meteorología adversa en las operaciones aéreas", *Cienc. Poder Aéreo*, vol. 20, núm. 1 (Enero-Junio), pp. 59–67, 2025.

[3] Contraloría, "Contraloría General logra resarcimiento por $22 mil millones, con la puesta en funcionamiento de 4 radares meteorológicos del IDEAM", Contraloria. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://www.contraloria.gov.co/w/contraloria-general-logra-resarcimiento-por-22-mil-millones-con-la-puesta-en-funcionamiento-de-4-radares-meteorologicos-del-ideam

[4] IDEAM, "¿Qué es un radar meteorológico? Ideam explica cómo esta tecnología permite monitorear el clima en Colombia | Instituto de Hidrología, Meteorología y Estudios

Ambientales”. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://www.ideam.gov.co/sala-de-prensa/noticia/que-es-un-radar-meteorologico-ideam-explica-como-esta-tecnologia-permite-monitorear-el-clima-en

[5] “Avionics Source: New & Used Avionics Sales. Instruments. Aircraft Parts. Pilot Supplies.”, AvionicsSource.com. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://avionicssource.com/

[6] J. M. Quiroga, “Primeros desarrollos de tecnología radar en los principales beligerantes de la II Guerra Mundial. Un análisis desde la perspectiva Ciencia, Tecnología y Sociedad”, *Cienc. Docencia Tecnol.*, vol. 29, núm. 57, pp. 36–59, 2018.

[7] Aeronaves y aviación, “Radar meteorológico de avión: todo lo que debes saber sobre esta tecnología indispensable - Aeronaves y Aviación”, el 9 de septiembre de 2024. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://aeronavesyaviacion.com/radar-meteorologico-de-avion/

[8] Training weather services, “History of RADAR”. Consultado: el 27 de junio de 2025. [En línea]. Disponible en: https://training.weather.gov/nwstc/NEXRAD/RADAR/Section1-1.html

[9] B. M. Ferber y T. A. da Silva, “INTERPRETAÇÃO DO RADAR METEOROLÓGICO E A TOMADA DE DECISÃO: UMA DISCUSSÃO ACERCA DO CONHECIMENTO ADQUIRIDO SOBRE METEOROLOGIA NOS CURSOS DE FORMAÇÃO DE PILOTO COMERCIAL NO BRASIL: INTERPRETATION OF WEATHER RADAR AND DECISION MAKING: A DISCUSSION ABOUT THE METEOROLOGICAL KNOWLEDGE ACQUIRED IN COMMERCIAL PILOT TRAINING COURSES IN BRAZIL”, *Rev. Bras. Aviação Civ. Ciênc. Aeronáuticas*, vol. 3, núm. 3, pp. 151–180, jul. 2023.

[10] V. Guerrero, “Radar Meteorológico de los Aviones | Museo Aeronáutico de Málaga”. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://aeromuseo.org/radar-meteorologico-de-los-aviones/

[11] “Con una inversión de $345.000 millones la Aerocivil adquirirá 14 radares”. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://caracol.com.co/2023/08/16/con-una-inversion-de-345000-millones-la-aerocivil-adquirira-14-radares/

[12] TEDAE, “Los mecanismos de seguridad en los aviones ante fenómenos meteorológicos adversos”, TEDAE. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://tedae.org/aeronautica/los-mecanismos-de-seguridad-en-los-aviones-ante-fenomenos-meteorologicos-adversos/

[13] ScienceDirect, “Radar de banda X: una visión general | Temas de ScienceDirect”. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://www.sciencedirect.com/topics/engineering/x-band-radar

[14] R. O. Cubillos Sánchez, E. G. Vargas, O. D. Montoya, R. O. Cubillos Sánchez, E. G. Vargas, y O. D. Montoya, “Modelo para la Detección y Eliminación de Ecos de Tierra en Radares Meteorológicos en Banda C”, *Cienc. En Desarro.*, vol. 15, núm. 1, pp. 70–83, jun. 2024, doi: 10.19053/01217488.v15.n1.2024.16631.

[15] L. P. S. Maldonado, “Implementación y evaluación de un sistema de asimilación de datos de radar meteorológico en escala convectiva para el desarrollo de un sistema de pronóstico por ensambles a muy corto plazo”, 2022.

[16] D.-I. (FH) C. Wolff, “Fundamentos de radar - Coherencia”. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://www.radartutorial.eu/11.coherent/co05.es.html

[17] A. B. Technology, “Avionics Test & Simulation Terms and Definitions”, 2020, [En línea]. Disponible en: https://www.acalbfi.com/media/pdf/Whitepaper-Avionics-test-and-simulation-terms-and-definitions.pdf

[18] A. E. de Meteorología, “Interpretación - Agencia Estatal de Meteorología - AEMET. Gobierno de España”. Consultado: el 27 de junio de 2025. [En línea]. Disponible en: https://www.aemet.es/es/eltiempo/observacion/radar/ayuda

[19] Astronics, “Tutoriales de bus de datos de aviónica | Astronics”. Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://www.astronics.com/avionics-databus-tutorials

[20] “Alta ARINC Summary”. Consultado: el 15 de octubre de 2025. [En línea]. Disponible en: https://www.altadt.com/wp-content/uploads/dlm_uploads/2013/11/ARINC-Protocol-Summary.pdf

RCTA
Revista Colombiana de Tecnologías de Avanzada
UNIPAMPLONA

[21] S. Lee, “The Science Behind Radar: Atmospheric Insights”. Consultado: el 27 de junio de 2025. [En línea]. Disponible en: https://www.numberanalytics.com/blog/science-behind-radar-atmospheric-insights

[22] I. Yuste Avilés, “Impacto de la meteorología en la operativa aeroportuaria: análisis en el aeropuerto de Bilbao”, jun. 2023, Consultado: el 30 de diciembre de 2025. [En línea]. Disponible en: https://titula.universidadeuropea.com/handle/20.500.12880/5196

[23] ibreTex, “8.2: Weather Radars - Geosciences LibreTexts”. Consultado: el 27 de junio de 2025. [En línea]. Disponible en: https://geo.libretexts.org/Bookshelves/Meteorology_and_Climate_Science/Practical_Meteorology_(Stull)/08%3A_Satellites_and_Radar/8.02%3A_Weather_Radars

[24] “HONEYWELL BENDIX/KING RDR 2000 INSTALLATION MANUAL Pdf Download”, ManualsLib. Consultado: el 15 de octubre de 2025. [En línea]. Disponible en: https://www.manualslib.com/manual/3351223/Honeywell-Bendix-King-Rdr-2000.html