Expandable Radio Observation System (EROS)

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Abstract

The Expandable Radio Observation System (EROS) introduces a novel solution to a longstanding limitation in conventional radio telescopes: the fixed, large-diameter dish. Such systems face challenges in detecting the weak or distant cosmic signals due to limited collecting area, resulting in reduced sensitivity and angular resolution.

Our proposed design features a telescopic sliding-panel mechanism, inspired by the folding mirror concept of the James Webb Space Telescope (JWST). This mechanism allows the dish to expand from 5 meters to 7.5 meters using lightweight yet structurally stable panels, driven by compact electric motors.

The expansion increases the effective collecting area, resulting in a 2.25× improvement in sensitivity and an approximate 33% enhancement in angular resolution. Simulation results demonstrate improved signal clarity, greater temporal stability, and higher signal-to-noise ratio (SNR), enabling detection of weaker signals previously undetectable by smaller telescopes.

EROS offers an efficient and low-maintenance solution for research and educational applications by combining high-performance radio observation capabilities with practical and scalable mechanical design.

Introduction / Background

Radio telescopes are essential astronomical instruments that detect naturally occurring radio waves emitted by celestial objects. These telescopes typically use large parabolic dishes to collect and focus weak signals onto sensitive receivers. However, traditional fixed-diameter dishes face significant limitations: their restricted collecting area leads to reduced sensitivity and limits their ability to detect faint or distant signals.

One promising approach to overcome this limitation is to expand the effective diameter of the dish, thereby increasing the telescope's sensitivity and resolution. Drawing inspiration from advanced space telescopes like the James Webb Space Telescope (JWST), our proposed system introduces a ground-based expandable radio telescope. This design dynamically increases the dish diameter as needed, allowing for improved signal detection across a wider frequency range while maintaining a compact form factor when not fully expanded.

System Model / Methodology

An analysis of radio telescope performance versus dish diameter revealed that expanding the diameter by a factor of 1.5× results in:

- An approximate 33% gain in angular resolution.
- A 2.25× improvement in signal sensitivity.

As shown in Table 1, a comparison with existing educational and research telescopes, including the University of the Philippines Radio Telescope (5.0 meters), the Malaysian Radio Observatory (7.3 meters), and the Leighton Radio Telescope (10.4 meters), demonstrates that a 1.5× to 2.0× expansion ratio offers the optimal balance between enhanced performance and manageable mechanical cost.

Therefore, extending the dish from 5 meters to 7.5 meters is determined to be the most suitable approach for research and educational applications.

The sliding-panel telescopic expansion mechanism was selected based on several engineering advantages:

- Higher structural stiffness.
- Greater resistance to wind loading and vibrations.
- Reduced friction and lower maintenance requirements.
- Lightweight construction.
- minimized mechanical hazards.

Mechanism Overview:

The outer dish consists of integrated telescopic sliding panels that form part of the primary structure. When expansion is needed, the panels smoothly extend using precise, compact electric motors, increasing the effective dish diameter from 5 to 7.5 meters without requiring external support arms.

Table 1. Comparison of Research and Educational Radio Telescopes.

Telescopes	Radius	Angular Accuracy θ	Rotation Speed
PNU	5.0 m	2.94°	—
PNU(Expandable)	7.5 m	~1.9°	—
Malaysia RT	7.3 m	1.65°	—
Leighton	10.4 m	1.41°	min/40°

Proposed Solution / Main Idea

The proposed system introduces a telescopic sliding-panel mechanism that allows the primary dish to expand dynamically from a radius of 5 meters to 7.5 meters. This expansion significantly increases the effective collecting area, enhancing the telescope's sensitivity and enabling the detection of weaker and more distant cosmic radio signals.

The design is inspired by the foldable mirror architecture of the James Webb Space Telescope (JWST), which optimized large-scale performance within strict space constraints. Similarly, our ground-based adaptation employs a sliding mechanism that offers scalable, high-performance radio signal observation while maintaining structural efficiency and mechanical simplicity

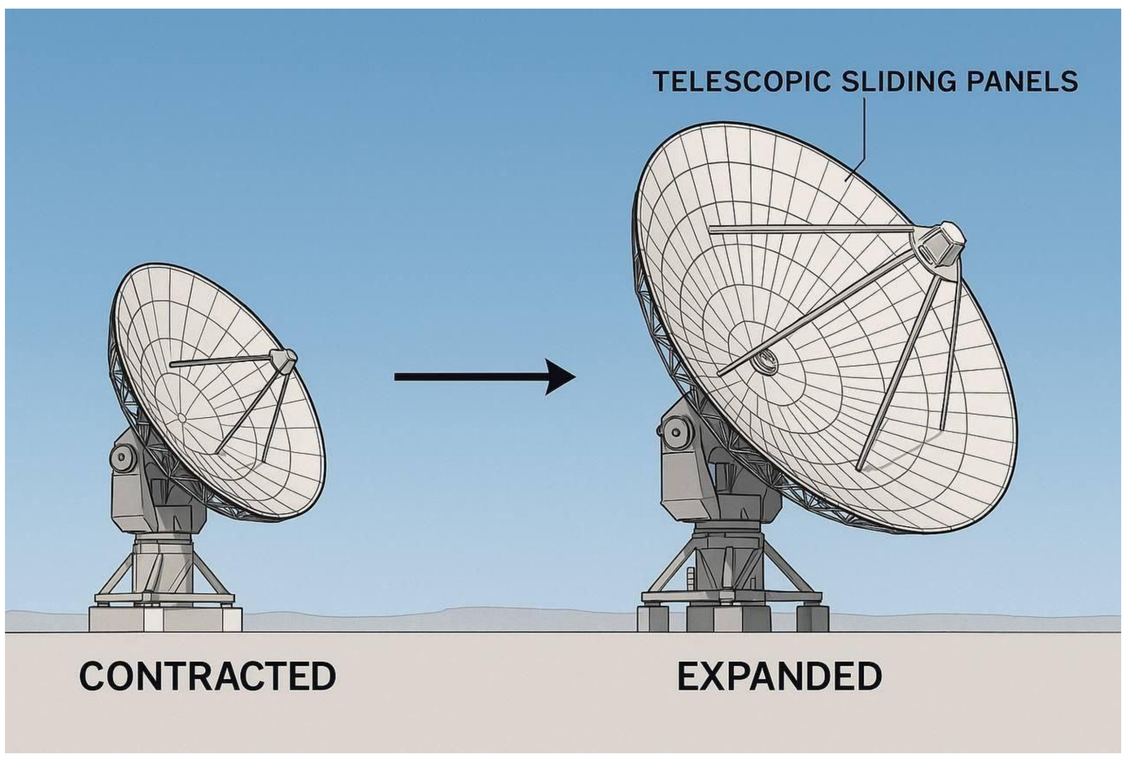


Figure 1. Proposed Design Model of a Telescopic Radio Antenna with Sliding Panels.

Results / Simulation / Discussion

Based on a comparative analysis of expansion strategies, the optimal solution involved increasing the dish diameter from 5.0 meters to 7.5 meters using a telescopic sliding-panel mechanism. This modification led to a substantial improvement in signal reception performance.

Before expansion, the telescope detected signals in the 1416.4 MHz to 1424.4 MHz range, with an average signal strength of approximately 0.00111. Detection was limited to relatively strong signals, and resolution remained moderate.

After expansion, and with a 2.25× increase in sensitivity and ~33% improvement in angular resolution:

- The same frequency band (1416.4–1424.4 MHz) exhibited clearer and more stable signal reception.
- The system successfully detected weaker signals that were previously undetectable.
- The average signal strength increased to ~0.00250, indicating improved performance in low-power and high-noise environments.
- Both signal-to-noise ratio (SNR) and angular resolution were significantly enhanced, facilitating more accurate and reliable data collection from deep space sources.

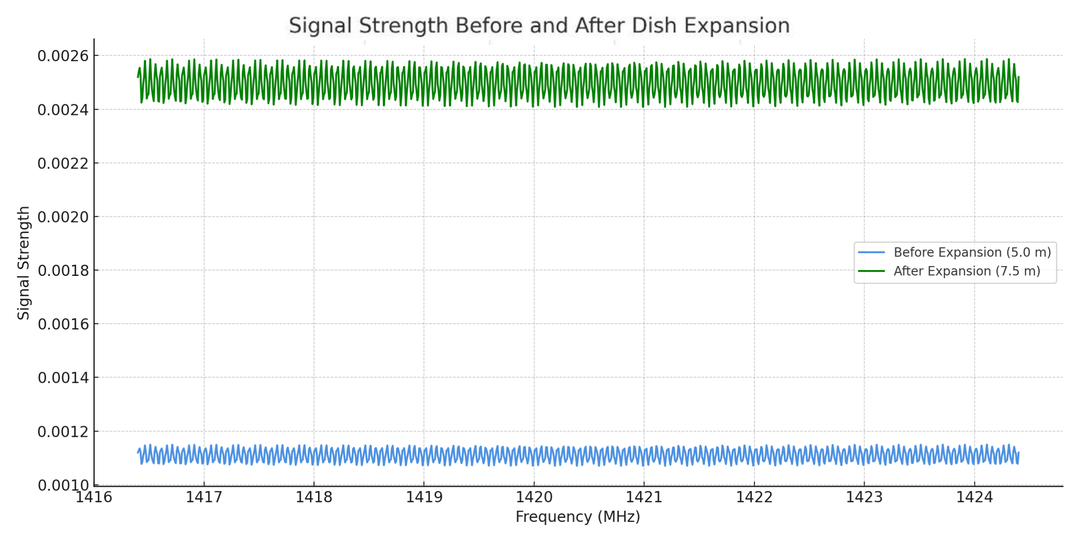


Figure 2. Signal Strength Before and After the Dish Expansion.

Conclusions

The Expandable Radio Observation System presents a practical and innovative response to the long-standing challenge of low sensitivity in fixed-diameter radio telescopes. By incorporating a telescopic sliding-panel mechanism, the system enables dynamic expansion from 5 to 7.5 meters, significantly enhancing its observational capabilities.

This design offers a compelling balance between performance and practicality, improving sensitivity and resolution without compromising structural stability or increasing mechanical complexity. Its ease of use, durability, and low maintenance make it especially suited for educational and mid-scale research environments.

Ultimately, this project introduces a scalable, cost-effective approach that makes advanced radio astronomy more accessible to institutions and researchers, bridging the gap between high-performance engineering and real-world application.

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References

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