



# The Race to Ubiquitous Connectivity: How ESAs Are Redefining Global Communications

The promise of seamless, high-speed internet access everywhere on Earth, from urban centers to remote oceans and aviation routes, remains one of the most compelling infrastructure challenges of our era. Despite advances in terrestrial networks, significant coverage gaps persist, limiting economic development and emergency response capabilities in underserved regions.

Electronically Steerable Arrays (ESAs) operating in the Ka-Band spectrum represent the technological breakthrough bridging Low Earth Orbit (LEO) satellite constellations and ground terminals. These sophisticated phased array systems eliminate mechanical tracking limitations while enabling the multi-gigabit throughput necessary for next-generation applications.

# Understanding Electronically Steerable Arrays

## The Technology Foundation

Electronically Steerable Arrays fundamentally reimagine satellite ground terminals by replacing mechanical actuators with solid-state beam control. Unlike traditional parabolic dish antennas that physically rotate to track satellites, ESAs manipulate electromagnetic phase relationships across hundreds or thousands of individual radiating elements to redirect signal beams instantaneously.

This phase-controlled architecture enables capabilities impossible with mechanical systems: simultaneous tracking of multiple satellites, beam steering in milliseconds rather than seconds, and operation in mobile environments without stabilization platforms. The result is a terminal that can seamlessly hand off between satellites in a LEO constellation without service interruption.

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### Element Array

Hundreds of antenna elements arranged in a planar configuration

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### Phase Control

BFICs adjust signal phase at each element

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### Beam Formation

Constructive interference creates directional beam

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### Dynamic Steering

Electronic adjustment enables instant tracking

# ESAs vs. Mechanical Dishes: A Paradigm Shift

## Mechanical Dish Antennas

- Physical motors and gimbals for tracking
- Limited to single satellite at a time
- Vulnerable to mechanical wear and failure
- Large, bulky form factor unsuitable for mobile applications
- Seconds-long handoff times between satellites
- Significant installation and maintenance costs

## Electronically Steerable Arrays

- Solid-state beam steering with no moving parts
- Simultaneous multi-satellite connectivity
- Enhanced reliability and reduced maintenance
- Low-profile, aerodynamic designs for vehicles and aircraft
- Millisecond beam switching for seamless handoffs
- Scalable manufacturing with semiconductor processes

The architectural advantages of ESAs become critical in LEO constellation scenarios where satellites traverse the sky in minutes. Traditional dishes cannot reacquire signals fast enough to maintain service continuity, while ESAs track dynamically without interruption. However, this performance requires sophisticated Beamforming Integrated Circuits (BFICs) - specialized semiconductors that manage phase and amplitude control across the array with nanosecond precision.

# The Ka-Band Spectrum: High Throughput at High Frequencies

The Ka-Band, spanning approximately 26.5 to 40 GHz, has emerged as the preferred spectrum allocation for next-generation satellite communications and 5G backhaul infrastructure. This frequency range offers fundamental physics advantages that make it ideal for high-throughput applications, despite historical concerns about atmospheric attenuation.

## Massive Bandwidth Availability

Ka-Band provides significantly wider channel allocations compared to legacy C-Band and Ku-Band systems. This expanded bandwidth directly translates to multi-gigabit data rates, essential for supporting bandwidth-intensive applications like 4K video streaming, cloud computing, and IoT sensor networks in remote locations.

## Smaller Antenna Apertures

Higher frequencies enable effective communication with physically smaller antennas due to the inverse relationship between wavelength and aperture size. This allows ESA terminals to achieve high gain in compact, low-profile form factors suitable for maritime vessels, aircraft, and ground vehicles, applications where large dishes are impractical.

## Spectrum Efficiency and Reuse

Ka-Band's propagation characteristics enable aggressive frequency reuse patterns through spot beam architectures. Satellite operators can deploy dozens of beams covering different geographic areas using the same spectrum, multiplying effective system capacity without additional orbital slots.



# Overcoming Ka-Band Challenges



## Rain Fade Mitigation

The primary historical limitation of Ka-Band has been susceptibility to rain fade - signal attenuation caused by water droplets absorbing electromagnetic energy at these frequencies. Modern systems address this through multiple strategies:

- **Adaptive coding and modulation (ACM)** dynamically adjusts signal parameters based on link conditions
- **Site diversity** leverages geographically separated ground stations to route around weather cells
- **Power margin allocation** in link budgets accounts for statistical fade events
- **Higher-order modulation schemes** maximize throughput during clear-sky conditions

LEO constellation architectures inherently improve rain fade resilience through satellite diversity; multiple satellites visible simultaneously provide alternative paths when one link experiences weather-induced degradation.



# Case Study: Sivers Semiconductors and Doosan Corporation

## Accelerating Commercial ESA Panel Deployment

The partnership between Sivers Semiconductors and Doosan Corporation exemplifies the commercialization trajectory of Ka-Band ESA technology. This strategic collaboration addresses the two critical bottlenecks in mass-market adoption: advanced semiconductor availability and manufacturing scalability.



### Silicon Innovation

Sivers supplies Ka-Band BFICs integrating transmit/receive chains, phase shifters, and power amplifiers in monolithic designs



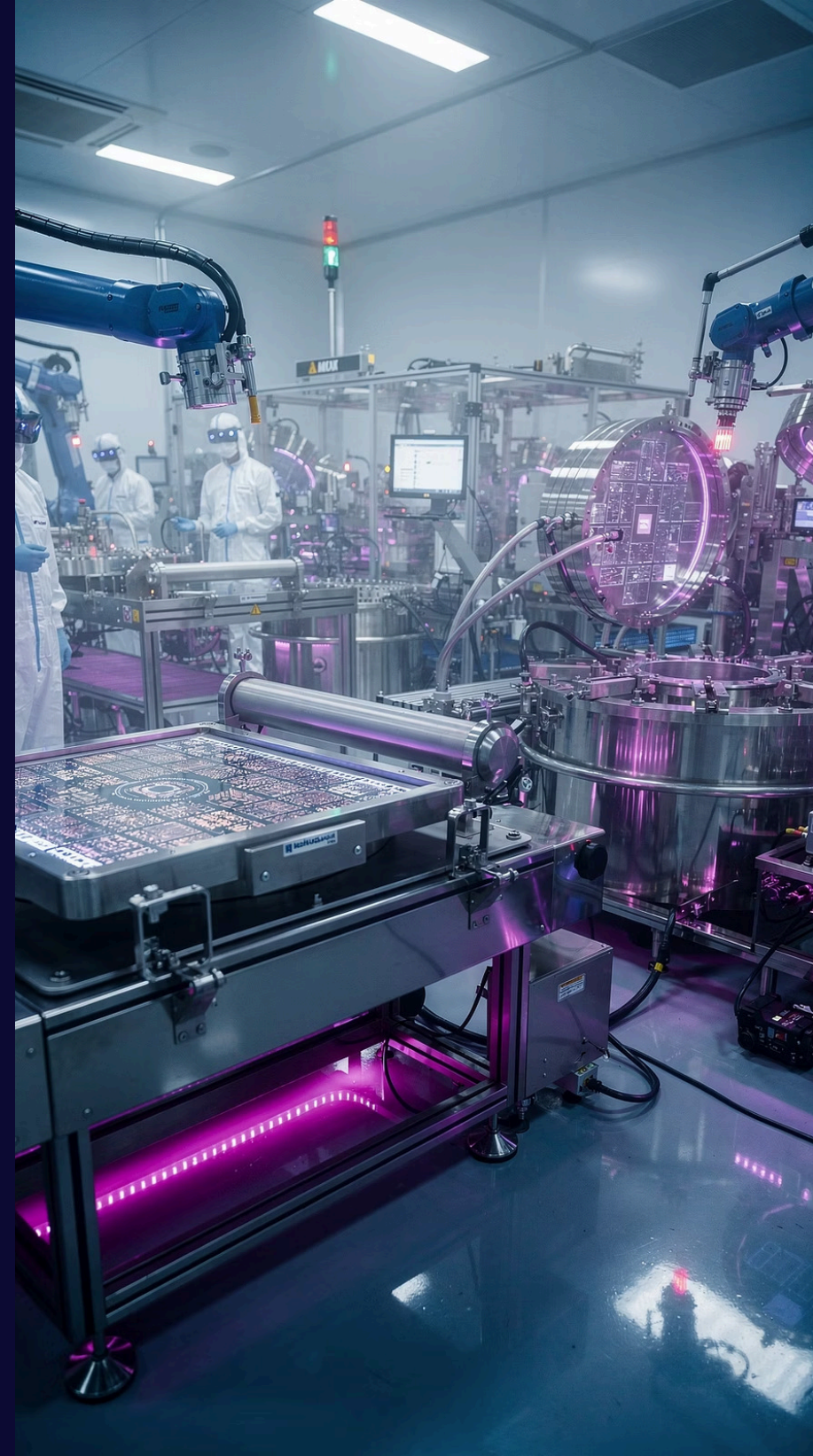
### Manufacturing Scale

Doosan provides advanced PCB fabrication, array assembly, and system integration capabilities for volume production



### Multi-Orbit Terminals

Combined solution enables ESA panels supporting GEO, MEO, and LEO constellation architectures

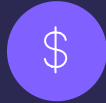


# Strategic Importance of the Partnership



## Korean SATCOM Infrastructure

The partnership specifically targets Korea's emerging satellite communications ecosystem, supporting domestic constellation development and ground segment manufacturing. This aligns with national strategic initiatives to establish sovereign space-based connectivity capabilities independent of foreign infrastructure.



## \$1.5M Development Contract

The initial development contract validates commercial traction and funds engineering optimization for production-ready designs. This milestone demonstrates that ESA technology has progressed beyond research prototypes to investor-backed product development with clear customer demand.



## Global Market Positioning

By combining European semiconductor expertise with Asian manufacturing efficiency, the partnership creates a competitive offering for international SATCOM markets. The scalable production model enables cost structures necessary for mass-market applications beyond premium maritime and aviation segments.

This collaboration represents a microcosm of the broader industry trend: specialized semiconductor designers partnering with established manufacturers to bridge the gap between laboratory innovation and commercial deployment at scale.

# Multi-Orbit Architecture: The Future of SATCOM

600km

**LEO Altitude**

Low latency, high bandwidth

8,000km

**MEO Altitude**

Regional coverage balance

36,000km

**GEO Altitude**

Continuous hemispheric service

## Hybrid Constellation Strategy

Next-generation SATCOM architectures leverage multiple orbital regimes simultaneously, optimizing for latency, coverage persistence, and capacity. ESA terminals must dynamically allocate resources across this heterogeneous infrastructure:

- **LEO constellations** provide ultra-low latency (20-40ms) and massive aggregate capacity through frequency reuse across thousands of satellites
- **MEO systems** offer regional coverage with moderate latency, serving as a middle layer for specific service areas
- **GEO satellites** maintain continuous coverage for broadcast and backup connectivity, especially critical for maritime and remote applications

ESAs uniquely enable terminals to participate in this multi-orbit ecosystem, seamlessly switching between constellation types based on application requirements, service availability, and economic optimization.



# Industry Transformation: Applications and Impact

## Aviation Connectivity

ESA terminals enable gate-to-gate broadband service for commercial and business aviation. The low-profile form factor minimizes aerodynamic drag while maintaining multi-gigabit connectivity for passenger Wi-Fi and operational data links.

## Autonomous Vehicles

Self-driving systems require continuous connectivity for HD mapping updates, fleet coordination, and teleoperation during edge cases. Ka-Band ESAs provide the throughput and reliability necessary for safety-critical automotive applications.

## Rural Broadband

Fixed wireless access via LEO constellations closes the digital divide in areas where fiber deployment is economically unviable. Residential ESA terminals provide fiber-equivalent speeds at dramatically lower infrastructure costs than terrestrial alternatives.

## Maritime Operations

Commercial shipping, offshore energy platforms, and passenger vessels benefit from always-available connectivity across oceanic routes. ESAs eliminate service gaps that plagued GEO-only systems while supporting crew welfare and operational efficiency applications.

# Convergence Point: Making Global Connectivity Reality

The maturation of electronically steerable arrays, Ka-Band spectrum utilization, and semiconductor manufacturing efficiency represents a technological convergence point that makes ubiquitous global connectivity economically and technically feasible for the first time.



The convergence of advanced semiconductor integration, high-frequency spectrum exploitation, and multi-orbit network architectures is transforming satellite communications from a specialized capability into universal infrastructure. ESA technology sits at the center of this transformation, enabling the ground segment to match the sophistication of space-based assets.

As partnerships like Sivers-Doosan demonstrate commercial traction and production-scale manufacturing comes online, the vision of seamless connectivity, from autonomous vehicles traversing remote highways to aircraft crossing polar routes, transitions from aspiration to engineering reality. The implications extend beyond consumer convenience to fundamental questions of economic development, emergency response capability, and technological sovereignty in an increasingly connected world.