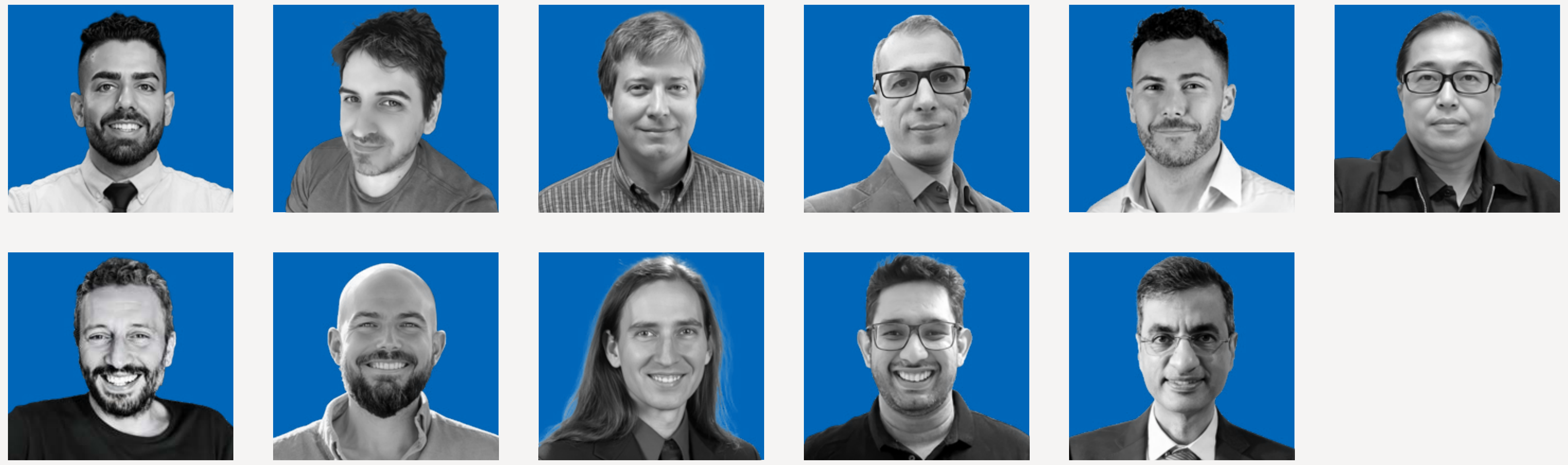
11 Experts Discuss Designing Space Electronics for the New Space Race



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MOUSER ELECTRONICS

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Meet Our Experts

Today's space systems—whether large constellations, fast-launch satellites, or software-defined payloads—are increasingly defined by the demands of flexibility and resilience. We interviewed eleven experts about the critical role of electronic subsystems in these environments and how engineers are addressing challenges in power delivery, RF performance, thermal management, and data movement through radiation-tolerant designs, integrated solutions, and future-ready technologies.

We hope you enjoy their insights!

David Rogelberg

David Rogelberg
Publisher,
Mighty Guides Inc.
david@mightyguides.com
(516) 234 2969

Amir Bigdeli
Lead Electrical Engineer,
K2 Space Corporation

Sebastián Caccavallo
Satellite Communication Engineering,
Satellogic

Chris Chipman
Space Segment Marketing Director,
Analog Devices

Giovanni De Luca
Senior Systems Engineer,
Thales Alenia Space

Eliot Fine
Product Line Manager,
Analog Devices

Mark Foo
Marketing Manager,
Analog Devices

Gianluca Furano
Senior Data Systems Engineer,
European Space Agency

Jeff Massman
Phased Array Sensors Leader,
Analog Devices

Jason Sekanina
Principal Engineer,
Technical Marketing, μModule Business Development & Product Apps,
Analog Devices

Naman Vaidya
Lead Electrical Engineer,
Pixxel

Hossein Yektaii
Wireless System Architect,
Analog Devices

Introduction

Space electronics have changed more in the last five years than in the previous two decades.

From a technology standpoint, software-defined payloads are steadily replacing fixed-function hardware to support more dynamic mission profiles. To support this flexibility, engineers are pushing data conversion closer to the antenna, reducing latency, and enabling tighter control over RF performance. At the same time, teams are relying more heavily on onboard processing to adapt capacity in real time, allowing satellites to respond to changing demand and link conditions without physical reconfiguration.

These architectural changes coincide with equally significant logistical shifts. Recent years have seen launch cadence increase dramatically while large satellite constellations are replacing one-off, dedicated satellites. As a result, satellite architects must now design not only for performance and survivability, but also for scale. Manufacturability, repeatability, and predictable behavior throughout large fleets increasingly shape design decisions.

At the same time, power and thermal budgets now constrain architecture decisions much earlier in the design process than ever before. As RF front ends, data processing, and power conversion consume the majority of available energy, engineers now have to trade peak performance for efficiency, stability, and longevity. Consequently, precision sensing and monitoring have become invaluable for providing the accurate voltage, current, and temperature data required to tighten operating margins.

In this eBook, we examine how New Space designers can confront modern constraints and how Analog Devices is responding to these challenges with system-level signal-chain solutions.

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Foreword

By **Bryan Goldstein**, CVP, Aerospace, Defense and Communications Business Unit, Analog Devices

Space systems are in a period of significant change. What was once defined by bespoke missions and fixed-function payloads is now shaped by large constellations, fast launch cadence, and software-defined architectures to address the demand for far greater flexibility. At the same time, satellites are expected to continue operating reliably in some of the harshest environments engineers will ever face. Radiation, extreme temperature cycling, thermal dissipation challenges, and long mission durations remain non-negotiable realities, even as economic and operational pressures push designs toward faster iteration and tighter margins.

This eBook examines the electronic subsystems that empower this new era of space design. It explores how engineers are addressing the practical challenges of harsh environments, power and thermal constraints, RF scalability, and reliable data movement on and off the satellite. It highlights the system-level interactions between power delivery, RF signal chains, data conversion, timing, and precision sensing that increasingly determine mission success.

Analog Devices is a leader in New Space. With deep expertise in high-performance RF, mixed-signal, analog, and power technologies, ADI supports space designers as they navigate complex trade-offs between performance, robustness, and scalability. Its portfolio spans radiation-tolerant signal chains, RF front ends, timing solutions, power management, and precision sensing that help engineers build predictable, resilient systems suited for modern space missions.

This guide brings together expert perspectives to illuminate how space electronics design is evolving and what it takes to succeed in the New Space race.

Chapter 1

SURVIVING AND PERFORMING IN HARSH SPACE ENVIRONMENTS

Space system engineers must design electronics for environments that expose weak margins and catalyze failure mechanisms. For example, orbits subject electronics to radiation, vacuum, vibration, and extreme temperature cycling. Meanwhile, modern mission profiles only increase the stress on the designer. With more frequent launches, engineers are being forced to trade conservative design margins for speed and manufacturability.

As a result, designers now face different dominant failure mechanisms than they did just five years ago. Low Earth Orbit (LEO) missions are becoming more common, and they reduce total ionizing dose exposure compared with Medium Earth Orbit (MEO) and Geosynchronous Orbit (GEO) missions. However, this benefit comes with a trade-off. Thermal cycling increases dramatically as satellites transition between sunlight and eclipse roughly every 90 minutes. In these changing thermal conditions, packages experience frequent expansion and contraction cycles, placing solder joints and die-attach structures under continuous mechanical fatigue. Over time, these stresses can degrade reliability even when radiation exposure remains within acceptable limits.

> “
>
> ***Unlike legacy satellites built with rad-hard components, modern Low Earth Orbit (LEO) mega-constellations rely on commercial off-the-shelf parts, making them far more susceptible to the harsh realities of the space environment. Consequently, these systems now suffer predominantly from ‘soft’ failures, such as control-plane software crashes and network synchronization drops, triggered by the rapid thermal cycling and radiation upsets flipping memory bits.”***

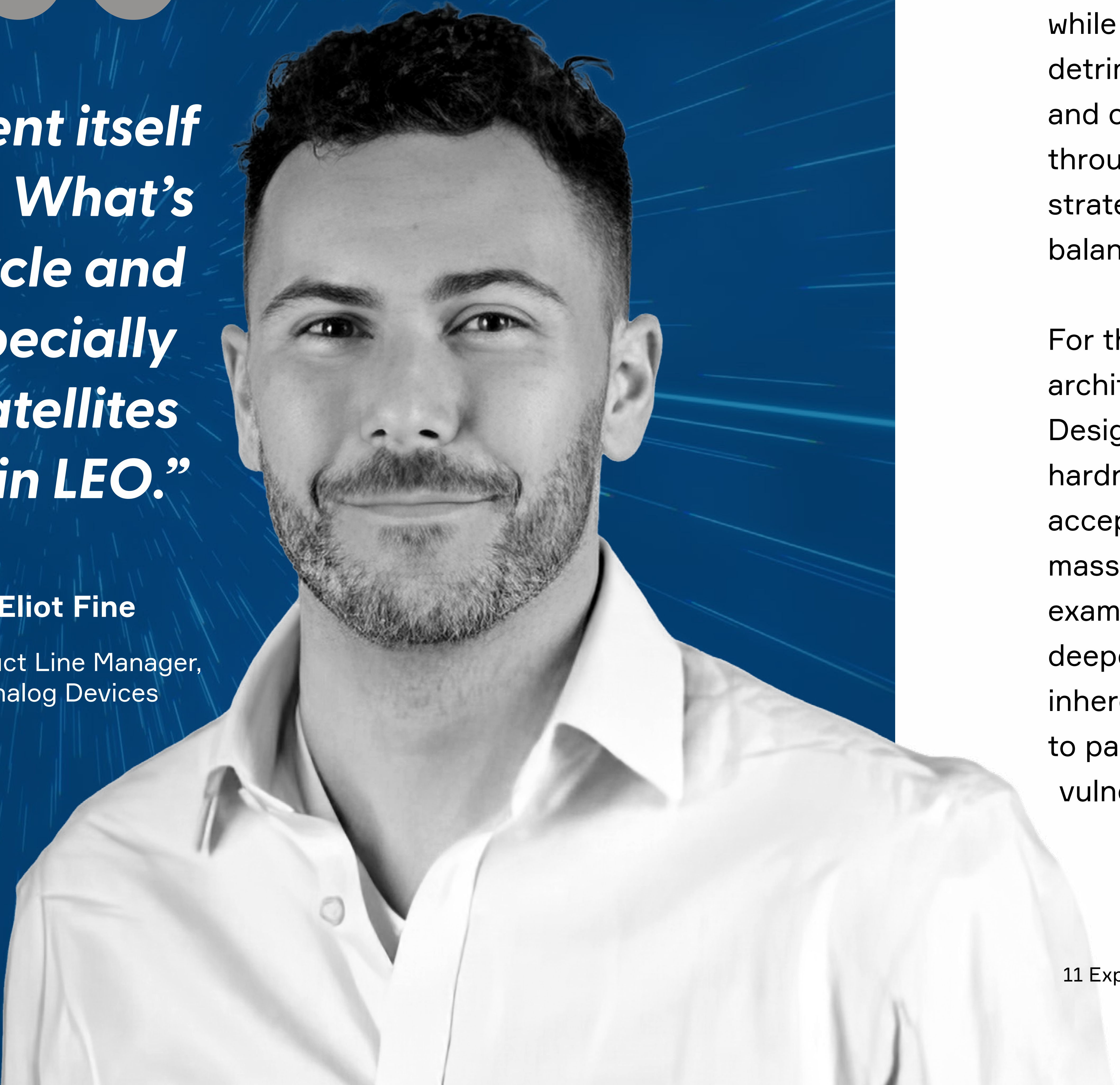
Gianluca Furano

Senior Data Systems Engineer, European Space Agency

> *The space environment itself hasn't changed. What's changed is the lifecycle and the expectation, especially with many more satellites operating in LEO."*

Eliot Fine

Product Line Manager,
Analog Devices



How Radiation Effects Impact Design Choices

Still, single-event effects (SEE) are a major threat to mission continuity. Within SEE, single-event latch-up is the primary cause of catastrophic failure, while single-event transients and upsets can still be detrimental by disrupting clocks, data converters, and control loops. Designers can mitigate these risks through architectural redundancy and fault-detection strategies, but these protections must be carefully balanced against power, mass, and cost constraints.

For these reasons, radiation requirements influence architecture decisions early in the design process. Designers need to evaluate tolerance versus hardness based on orbit, mission duration, and acceptable attrition while also balancing shielding mass against performance and launch cost. For example, teams might relocate critical functions deeper within the spacecraft to take advantage of inherent shielding. Similarly, designers might choose to partition systems to better isolate and protect vulnerable functions.

Data acquisition architectures embody many of these trade-offs directly. Here, engineers often adjust pipeline depth, redundancy, and calibration strategies to manage radiation sensitivity while balancing resolution and sampling rate against robustness and power consumption. In practice, teams often accept lower peak performance in exchange for greater long-term reliability. Where mission value justifies the complexity, engineers can deploy digital correction techniques selectively to recover performance.

Given the many challenges with New Space electronics development, teams are steadily adopting radiation-tolerant and screened commercial devices for their designs. Where constellation economics favor faster iteration and predictable availability, designers are prioritizing known radiation behavior over custom hardening. They can use screening, characterization, and system-level mitigation to help control risk while reserving fully hardened components for the most critical paths.

Sensing and Instrumentation

Within this context, there are many reasons that precision sensing has become a prominent system function. As engineers rely on accurate voltage, current, and temperature measurements to tighten operating margins and continuously monitor subsystem health, high-precision sensing technology can significantly impact system longevity and performance. Instead of retroactively responding to failures, designers with precision sensing systems can continuously monitor subsystem health to detect degradation earlier and enact controlled derating strategies that extend mission life.

> ***“Thermal cycling, radiation-induced bit flips, and memory aging remain dominant failure mechanisms. Modern designs mitigate these through robust hardware, error detection and correction, and redundancy at both component and system levels.”***

Giovanni De Luca

Senior Systems Engineer, Thales Alenia Space

> ***Successful designs recognize that not every function needs maximum performance. Designers should allocate performance where it delivers value and prioritize robustness everywhere else.”***

Chris Chipman

Space Segment Marketing Director,
Analog Devices

Instrumentation accuracy also directly influences mission availability. Power systems need stable sensing to avoid overstress, and thermal management relies on precise temperature feedback to control drift. By maintaining visibility into system behavior, designers can prevent cascading failures.

Analog Devices supports harsh-environment New Space designers with

- Radiation-tolerant signal chains that perform reliably across extreme temperature cycling and long-duration exposure.
- Space-qualified and screened components with predictable behavior, long lifecycles, and traceable manufacturing flows.
- System-level mitigation strategies that balance size, weight, and power (SWaP) constraints without depending exclusively on component hardening.
- Precision sensing and data-conversion technologies that help engineers detect degradation early and manage performance derating.

"Launch costs tightly depend on spacecraft mass and volume, driving miniaturization across avionics and power electronics, especially in SiP and SoM architectures. PCUs and PDUs, built with rad-tolerant power devices and supervisory controllers, remain major contributors to mass and board area. Our µModule DC/DC regulators significantly reduce SWaP, enabling added payload capability. Spacecraft design is further constrained by power budget and thermal dissipation limits. High-demand payloads—such as RF PAs and FPGAs—and orbital thermal cycles define the thermal envelope, making heat-rejection capability a primary factor shaping system architecture and component selection."

Mark Foo

Marketing Manager, Analog Devices

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Key Points

- **Engineers designing LEO satellite constellations now prioritize thermal cycling and single-event resilience over absolute radiation hardness.**
- **Precision sensing enables tighter margins, early fault detection, and controlled degradation.**
- **Analog Devices delivers stable, radiation-tolerant signal-chain technologies that help engineers manage harsh environments to preserve performance and scalability.**

POWER AND RF AS SYSTEM BOTTLENECKS

Given current trends, power delivery and RF performance have become primary constraints on satellite payload capability. Digital processing continues to scale, but power dissipation and heat removal limit usable performance. At the same time, RF front ends define link margin, coverage flexibility, and overall system stability.

Because of these realities, designers are forced to size payload architectures around thermal limits rather than peak compute or RF output. Power systems, therefore, must convert, distribute, and regulate energy efficiently to minimize losses under extreme thermal gradients. RF subsystems further intensify these constraints by concentrating high power density into compact footprints. For example, power amplifiers and phased-array elements generate significant localized heat. Without efficient power conversion, these devices will raise junction temperatures, increase the risk of thermal runaway, and degrade long-term reliability.

Packaging and integration, therefore, are non-negotiable. Heat removal depends on predictable thermal conduction paths, and engineers need to select packages that dissipate heat consistently across the specified temperature range. For instance, flat thermal interfaces can simplify heatsinking and mechanical integration to reduce uncertainty in thermal performance.

> ***“Moving away from traditional mechanical dishes powered by a single, massive amplifier, modern satellite designs utilize flat-panel phased arrays to achieve rapid, electronic beam steering. This architectural shift relies on the dense integration of thousands of low-power Transmit/Receive modules that dynamically shape the RF signal, demanding exceptionally precise phase and amplitude matching. Furthermore, because packing so many active amplifiers into a compact space generates heat spots, strict thermal management is now a primary bottleneck in array design.”***

Gianluca Furano

Senior Data Systems Engineer, European Space Agency

> ***Thermal management really drives the entire payload architecture, because once you exceed what you can remove as heat, no amount of processing or RF performance matters anymore."***

Jason Sekanina

Principal Engineer, Technical Marketing,
µModule Business Development & Product Apps,
Analog Devices

Phased Arrays and RF Performance

One of the most consequential shifts in New Space payloads is the growing reliance on phased-array architectures. Modern missions demand dynamic coverage and rapid reconfiguration. Phased arrays meet these needs by electronically steering beams and reshaping coverage without mechanical motion, allowing operators to adapt to changing link conditions and mission priorities.

This shift is reshaping RF requirements. As beamforming becomes increasingly software-defined, reconfiguration speed and beam count rise, tightening tolerances on element-level gain and phase consistency. Calibration must scale across large channel counts and remain valid across operating states, not just at initial bring-up, so beam performance remains repeatable over time, temperature, and load variation.

RF linearity is a primary driver of array-level predictability. Nonlinear AM/AM and AM/PM behavior in the RF signal chain can manifest as element-to-element amplitude and phase error, degrading beam shape and elevating sidelobes.

These effects can worsen as operating conditions shift with temperature, bias drift, and output power. Designers therefore preserve operating headroom where needed, trading peak efficiency for calibration stability and predictable beamforming performance.

Power and Thermal

Thermal drift tightly couples RF and power stability. Temperature variation shifts gain, phase delay, and bias conditions across the signal chain, which can invalidate static calibration assumptions, especially in LEO, where frequent sunlight/eclipse transitions drive repeated thermal cycling. As a result, calibration increasingly must be state-aware, supported by sensing, telemetry, and control loops that track temperature and operating point without disrupting service.

Power-efficiency thresholds also limit payload scalability. Inefficient conversion becomes waste heat, consuming scarce thermal margin and forcing conservative derating of RF and processing functions. Designers target high conversion efficiency where noise and regulation budgets allow, using switching regulation broadly while reserving low-noise regulation for the most sensitive rails. Efficient power delivery preserves thermal margin for RF output and onboard processing.

Ultimately, power architecture decisions permeate the payload. Load uncertainty encourages oversizing to protect against transients, but oversizing increases mass and loss. Redundancy improves fault tolerance, yet it compounds these penalties. Constellation operators balance resilience against cost and replacement strategy, often accepting controlled risk for shorter-life missions while reserving heavier protection for higher-value platforms.

> **“*The biggest shift has been toward software-defined payloads and much heavier onboard processing and consequently higher power requirements. We’ve moved to architectures that look more like data centers than traditional spacecraft.*”**

Amir Bigdeli

Lead Electrical Engineer, K2 Space Corporation

> ***"Calibration assumes a stable per-channel transfer function. As compression, bias drift, and thermal gradients change channel gain and phase, the effective transfer function shifts and the calibration residual reduces beam coherence, which is often observed as sidelobe growth, beam-shape distortion, and, in some cases, pointing bias."***

Jeff Massman

Phased Array Sensors Leader,
Analog Devices

Analog Devices supports power-constrained satellite payloads by

- Delivering high-efficiency power-conversion solutions that reduce waste heat and preserve thermal margin.
- Providing scalable power architectures that can respond to varying payload demands.
- Offering products that unlock predictable transient response and power integrity.

> *“Achieving conversion efficiencies above 95% at the Point-of-Load is critical; every percentage point lost is heat that the satellite cannot easily radiate into a vacuum.”*

Sebastián Caccavallo

Satellite Communication Engineering,
Satellogic

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RH5596S-CSH RMS Power Detector

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Key Points

- **Power delivery and RF performance now set payload limits, meaning engineers need to design around thermal behavior and efficiency.**
- **Reliance on phased-array architectures increases demands on RF linearity, calibration stability, and temperature compensation.**
- **Power efficiency thresholds directly influence payload scalability and mission economics.**
- **Analog Devices provides coordinated power and RF solutions that help engineers manage thermal constraints without sacrificing calibration accuracy and system stability.**

MOVING DATA RELIABLY ON AND OFF THE SATELLITE

Data movement is a system-level reliability problem, not just a throughput challenge. Today, satellite payloads generate more raw data than downlinks can continuously support, forcing teams to decide which data to process onboard and which to transmit. As a result, satellite architects are pushing intelligence closer to sensors and RF front ends.

But onboard processing comes at the cost of increased dependence on precise timing and deterministic data paths. While digital signal processing chains rely on coherent sampling and stable clocks, timing uncertainty can introduce phase noise, jitter, and synchronization errors that propagate through modulation and data fusion stages.

Power integrity also couples directly into data integrity. Transient load changes can affect reference voltages and clocks, which, in turn, can impact data converters and serializers. Designers must therefore manage power and timing together.

Similarly, radiation and temperature further complicate data reliability. SEEs can disrupt logic states and clock trees, while thermal variation impacts propagation delay and reference stability. Systems must tolerate transient errors without cascading failure.

> ***Rather than acting as simple 'bent-pipe' relays that merely bounce analog signals back to Earth, modern satellites utilize onboard processing to function as highly intelligent, autonomous network switches in space. To successfully route traffic and maintain high-speed inter-satellite links without constant reliance on ground stations, these spacecraft require ultrastable local master clocks. These precision clocks are the only way to synchronize massive digital data streams across various subsystems and ensure flawless handoffs between nodes moving at orbital velocities."***

Gianluca Furano

Senior Data Systems Engineer, European Space Agency

> ***"Radiation effects and specifically single-event transients can have a major implication on clock signal integrity, so this is yet another reason why radiation performance and IC reliability are so critical in a satellite system."***

Eliot Fine

Product Line Manager,
Analog Devices

Data Links and Timing

High-speed data links only magnify these signal-integrity challenges. Faster interfaces reduce voltage margins and tighten timing windows, meaning designers must manage impedance, crosstalk, and reference stability as even small disturbances can corrupt large data bursts. Spectral purity also becomes limiting as satellite internet supports more simultaneous links. Wideband modulation spreads energy across crowded spectra, and phase noise raises error vector magnitude and degrades link efficiency. Engineers must control spurs and noise to preserve usable throughput.

Among these other constraints, designers also need to balance flexibility against determinism. Software-defined payloads can reconfigure modulation, bandwidth, and routing, but each reconfiguration introduces transient timing and power disturbances. Systems must be able to predictably recover if they are to maintain link continuity.

Similarly, clock distribution influences every stage of data movement.

Centralized clocks simplify synchronization but increase single-point risk, while distributed clocks improve resilience but complicate phase alignment. Engineers should select architectures based on mission tolerance for drift and resynchronization.

Analog Devices supports reliable satellite data movement with

- Precision timing and clocking solutions that can maintain low jitter and phase coherence.
- High-performance data converters and synthesizers that preserve signal integrity and spectral purity at high data rates.
- Coordinating timing, data conversion, and power integrity within cohesive signal-chain architectures.

> ***“Onboard processing reduces data transmission needs but increases dependence on precise, robust clock distribution. Deterministic timing is essential for mission-critical operations and must be treated as a key design parameter.”***

Giovanni De Luca

Senior Systems Engineer,
Thales Alenia Space

> ***“Supporting higher-order modulation and wider bandwidths means that designers have to pay a lot more attention to spectral purity.”***

Hossein Yektaii

Wireless System Architect,
Analog Devices

> *“As teams have gained deeper insight into orbital environments, the industry’s risk appetite has increased. With rising requirements for onboard AI, designs have become more integrated, stretching power, thermal, and reliability limits.”*

Naman Vaidya

Lead Electrical Engineer,
Pixxel

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Key Points

- **Satellites rely heavily on onboard processing, which necessitates deterministic timing and stable data paths.**
- **High-speed data links tighten signal-integrity and spectral-purity requirements, making clock quality and reference stability important.**
- **Flexible, software-defined payloads introduce transient disturbances that systems must absorb.**
- **Analog Devices delivers integrated timing, data-conversion, and connectivity solutions that help engineers reliably move data through harsh, volatile space environments.**

Conclusion

The New Space race is being won by those who can successfully navigate the trade-offs between high-performance capability and rugged reliability. As we have explored, the trend toward software-defined payloads and massive LEO constellations has changed the engineering focus from bespoke, “fail-safe” components to scalable, system-level resilience. Managing the delicate balance between power efficiency, thermal constraints, and high-speed data integrity is now a prerequisite for mission viability.

By treating the signal chain holistically, designers can push the boundaries of what is possible in orbit. Analog Devices is committed to providing the radiation-tolerant technologies and architectural expertise needed to turn these complex challenges into successful New Space missions.

Learn More About Our Experts

Amir Bigdeli

Lead Electrical Engineer, K2 Space Corporation

Amir Bigdeli is an electrical engineer specializing in power electronics and mixed signal hardware development. He has contributed to advanced hardware programs at Tesla, Amazon Kuiper, and K2 Space, a series C satellite startup, leading development of radiation-tolerant avionics and power electronics. His work spans isolated DC/DC converters, phased-array RF hardware, and solenoid drivers. He has driven complete hardware development through production for high-volume vehicle platforms.

Sebastián Caccavallo

Satellite Communication Engineering, Satellogic

Sebastián Caccavallo studied electronic engineering at the National Technological University in Buenos Aires, Argentina and has over 20 years of experience in multidisciplinary electronic design, participating in aerospace, military, medical, and industrial projects. In recent years, he has focused on radio frequency and distributed elements and has participated in various projects in the satellite and IoT industries for global companies. His career includes university teaching in PCB design and technical consulting in signal integrity and international IEC/IPC standards. He currently continues to work in the electronic design industry and as a peer review consultant for electronic product design.

Chris Chipman

Space Segment Marketing Director, Analog Devices

Chris Chipman is Space Segment Marketing Director at Analog Devices, guiding the company's global space portfolio and long-range strategy across commercial constellations, the lunar economy, and deep-space missions. With 30+ years in aerospace, defense, and space electronics, he has led global teams and multi-million-dollar product lines and built partnerships that translate high-reliability mixed-signal, analog, and RF technology into growth.

Giovanni De Luca

Senior Systems Engineer, Thales Alenia Space

Giovanni De Luca is a Senior Systems Engineer at Thales Alenia Space with over 20 years of experience supporting mission-critical aerospace infrastructure. He specializes in EGSE, AIT clean-room operations, and cross-platform system administration across Linux, UNIX, and Windows. His work spans major programs including Galileo, Cosmo-SkyMed, Sentinel, Globalstar, and Sicral, with strengths in virtualization, cybersecurity hardening, and high-availability testing environments.

Learn More About Our Experts

Eliot Fine

Product Line Manager,
Analog Devices

Eliot Fine leads the High-Reliability Space portfolio in ADI's Aerospace, Defense, and Communications Business Unit. Prior to this role, he spent five years in ADI's Customer Solutions Group, supporting aerospace, industrial, and automotive customers across a wide range of technology requirements. Eliot graduated from Worcester Polytechnic Institute (WPI) in 2019 with a Bachelor of Science in Electrical & Computer Engineering.

Mark Foo

Marketing Manager,
Analog Devices

Mark Foo is a Strategic Marketing Manager at Analog Devices in Singapore, bringing decades of APAC experience spanning semiconductors, SoC/ASIC, and smart metering solutions. Before joining ADI, he led product and solutions teams at EDMI and held senior business development and regional sales roles at companies including Qualcomm Atheros. He earned a B.Eng. (EEE) from Nanyang Technological University.

Gianluca Furano

Senior Data Systems Engineer,
European Space Agency

Dr. Gianluca Furano is a Senior Data Systems Engineer at the European Space Agency's Data Systems Division. He spearheads research and development activities, with a significant focus on the integration of on-board artificial intelligence for space-grade microprocessors, avionics systems crucial for safety-critical operations, and advanced data communication protocols. His pioneering work has directly influenced the design and implementation of numerous successful space systems. Dr. Furano is a recognized leading expert in the application of RISC-V in mission-critical and safety-critical systems and has authored or co-authored over 100 influential publications in the field.

Jeff Massman

Phased Array Sensors Leader,
Analog Devices

Jeff Massman is a Phased Array Sensors Leader at Analog Devices, architecting reusable AESA platforms that integrate antenna tiles, TR modules, digitizer modules, and calibration/beamforming software. A Ph.D. electrical engineer with 16+ years in radar, communications, and EW, he previously led antenna and EM structures teams at the Air Force Research Laboratory, delivering digital array payloads for space and autonomous platforms.

Learn More About Our Experts

Jason Sekanina

Principal Engineer, Technical Marketing, μModule Business Development & Product Apps, Analog Devices

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Naman Vaidya

Lead Electrical Engineer, Pixxel

in

Hossein Yektaii

Wireless System Architect, Analog Devices

in

Jason Sekanina is a Principal Engineer in Technical Marketing for Analog Devices' μModule business, focused on compact SMT DC/DC converters and power μModule product definition and applications. He brings 25+ years of power-conversion experience across design and applications roles at ADI/Linear Technology, Primarion, Artesyn, Datel, and Elgar, and holds a California Institute of Technology B.S. in Applied Math and Engineering.

Naman Vaidya is a Lead Electrical Engineer at Pixxel, building satellite electronics for space missions. He enjoys designing reliable systems and solving complex engineering challenges. By day, he works on hardware that goes into space. By night, he's changing diapers and being a hands-on dad—balancing satellites and family life.

Hossein Yektaii is a Wireless System Architect at Analog Devices with more than 25 years of experience in the wireless communications industry. Prior to joining ADI in 2016, he held various roles at Nokia, Alcatel-Lucent, and Nortel, progressing from RF design engineer to radio system designer. In his current position, he applies his comprehensive end-to-end radio system expertise to interpret customer needs and define the architecture and specifications of increasingly advanced ADI solutions, with a particular emphasis on Satcom applications.