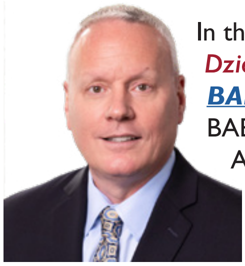
# COMMAND CENTER JOE DZIEZYNSKI

## Director, Space Systems
## BAE Systems Electronic Systems Sector

***The final frontier: The innovative, rad-hard space technologies that are taking us to new heights***

***From the first satellite, space shuttle launch, moon landing, international space station, and beyond—space has become an ever more important domain. Today, space missions have evolved to include planetary exploration, communications, national security, surveillance, and weather missions. One constant through it all is the need for reliable and resilient technologies to ensure operational excellence and mission assurance across defense and commercial sectors.***



*Joe Dziezynski*

In this ***Command Center*** discussion with *Joe Dziezynski*, who leads Space Systems for ***BAE Systems' Electronic Systems*** sector, BAE Systems' history of radiation hardening, from Apollo to Mars rovers, is discussed as well as the technologies that enable missions and the trends and demand signals that are shaping the industry.

*How has BAE Systems' expertise in radiation-hardened solutions contributed to missions that go back to the "space race" days?*

***Joe Dziezynski***
You may not realize it, but our space products help hundreds of millions of people each day with GPS, satellite radio, weather data, and other services across the defense and commercial sectors.

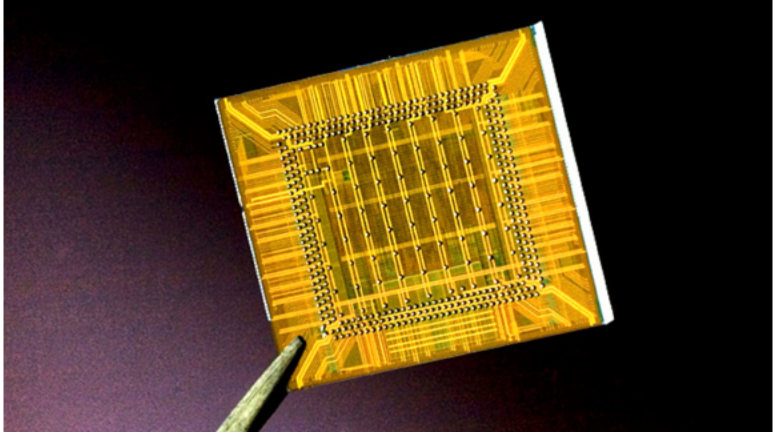
Our heritage spans everything from the earliest days of the space program to planetary exploration as well as commercial and defense missions.

With contributions to iconic missions such as **Apollo 11**, the **Cassini** space probe and four generations of **Mars rovers**, our *radiation-hardened* (**rad-hard**) solutions have played a critical role in extending the operational lives of electronic systems, enabling space agencies to achieve their mission objectives and push the boundaries of space exploration. Rad-hard electronics at the component, card, and unit levels specifically designed for high-reliability demands are required to withstand the harsh space environment and perform long-term missions.

As a merchant supplier, we develop and produce high-reliability space products, from standard components and *single-board computers* (SBCs) to complete system payloads. We have flown more than 1,100 SBCs, with a cumulative total of over 13,000 years of successful operations in space.

Our RAD750® SBC has been the workhorse of the industry and has been manufactured in 250 nanometer (nm), 180nm, and 150nm technology. Those systems powered more than 100 satellites for the last 20 years, including playing a key role in the navigation payload on ***GPS III*** satellite constellation. Today, it provides the computing power for ***NASA's Curiosity*** rover that landed on Mars in 2012, and, of course, the ***James Webb Space Telescope***.


*GPS III satellite launched with BAE Systems' RAD750® single board computers. Photo courtesy of the company.*



customer needs. Rapid prototyping gets developmental hardware to our users faster, which allows them to test earlier, resulting in reduced design cycle time and cost.

With the introduction of Endura, we are transforming our business model to provide a more responsive and cost-effective experience for our customers. By harnessing the power of economies of scale and optimizing processes, we are able to offer it at a lower price point and with faster delivery times.

We are now accepting orders as we prepare to launch our family of products to the market in the coming months.

*With evolving missions, what technologies are improving radiation-hardening? What is BAE Systems doing on this front?*

***Joe Dziezynski***
We're seeing a growing demand for higher processing capabilities, lower power consumption, and smaller form factors driving the development of new radiation-hardened processors.

Physical space and weight are at a premium on satellites, so the ability to pack more processing power into a smaller footprint is a key enabler for the future.

Our ***RH45***® technology enables customers to develop their own solutions with a library of advanced capabilities and proven ***application-specific integrated circuit*** (**ASIC**) design and manufacturing methods.

RH45 chips offer exceptional radiation performance in natural and manmade environments and are based on commercial 45nm ***Partially Depleted Silicon-on-Insulator*** (**PD-SOI**) technology. We will reestablish our RH45 Storefront in 2025 for new designs and production runs.

The next step in speed and surety is our ***RH12***™ technology. Ten times denser than RH45 technology, RH12 allows users to build rad-hard chips using a suite of qualified ***intellectual property*** (**IP**) blocks compatible with industry-standard design tools. Each IP block is radiation-hardened, tested, and qualified for space applications.

The RH12 technology provides a proven, low-risk ASIC development capability for demanding space applications.

Our latest computer product, the ***Endura™ SBC***, uses RH45 technology to deliver three times the performance capability of our industry standard ***RAD750 microprocessor***. It requires less power and offers exceptional radiation hardness.

Available to space agencies and spacecraft manufacturers, Endura uses software compatible with the RAD750 SBC making it a flexible solution for current and future applications. To support customer insertion of the Endura SBC, a ***software development unit*** (**SDU**) is available for immediate delivery.

The SDU enables users to develop, integrate, and test their applications on an inexpensive lab asset equipped with the exact same chipset as our flight hardware. The approach mitigates risk and enables easier adoption of the new solution.

The Endura SBC will launch in industry-standard 3U form factor. We are developing rapid prototype 6U Endura SBCs with enhanced capabilities such as rad-hard memory, ***SpaceVPX***, ***field-programmable gate array*** (**FPGA**) resources, cybersecurity, and Ethernet to address customer needs.

*What shifts are you seeing toward small satellites and radiation-tolerant solutions?*

***Joe Dziezynski***
We continue to see the demand for advanced rad-hard electronics, even while there is also a trend toward small satellites in ***proliferated Low Earth Orbit*** (**pLEO**) constellations. This is creating a new market for radiation-tolerant solutions that balance performance and cost.

These satellites are for shorter duration missions and don't require the level of surety and radiation-hardness that we provide for a Mars rover.

As small, LEO satellites don't have the extreme surety requirements that we've historically served, we can back off on some mission assurance requirements related to parts selection, materials, and processes.

There are two advantages worth highlighting. **First**, we can use advanced organic packaging techniques to more affordably enclose our chips. **Second**, we can use automotive and aviation components which provide additional performance at a lower power threshold to implement capabilities, such as high-speed Ethernet.

We see a best-value product as a hybrid approach using rad-had technology for core components such as processors, surrounded by lower-grade components with suitable radiation-mitigation technologies.

From the owner-operator side, that frees up customers to affordably do things that they couldn't do with exclusively radiation-hardened components, at surety levels that are appropriate for the environment, and with the "*always on*" performance that is expected from BAE Systems.

*How can you use ASICs and still have a flexible design?*

***Joe Dziezynski***
Design flexibility is crucial in supporting space missions, as it allows us to tailor our solutions to specific mission requirements and constraints. Rad-hard ASICs design services, for example, provide customers with a competitive advantage. RH45 and RH12 ASICs not only resist radiation damage and upset, but they have 10-to-1 power and performance advantages over FPGAs in the same technology.

This is opening the design trade space to have lower cost points and more capable processing that lets you conduct different missions from LEO constellations compared to a large single satellite in another orbit.

Looking forward and aligning with today's need for speed, we've pivoted our design and production process to provide rapid prototype circuit cards and boxes for early integration by our customers.

We are able to get an affordable SBC product variant into the lab in six months or less, dramatically accelerating design and fielding cycles.

Ethernet switching, channelization, and non-uniformity correction are examples of functions on spacecraft that don't change from system to system. These functions are prime candidates for committing to ASIC to capitalize on power and performance advantages, all without loss in flexibility of the overall system.

ASIC technologies are also compatible with a wide variety of commercially available design tools. Compared to designs using off-the-shelf hardware, ASICs provide unique processing capabilities with lower size, mass, power consumption, and recurring cost while allowing our customers to implement their own unique algorithms and architectures. They are true force multipliers in spacecraft design.

***What emerging technologies are expected to have a significant impact in the coming years?***

***Joe Dziezynski***

Emerging technologies like advanced radiation-hardened processors, ***software-defined radios*** (**SDR**), modular payloads, and autonomy are expected to have a significant impact on the space industry.

These technologies will enable more capable and flexible space systems that can support a wide range of missions.

BAE Systems is known as a capability provider in the air, land, and maritime domains as well. What this allows us to do now is take the operating capabilities that we have in those domains and push them up into pLEO orbits to provide more capability for our customers.

We are demonstrating the latest, state-of-the-art, software-based waveforms capable of communicating from land to space and back. The significance of this is increased resiliency for the warfighter. Many of our waveforms are developed with a combination of software, firmware, and hardware.

As this this is a software-only based waveform, configured and developed quite rapidly, we've been able to integrate and test it quickly to meet mission needs.

We are developing modular open system architecture SDR systems that are suitable and affordable for every orbit from LEO to ***Geostationary Earth orbit*** (**GEO**).

Autonomy is a new paradigm, where the spacecraft makes intelligent decisions on what to do next based on available information.

Autonomy requires advanced processing, much of which is done today in data centers. We will not be flying a data center in space any time soon, but we are working to develop autonomous recovery tools and techniques that allow us to fly state-of-the-art processors with mission appropriate radiation mitigation.

***How do you see the space community changing in terms of collaboration between government, defense companies, and commercial providers?***

***Joe Dziezynski***

The last 20 years has brought a flurry of activity from new organizations, like **U.S. Space Force**, **SpaceX**, and **Planet**, to new objectives, such as **Joint All-Domain Operations**. In essence, space is new again.

However, what hasn't changed is that customers want their mission delivered when it counts... **every time.** Defense requirements for control, resilience, and security will provide a ceiling on what commercial alone can do. Warfighters will continue to demand "*always on*" military capabilities.

For low-density constellations, radiation-hardened solutions are required for foundational spacecraft services such as avionics, security, and networking to deliver that level of availability.

With a focus on speed, affordability, and new technologies, we're seeing increased collaboration across industry and sectors. You can advance commercial capabilities by applying rad-hard techniques to bring them to space.

We're advancing space capabilities by adding ***Radiation-Hardened By Design*** (**RHBD**) to the commercial market. We're working with commercial companies to bring cutting-edge capabilities to space.

RHBD uses the same processes at the same foundries as commercial electronics, but adds design features in silicon to mitigate data loss, upset, and destruction.

By applying RHBD techniques to commercial chip designs, such as processor cores and analog-to-digital converters, purpose-built chips are created that provide the same operational availability as their terrestrial counterparts, just in space.

Reliability and process stability of using a purely commercial process is also obtained, so there are no boutique fabs with short production runs that vary on a lot-by-lot basis.

No matter the altitude, BAE Systems is committed to developing and delivering highly reliable and qualified products that support the evolving needs of the space community.

***www.baesystems.com/en-us/who-we-are/electronic-systems/c4isr/space-electronics***