

RF/Microwave Technologies- A Better Alternative In Defense Electronics

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Executive Summary

For the U.S. defense industry, a backdrop of political dysfunction, the lack of bi-partisan problem solving in Washington and budget uncertainty have all conspired to put the defense industrial base in a period of transition. New program starts are fewer and farther between and existing programs are under closer scrutiny. At the same time, the U.S. Department of Defense (DoD) is asking for more disciplined procurement measures without sacrificing innovation. Under the Procurement 2.0 guidelines, now called Better Buying Power 2.0; innovation, the adoption of open architectures, and the encouragement of viable commercial enterprises to support the defense industrial base cannot be to the exclusion of expense management.

In spite of these challenges, the U.S. defense budget remains in the \$500 billion range and is likely to remain so for years to come. With this level of spending there are multiple opportunities to be exploited. The DoD's "Pacific Pivot" strategy, upgrades to aging military platforms, and international military sales, to name a few. However, taking advantage of these opportunities requires a new relationship model between the defense prime contractors and their suppliers.

This white paper:

- Reviews the challenges facing the defense industry
- Highlights how key industry trends are putting pressure on internal and external R&D, crowding out investments, and reducing tolerance for risk taking
- Provides insight to those real opportunities that still exist within this changing environment
- Walks through our RF/Microwave capabilities and solutions and our strategy for growing this segment of our business
- Discusses open architectures and why they are a game changer in RF/Microwave solutions
- Provides a description of Mercury Systems' dual Advanced Microelectronics Centers of excellence and what makes them unique and relevant

A New Defense Climate - Our Perspective

The challenges within the defense industrial base break down into three areas. The first is political dysfunction in Washington. This is creating budget uncertainty in the short term. There is also the potential for crowding out of defense funding, as social entitlement programs, the potential of higher costs associated with servicing our growing national debt, and other factors potentially reduce the available funding for our national defense. Finally, defense procurement reform is changing the defense industry economics.

With that said, the news is not all bad. As an example, the defense electronics industry is a \$45 billion marketplace within a \$500 billion defense industry. We see specific opportunities in three key areas:

- New roles and missions which are shifting our focus to the Pacific
- An aging fleet of military platforms that need to be upgraded
- A government mandated export requirement that helps our allies protect themselves while providing the U.S. a better return on our defense investments

Before providing a more in-depth description of these opportunity areas, a more detailed look at the challenges facing the defense sector is in order.

How The Macro Climate Is Starting To Play Out - Challenges

Politics



The political climate is likely to remain uncertain for some time, as the on-going dysfunction and potential for continuing resolutions remain dominant themes that are not likely to go away any time soon. A tougher budget climate in Washington has led to fewer new defense programs and potentially less funding

for existing programs. The halting roll-out of the Affordable Care Act and other party-specific pet projects further adds to a general climate of budgetary uncertainty. While Congress did approve a federal budget appropriations bill that President Obama signed into law, the defense industrial base cannot count on this as a clear signal that Washington dysfunction has ended.

Crowding Out



Beyond the political scenario, a potential for crowding out of the defense budget is being driven on two levels. First, from a broader national priorities perspective, we see the U.S. economy recovering, but doing so unevenly and more slowly than most policy makers and the public in general would like. At the same time our

expenses, particularly healthcare and other social entitlement programs, are rising much faster than inflation. These expenses are also rising at a much higher rate than our ability to collect taxes. Hence, the growing national debt our country is experiencing. At current count, this debt is over \$17 trillion and over 100% of GDP. The debt servicing has been manageable so far, but as interest rates inevitably rise over time, servicing the debt becomes problematic. These higher entitlement costs coupled with our growing debt service costs might result in less available funding for critical defense programs.

There is also crowding out from a more micro level, within the defense budget itself. Our military expense costs associated with personnel, namely compensation and healthcare, are rising at a rate much higher than the rate of our overall defense spending. At the same time we have an aging fleet of military platforms that increases the cost of Operations and Maintenance (O&M). The higher personnel costs plus maintenance on aging platforms means potentially reduced funding for program Research, Development, Test and Evaluation (RTD&E) and procurement. In other words, crowding out of the very technologies and programs that can help us achieve our national defense strategies and objectives.

Buying Power 2.0



Finally, as the DoD rolls out its evolution of Procurement 2.0, now known as Better Buying Power 2.0 (BBP 2.0), there are challenges presented but also opportunities for those within the defense industrial base who remain competitive. BBP 2.0 presents many challenges around the

strong drive to a "should cost" model, promotion of a firm fixed pricing model over the legacy variable cost model, and an overall stricter focus on affordability and cost controls. At the same time, the BBP 2.0 mandate promotes many best practices that should result in, over time, a better and more effective delivery of technologies and programs for our nation's defense. Among these directives are the encouragement of open technologies and architectures, the promotion of competition within commercially based organizations, the elimination of redun-

dancy and bureaucracy within the procurement process, upgrading of the acquisition workforce, and an overall climate to promote innovation among the companies that support key defense programs. As organizations work within this emerging procurement environment, and as the DoD continues its work to fine tune the new procurement model, it will take on an even greater reality. This is not a temporary trend. It is a new way of doing things. While we support it on many levels, clearly it presents challenges across the defense industrial base.

Opportunities Amidst Change

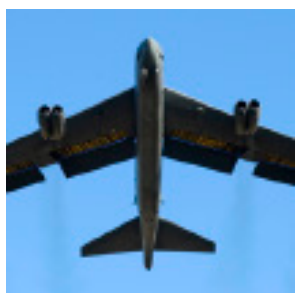
The Pacific Pivot



Potential new roles and missions are rising from the end of the war in Iraq and the draw-down in Afghanistan. We are now, as a nation, seeing the emergence of peer or near peer threats in the Pacific region. The Pacific Pivot strategy that has resulted in reaction to these threats presents new challenges.

Operating in contested air space, the need for surveillance platforms that can operate in higher altitudes, Anti-Access/Anti-Denial (A2/AD) capabilities, the requirement for aerial surveillance that can “see” into foliated areas, and more - are all potential Pacific Pivot challenges we didn’t face in recent conflicts. The Pacific Pivot represents enormous new challenges but also important opportunities for those who are prepared with the right technologies and capabilities.

Aging Platforms



Many of our nations’ military platforms, such as our strategic bomber fleet, are of World War II vintage. The U-2 high altitude surveillance and reconnaissance aircraft first went into service in 1957. The U.S. has many technologies and platforms that need to be upgraded. In fact, the last time the U.S. went

through a major recapitalization of our military assets was during the Reagan administration in the 1980’s. Given the budget environment discussed above, at least in the near term, we will not be able to fund development of completely new weapons platforms. They cost too much and the risk is too great. So the most productive path will be to upgrade existing platforms.

Government Export Mandate



The DoD is looking to export or allow the defense industrial base to export more of its technology to our foreign allies to make them more technologically self-sufficient.. We are doing this for two reasons, the first of which is so our trusted allies can provide for a greater part of their own national defense. Secondly, the export of our

defense technologies allows both the DoD and defense companies to get a better return on the many billions of dollars that are invested. This is not easy to do, as defense technologies and platforms must be “exportable”. That is to say that the technology and Intellectual Property (IP) must be protected in the event they end up in enemy hands.

Mercury Systems Has Invested \$450 Million over the Past Five Years To Address These and Other Industry Challenges

Over the past five years Mercury Systems has invested in a strategy to align our technology, product portfolio and business model to address the challenges highlighted above. ***We have reshaped our business while investing nearly half a billion dollars (\$450M) developing capabilities that are enabling customers to win new awards while also keeping programs sold in a highly competitive marketplace.*** We have historically invested 20% of revenue in Internal Research And Development (IRAD). The company has implemented a total product refresh. Today, hands down, we’ve got the best compute processing portfolio in the industry. We have invested in server-class processing while also developing the world’s most innovative packaging and thermal management technologies. We have developed advanced security or exportability features that are going to allow our customers to export more of their products to markets overseas. We have pioneered the use of Graphics Processing Units (GPU) into the sensor processing space for onboard exploitation of information being gathered. In addition to this portfolio refresh, over the last five years we have invested in key capabilities in the RF/Microwave dimension.

Question: How do organizations take advantage of best of breed RF/Microwave technologies as they seek to contribute viable solutions that address the key challenges around platform modernization, readiness for the Pacific Pivot, and building solutions for exportability?

RF/Microwave and Modular Open System Architectures

As described earlier, today's defense procurement environment for electronic systems is extremely challenging for prime contractors. Among the pressures they face are the need to meet open architecture standards, requirements to reduce Size, Weight and Power plus Cost (SWaP-C), demand for more affordable systems with shorter development cycles, and increased competition for technology refreshes, modernizations and upgrades.

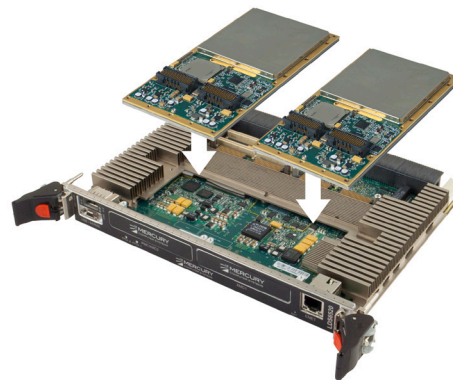
Electronic System Architects and Design Engineers are continually seeking ways to leverage new, commercial technology advancements while still reducing SWaP-C. These systems also need to perform in severe environmental conditions. Lastly, in addition to up-front costs, the total lifecycle costs must be considered. At a higher level, program management executives, procurement leaders, supply chain executives, and senior business decision makers within prime contractors, are looking to consolidate suppliers, technologies and subsystems. But they seek to do so in a way that still allows them to add value to their end customer, deliver on time and on budget, while adhering to ever more stringent procurement processes and mandates.

To add to the challenges many prime contractors face, many electronic systems on defense platforms were designed as separate RF/Microwave and digital packages. Not only does this increase SWaP-C, it also adds complexity and cost to the system. There is a better alternative. One powerful way to meet many of these disparate challenges is by leveraging open RF/Microwave building blocks and combining them with commercial, high-performance digital signal processing components – all in a single, compact and affordable package.

Why is the DoD and industry focused on SWaP-C? A lot of it has to do with the need to place sophisticated electronics on space limited platforms such as unmanned vehicles and systems, manned fixed-wing aircraft, and certain ship-board applications. Another reason is placing digital signal processing power, displays, communications, and sensors on an already overburdened warfighter. In the electronic Electronic Warfare (EW) market, the challenge is to keep pace with the ever evolving and emerging threats and asymmetrical problem sets. As for cost, affordability is critical in today's budget and procurement environment.

Overall, today's focus on small, lightweight electronic systems that consume minimal power is driven by the need to bring as much capability to the warfighter on the battlefield as possible, in the shortest development time, at the lowest life cycle cost. The real objective is to provide a system with increased performance while reducing SWaP-C. This can be achieved through higher levels of

integration in application specific solutions and strict adherence to industry standards in a Modular Open Standard Architecture (MOSA) environment. Simply defined, MOSA is achieved through the use of standard interfaces and operating systems to yield elements to build a system. MOSA is "plug and play", producing interchangeable assemblies. This philosophy allows for easier scalability and provides a technology upgrade path through the replacement of assemblies that maintain the common interface. The use of MOSA-compliant designs can help significantly reduce a program's life-cycle cost while at the same time providing higher performance compared to legacy systems. The use of MOSA will also shorten the development path for EW and other technologies, often allowing newer technologies to be folded into legacy systems, eliminating the need to "rip and replace" the legacy platform.

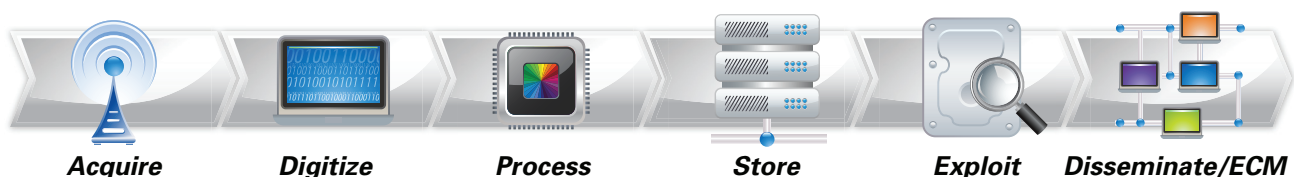


Modular Open System Architecture (MOSA)

With the trend toward open architectures well underway, digital signal processing is now integrated into narrow band systems. The trend in the defense electronics market has a similar objective; moving the A/D (receive) and D/A (transmit) circuitry as close as possible to the antenna. The major difference is the fact that these systems (radar, EW and EA, ECM, ELINT, COMINT, SIGINT) tend toward broad instantaneous bandwidths. By integrating the RF/Microwave portions with digital solutions and leveraging MOSA, primes can provide the benefits of application specific device/module performance while retaining the flexibility to upgrade the system during technology refresh cycles. In addition they lower life cycle cost.

There are many examples of Mercury Systems leveraging MOSA open architectures in Signals Intelligence (SIGINT) and Electronic Intelligence (ELINT) environments. The Mercury open RF/Microwave architectures allow for a software control interface that is reusable across multiple applications, permitting our customer, the prime contractor, to focus on development of algorithms and critical applications. Mercury's work

Sensor Processing Chain



in SIGINT Direction Finding (DF) receivers and ELINT Wideband Detection Systems Receivers, built on a MOSA open architectures, allows the data movement (FPGA data plane) infrastructure to be common between different applications. With strict adherence to MOSA and Industry Standards, Mercury Systems provides our customers, from the executive decision maker to the systems designers, the opportunity to concentrate on the application layer in order to maximize systems performance at the lowest possible cost. By doing this we can help the prime to adhere to industry standards with shorter time-to-market, provide flexibility for incorporation of new features as systems are upgraded, and provide non-proprietary hardware and firmware/software solutions; all while providing performance equal to or exceeding what would have been provided with an applications specific solution; all at a lower cost.

Mercury RF/Microwave Solutions

Mercury Systems offers a full menu of technologies across the RF/Microwave spectrum. Whether the application is EW, radar, for airborne and space, naval or terrestrial end uses Mercury Systems has the solutions, from components up to subsystems. Our capabilities and products include:

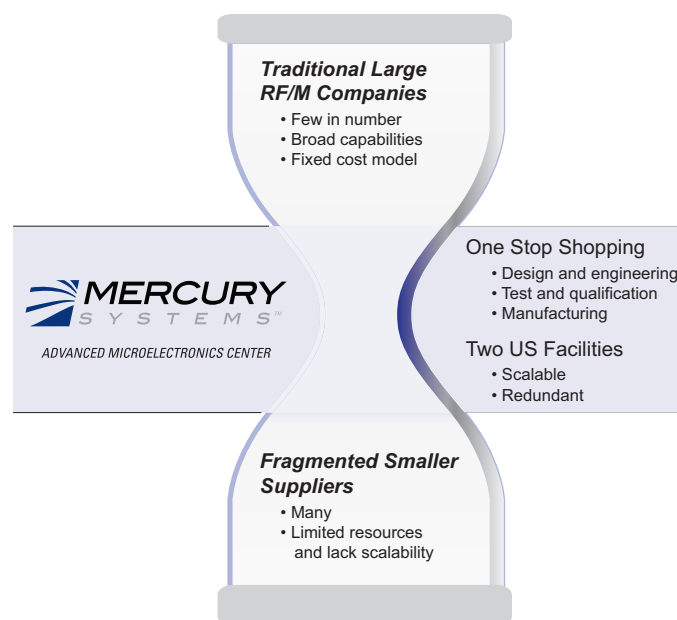
- A broad selection of off-the-shelf RF/Microwave components, including mixers, isolators, circulators, equalizers, power amplifiers, power switches, limiters, and noise sources
- Complex IMAs utilizing densely routed multi-layer RF substrates
- Full RF subsystems including major RF functions, associated power supplies, and system level digital interfaces (e.g., transceivers and RF distribution networks)
- Operating frequencies from 100MHz through 60GHz in both narrowband and broadband (multi-octave) applications
- IMA and subsystem level products that include broadband up/down converters/tuners, broadband fast tuning frequency synthesizers, complex RF distribution networks, and high order switch matrices
- Build-to-print services with both design and manufacturing engineering support

We are proud of our broad and deep capabilities across the RF/Microwave solution spectrum. Key differentiators for us are the way we do business with our customers and our focus on innovation. It's different than any other player in the industry. An example of this is our application of a Modular Open System Architecture to our RF/Microwave solutions.

The RF/Microwave "Hourglass"

As we were looking at the RF/Microwave industry, we came to realize that it was essentially broken. Broken because the industry structure is very much like an hourglass. The top part of the industry has a few big players capable of developing complex RF/Microwave components and subsystems and then manufacturing these microelectronics assemblies in large volume. Some of these big players actually compete with their prime contractor customers. When they aren't busy competing with their customers and they at times use temporary pricing leverage for their short-term gain, all at their customers' expense. At the bottom of the hourglass there are several highly fragmented smaller companies or "job shops". These smaller players, while they do some interesting work on a small scale, typically have great difficulty seeing their work through from prototype to production. They do not have the depth in their organizations to enable them to provide the appropriate level of quality assurance (QA), engineering, manufacturing, and test maturity that is essential for electronic products designed for use in high stress military environments and manufactured in volume.

To address this gap in the RF/Microwave defense electronics industry, Mercury Systems has been methodically assessing, acquiring, and integrating companies within the RF/Microwave domains. Our vision is to bridge the gap between the large and small RF/Microwave players; to provide the benefits of each, while eliminating each of their associated negatives.



Delivering Value - Advanced Microelectronics Centers



We have scaled our RF/Microwave design and manufacturing capabilities to provide the capacity needed for large, complex projects, with high volume potential. We have established redundant world-class microelectronics facilities; our Advance Microelectronics Centers

(AMCs) in West Caldwell, NJ and Hudson, NH, which both provide state-of-the-art design, assembly, and test automation for enhanced reliability and performance at low cost. This coupled with the program management, engineering, and manufacturing process sophistication that has been shared and leveraged from the legacy Mercury businesses, enables us to compete directly with the large players in the RF/Microwave space, but without the typical baggage of these competitors.

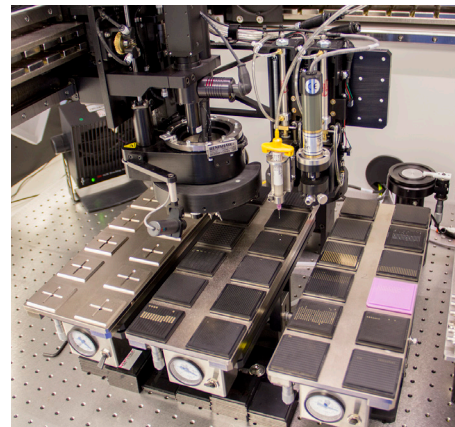
We have a significant amount of expertise in the design, development, and manufacture of RF/Microwave components through subsystems, enabling us to deliver products for advanced radar and EW subsystems using state-of-the-art technologies. When desired by our customer, coupling of our legacy Mercury digital and IF technologies with our RF/Microwave capabilities provides Mercury with the unique ability to supply end-to-end hardware solutions across the sensor chain. Our goal is to develop true partnering relationships with our customers, where we participate early on in the system development phase so that we can be sure to provide the highest performance and most cost effective solutions. In many cases this partnering relationship results in significant investment by Mercury into our customers' programs, thereby enhancing their ability to win.

When it comes to our RF/Microwave design and manufacturing capabilities, as well as our business strategy, Mercury is the better alternative as we believe that Mercury Systems now occupies the "sweet spot" in the middle of the hourglass. We have the engineering discipline and manufacturing scale our customers have come to expect from organizations at the top of the hourglass in addition to the entrepreneurial DNA of the smaller firms who occupy the lower portion. In effect we offer the best of both worlds. The key to Mercury Systems occupying this unique space in the marketplace largely resides with our centers of excellence, the AMCs.

Our Advanced Microelectronics Centers provide complete design and production services, comprehensive manufacturing capabilities to help reduce program risk, multi-plant redundancy, DSS superior ratings, and ISO 9001 certification. We are the only mid-sized RF/Microwave

manufacturer that combines world-class design-to-automation services and advanced packaging solutions for rugged deployment. We provide robust build-to-print manufacturing expertise and can deliver high-density, next-generation integrated microwave assemblies, subsystems, as well as components. We have also co-located the engineering and design teams alongside manufacturing. In total, we often refer to it as "smart manufacturing".

We've invested in the best automation, manufacturing, and tune & test capabilities. This puts us in the best position to help our customers build affordable RF/Microwave technologies, with the processes and scalability that will allow our customers to reach full rate production when needed. Our AMCs make us the better alternative for our customers when it comes to building RF/Microwave solutions, from the component to the subsystem level. These centers of excellence can help prime contractors in their on-going efforts to migrate from a cost-plus model to a fixed-cost model, enabling adherence to the latest procurement mandates. At the same time, we act as a partner, not a competitor. Although we offer significant cost savings, it is our redundant capabilities, best practices, world-class engineering teams, consistent processes, and scalable manufacturing that really sets us apart.



Our AMCs provide secure clean-room facilities, volume-ready capabilities, along with program management and processes and procedures that mirror our prime contractor customers. We have a flexible business model, where there are co-investment opportunities from concept, to prototype, to full production. Because we have co-located both engineering and manufacturing capabilities within the AMC facilities, we are in a position to effectively and efficiently absorb outsourced work from the primes. The fact that there are two AMCs enables redundancy, something an outsourced partner often cannot offer.

RF/Microwave Solutions- Delivered Affordably

Mercury Systems has invested in best of class RF and Microwave technologies on behalf of our customers. We have a long-term commitment to this important sector within defense electronics. We leverage open architectures, deploy our best engineers and technicians, drive architecture and design with both performance and cost in mind, and have built state-of-the-art Advanced Microelectronics Centers to build and test our solutions. Within these centers we deploy full automation in manufacturing and test, with paperless control flow and best practices across the continuum of manufacture and test. We never take our eye off the ball when it comes to delivering what you need, at the cost you need it. We also lower risk and cost by deploying prototypes to ensure system success from a schedule and performance standpoint. By meeting your schedule, leveraging open architectures where possible, and adhering to performance and quality needs, we can lower cost of ownership.

Conclusion

The near-term outlook for DoD programs and initiatives is cloudy at best. A divided government remains, although some budget certainty is clearly better than none. Procurement reform and Better Buying Power 2.0 makes adapting to a challenging environment even more difficult. Yet the Pacific Pivot, modernization of critical defense platforms, and the opportunity to export key technology and platforms to our trusted allies, all create if managed properly.

All of this means your outsourcing partner needs to be in touch with the industry and maintain an appropriate stance in supporting our Prime Contractor customers. We believe our investment in research and engineering, design, manufacturing and test, and consistent processes within the all-important RF/Microwave market, is yet another proof point that demonstrates our commitment to our customers. As you help build solutions and platforms in electronic warfare, electronic countermeasures and electronic attack, Mercury has a portfolio of expertise and products, an understanding of the marketplace, and the ability to deliver, that truly makes us the better alternative. We have invested \$450 million into IRAD and acquisitions. Our growing capabilities in RF/Microwave technologies are another example of how this investment is paying off. We believe it's an investment that can pay off for your organization.

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