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Meeting the Challenges of the 2018 National Defense Strategy

Fulfilling the goals of sharpening our competitive advantage in electronic systems

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In Secretary of Defense James Mattis' Summary of the 2018 National Defense Strategy: Sharpening the American Military's Competitive Edge, he provides a critical framework for driving "urgent change at significant scale." This paper describes the role that Cadence can play in assisting the nation and its partners in achieving that urgency and scale of change called for in the vision and goals set out by the Secretary. For the creation and modernization of electronic systems, Cadence possesses the significant technology, intellectual property, and a skilled workforce that can assist the Department of Defense (DoD), its affiliated agencies, and contractors that are ready to pursue urgent change at significant scale. Cadence has the historical relationship base and global reach to be effective in catalyzing, and, if empowered, driving change to fulfill the vision of the new national defense priorities and strategy.

Contents

Introduction

Secretary Mattis' strategy lays out specific changes to historical practices, including modernizing key capabilities. "We cannot expect success fighting tomorrow's conflicts with yesterday's weapons or equipment," he said. In doing so, he outlines a strategy that calls for a "transition of a culture of performance where results and accountability matter… deliver[ing] performance at the speed of relevance."

The role of electronics is a central one in all the cited critical areas to address, including:

- Modernizing nuclear forces
- Investing in space and cyberspace as warfighting domains
- Prioritizing developing command, control, communications, computers and intelligence, surveillance, and reconnaissance (C4ISR) information ecosystems
- Focusing on missile defense
- Prioritizing forward force maneuver and posture resilience
- Investing heavily in advanced autonomous systems
- Establishing and developing resilient and agile logistics

With electronics being at the heart of these systems in areas of priority for investment, organizations desiring to remain relevant to national security must "up-level" their electronics systems design capabilities. Secretary Mattis says that, "success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts." His response to this challenge is to prioritize speed of delivery, continuous adaptation, and frequent modular upgrades. To that end, he discourages "cumbersome approval chains, wasteful applications of resources in uncompetitive space, or overly risk-averse thinking that impedes change."

Leveraging commercial best practices within the confines and requirements of national defense is critical to success. Cadence has experience in navigating through this evolution with several major defense contractors and DoD entities.

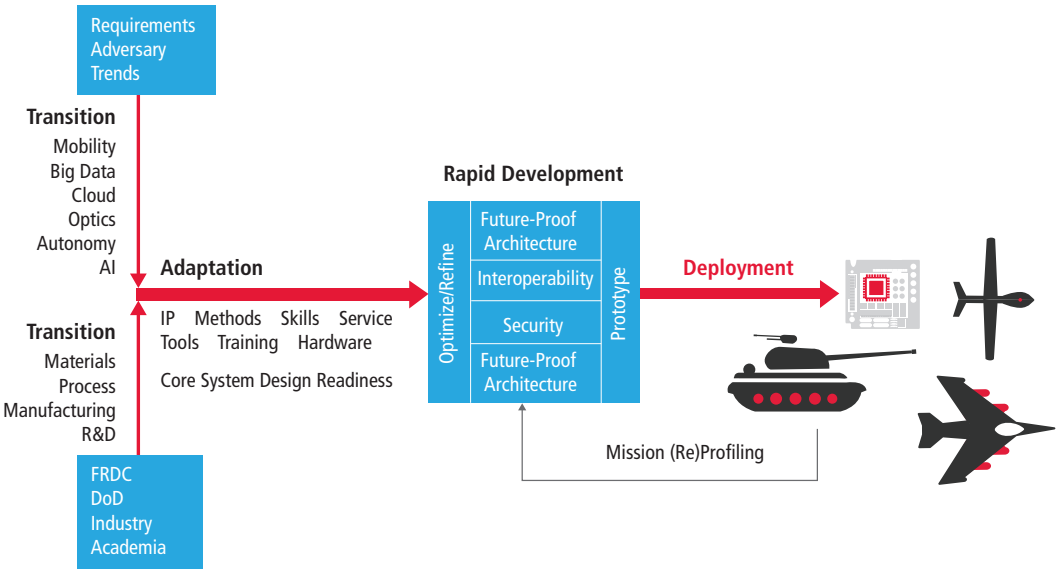

Figure 1: Cadence prepares your teams to tackle the next wave of technologies, trends, and requirements

Cadence has established key relationships with relevant congressional staff and within the DoD and its branches, is active on several DARPA programs such as Circuit Realization At Faster Timescales (CRAFT), Arrays at Commercial Timescales (ACT), Common Heterogeneous Integration and IP Reuse Strategies (CHIPS), and System Security Integrated Through Hardware and Firmware (SSITH). Additionally, Cadence is presently engaging with armed services branches on several new programs, such as the work to bring an emulation cloud capability to the Air Force Research Labs in Dayton Ohio.

Cadence is a direct performer on a several DoD projects and has commercial relationships with virtually every company that designs or provides electronics to the DoD. In many cases, this relationship is deeper than the typical user-suppler relationship; Cadence develops research programs, products, and solutions collaboratively with our customer-partners. Our customers use our leading-edge technology and services to design, verify and deploy state-of-the-art DoD electronics systems. Cadence provides the technology required for our customers to utilize the world's most advanced semiconductor manufacturing processes. Working with DoD entities, DoD Research Labs and DoD Primes, Cadence has deployed collaborative design and verification infrastructures that enable rapid access to these best in class technologies and services. Cadence possesses a DoD Facility Security Clearance, offers "cleared" engineering resources and is on the path for obtaining "Trusted Certification" for our design flow..

Over a thousand universities (over 250 in the US) participate in the Cadence® Academic Network program, which exposes roughly 30,000 students every year to the best industry practices and design technology. By working closely with the upcoming workforce, we forge strong long-term relationships with professors and train the next generation of technically sophisticated engineers for our workforce.

Cadence Solution Elements

Cadence is expert at catalyzing change: changes in practices, methods, and tools for the more efficient, cost-effective, and rapid development of electronic-centric systems. To make a transformational change in design capability, a broad set of areas of expertise that Cadence can bring to bear include:

- Methodology consulting to transition to industry best practices
- Educational services to ensure maximum capability leverage and self-sufficiency
- A partner network that can help connect with new DoD, industry, and ecosystem partners

- Best-in-class design automation tools that span concept through post-silicon validation
- Design services that provide embedded knowledge transfer and program team skill augmentation
- Intellectual property (semiconductor IP) that includes silicon-proven interfaces, memory controllers, and processors
- Vertical domain expertise, including AI/machine learning, hardware security, rad-hard-by-design verification, and functional safety
- Foundry, IP, and manufacturing co-R&D programs with market leaders that enable new industry-wide capabilities

Founded in 1988, Cadence has a long history in electronic design automation (EDA). The company employs over 7,000 people and its 2017 revenue was almost $2B. Almost 40% of that revenue is spent on R&D. Known for its innovative culture and for repeatedly being one of Fortune's 100 Best Companies to Work For worldwide, Cadence is headquartered in San Jose, CA, and has offices in cities around the country, including Washington DC, Cary, Boston, Austin, Dallas, Orlando, San Diego, and Orange County.

Cadence products and technologies are combined with ready-to-use packages of technologies assembled from our broad portfolio of IP and other associated components that provide comprehensive solutions for low power, mixed signal, and designs at smaller geometries (advanced process nodes), as well as popular designs based on design IP owned and licensed by other companies. These solutions are useful for designers who specialize in areas that include:

- System design and verification
- Functional verification
- Logic design
- Digital implementation
- Custom IC design and verification
- Printed circuit board (PCB) design
- IC package and system-in-package (SiP) design and analysis

Best known for its design automation tools, semiconductor IP, and solution flows that enable designers to create innovative electronic systems, Cadence's System Design Enablement strategy pushes us to deliver innovative solutions for a wide range of industries, including aerospace and defense.

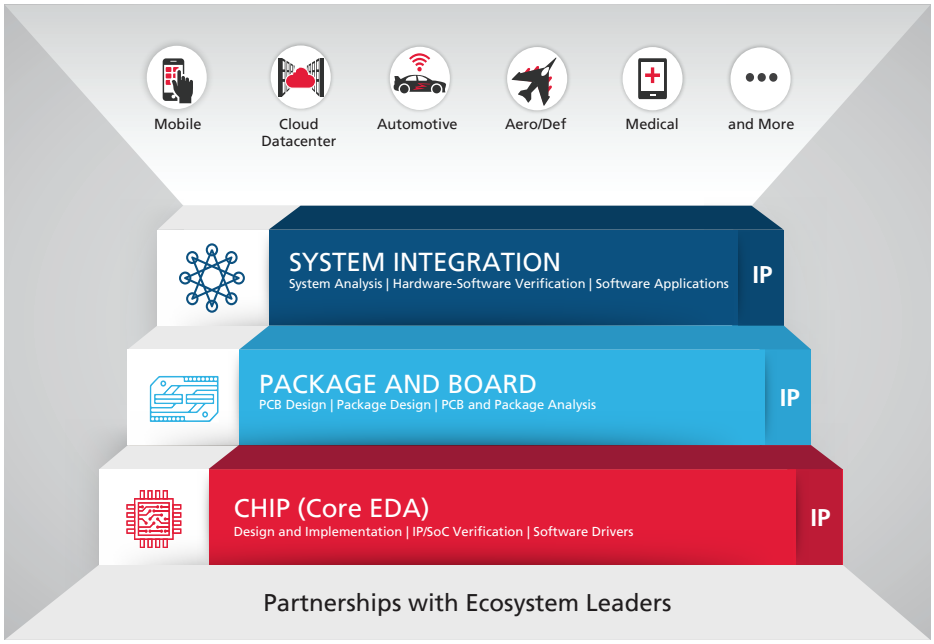

Figure 2: Cadence's System Design Enablement strategy guides our development of comprehensive solutions for the design of chips, boards, and systems

System Prototyping

In the Summary of the 2018 National Defense Strategy, Secretary Mattis lays out the plan to reform the DoD for greater performance and affordability. In the drive to deliver performance at the speed of relevance, he highlights the importance of streamlining iterative approaches from development and fielding.

> *"Prototyping and experimentation should be used prior to defining requirements and commercial off-the-shelf systems. Platform electronics and software must be designed for routine replacement instead of static configurations that last more than a decade. This approach, a major departure from previous practices and culture, will allow the Department to more quickly respond to changes in the security environment..."*

At Cadence, we believe that going from design straight into physical prototyping is a recipe for surprises and schedule delays. Present prototyping methods focus on the function of the system and the size, weight, and power (SWAP) requirements that are all but impossible to measure based on the physical prototype sacrifices. This means that valuable time, dollars, and human resources are wasted on solution paths that later prove to be infeasible.

Cadence has developed a new, improved system prototyping methodology that introduces an emulation and analysis step, as well as an explicit go/no-go step prior to committing an idea to a physical prototyping step.

Emulation is a vital technology for system prototyping because it provides the combination of capacity, runtime performance, accuracy, linkages to physical analysis (including performance, power, thermal, etc.), and the visibility necessary to make accurate go/no-go decisions. Its performance enables running application software on hardware designs resident in the emulator.

The Cadence Palladium® Z1 Enterprise Emulation Platform is the industry's leading emulation system and the only one working in system prototyping flows. It provides enterprise-level reliability and scalability to accelerate the verification of chips, subsystems, and IP blocks. Emulation technology coupled with a system prototyping development methodology provides the insurance that new device designs can interoperate with existing components, subsystems, and systems.

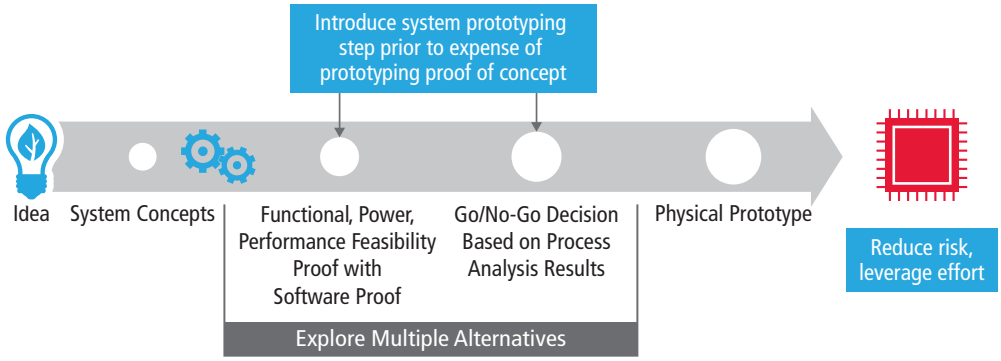

Figure 3: System prototyping is a proven approach for obsolete parts replacement and iterative system upgrades

This system prototyping methodology has been successfully applied to address the obsolescent parts problem. Part-for-part replacement is often not a good choice for systems that have been in the field for some time. A more effective approach is to look ahead for the likely next candidates for obsolescence and group them together with the present, thus yielding significant savings and improvements. Further, taking a broader architecture view, opportunities for system optimization and mission expansion can be applied to choose the scope of the upgrade to be undertaken. Becoming proficient at this methodology is the ultimate way to future-proof systems.

Hardware System Co-Design, Analysis, and Optimization

Traditionally, the design flow between the chip, package, and PCB has been a time-consuming and error-prone manual process, particularly with designs that use thousands of pins. Different designers working on different parts of the system—the IC itself, the PCB, and the packaging—have typically designed with tools meant for each particular substrate that do not communicate with each other, resulting in sub-optimal results.

An automated method to co-design and co-analyze across the different domains saves time and effort and results in higher-performing and cost-competitive systems. We provide those capabilities with the Cadence Virtuoso® System Design Platform, which is ideal for designs that integrate multiple heterogeneous ICs, including RF, analog, and digital devices.

The Virtuoso System Design Platform identifies errors that otherwise may not be detected until the design undergoes circuit simulation or until it is built. With the platform, the user can now move parts across different fabrics and assess the outcome, performing "what if" analyses to optimize interconnect routing, how the die in an IC will appear in the package, and so on.

Today, particularly with analog and RF designs, if an IC designer doesn't account for what is happening on the PCB or package, chances are that the chip won't work. By streamlining and automating the flow between the chip, package, and PCB, the Virtuoso System Design Platform provides IC designers with assurance that the chip they are designing will continue to function as designed when placed in the package, and then on the PCB, and finally, into the system, before building out the design.

Digital Twinning: The Path to Optimal Systems Development and Lifecycle Management

In 2003, John Vickers of NASA and Michael Grieves introduced the term "digital twin" to denote a digital copy of a physical product, both of which were virtually indistinguishable. The basic elements of a digital twin for electronics strongly parallel those used for predominately physical systems in the following domains:

- Physical electronic systems in real space
- System prototypes in emulation space
- Data connections that tie the virtual and real systems together

Operationally, the successful electronic system-digital twin pair relies upon mission data collection and transmission to the digital twin. Strategies for collection, compression, and distillation require careful forethought. It is possible that presumptions on mission profiles and environmental characteristics prevent critical insights that might be used to improve efficacy and avoid field failures.

Once adopted, the electronic system digital twin paradigm serves as a powerful ally in the creation of a successful rapid, iterative approach to fielding system that quickly deploys advanced capabilities to the warfighter and serves as a guard against obsolescence and acquisition risk. Further, as upgraded components are introduced, this methodology ensures interoperability with legacy systems.

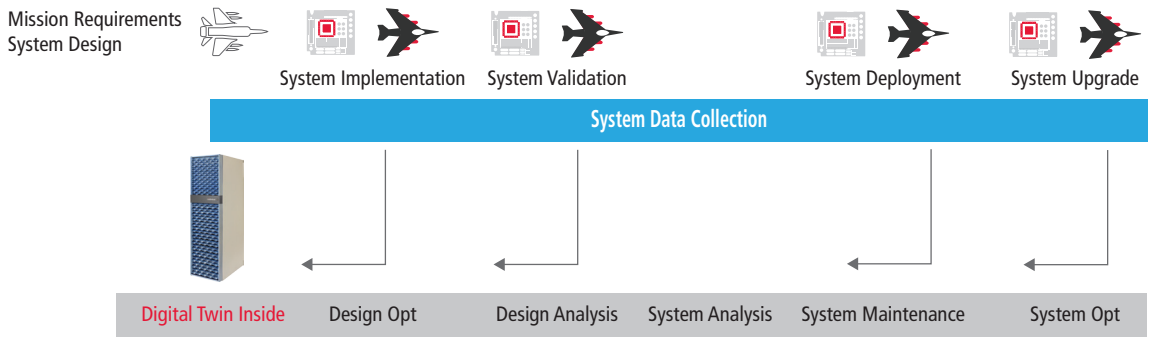

Figure 4: Digital twins can be leveraged throughout the system lifecycle, from concept formulation to prototype validation, field deployment to retirement

Agile Hardware Design

Agile hardware design practices can help transform today's iterative development methods but require a new, more globally optimal approach. Instead of executing design serially, the commercial world has transformed by overlapping the hardware and software development processes. Beyond the acceptance of the general values of rapid, agile design, Cadence has a host of recommended changes to electronics system development program execution including:

- Design the chip, package, and board in a common environment that speeds the overall system development
- Perform parasitic extraction incrementally as the physical chip layout progresses, detecting problems introduced by layout early, when correcting the problem is far simpler than at the end of the design
- Use tools that integrate the actual foundry approved signoff engines into the physical design optimization software, resulting in fewer iterations, faster time-to-tapeout, and better performance, power, and area
- Develop a metric-driven verification methodology that tracks the process towards verification signoff to eliminate last-minute surprises
- Overlap hardware and software development to reduce integration time and shorten the overall schedule
- Leverage commercially proven IP subsystems and blocks to speed the design cycle and cut costs

By effectively utilizing the core principles of agile hardware design, Cadence can help the national defense industry create meaningful change, improve operations, and speed design efforts.

We Want to Be Your Partner

Within this framework, Cadence can act as a key partner in assisting organizations to transform themselves to competitively meet the requirements of the new order. Cadence is an experienced transformation agent, enabling electronic design teams to reach world-elite status by leveraging the most advanced design styles, materials, processes, and manufacturing capabilities, using a first-pass-success methodology. Combinations of education, services, and technology that leverage the industry ecosystem are used to achieve quantum change needed for creating future-proofed systems. This change enables teams to achieve new levels of performance, efficiency, and speed required to be competitive as well as provide valuable contributions to the national security agenda.

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Cadence software, hardware and semiconductor IP enable electronic systems and semiconductor companies to create the innovative end products that are transforming the way people live, work, and play. The company's System Design Enablement strategy helps customers develop differentiated products—from chips to boards to systems www.cadence.com