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2017 State of the VITA Technology Industry

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by: Ray Alderman, Chairman of the Board, VITA

This report provides the reader with updates on the state of the VITA Technology industry in particular and of the board and system industry in general, from the perspective of Ray Alderman, the Chairman of the Board of VITA. VITA is the trade association dedicated to fostering American National Standards Institute (ANSI) accredited, open system architectures in critical embedded system applications. The complete series of reports can be found at Market Reports. (www.VITA.com/MarketReports)

Introduction

We are not going to talk about North Korea shooting missiles over Japan or their recent nuclear test of a claimed hydrogen bomb. We're not going to talk about Iran threatening to shoot-down American spy planes and drones coming close to their borders. We are not going to talk about China and India's conflict on their borders in Doklam. We are not going to talk about India and Pakistan fighting over Kashmir recently. And we are not going to talk a lot about world economic conditions this time, since things seem to be improving, especially in U.S. gross domestic product (GDP). We are going to focus on technology in this white paper, with a brief side trip to Europe's latest shenanigans. There's plenty to explore after you read this report.

Moore's Law is dead. Dennard's Law is dead. And those events are leading to the death of von Neumann computer architectures being replaced with neural networks and quantum machines. We are going to talk about new "open architecture" standards efforts in data center, telecom, and the military. And we're going to talk about Col. John Boyd's Observe, Orient, Decide, and Act (OODA) loop, and how VITA standards efforts need to adapt to the new technologies coming to our little world. This report is a very short brief on the tremendous changes happening around us, and how they will affect us. Abandon hope, all ye who enter here.

Business Conditions

U.S. GDP grew at 1.2% (final estimate) in 1Q2017, and increased to 2.6% (first estimates) in Q2.[1] One look at the chart of U.S. GDP history since 2012 shows that growth has been erratic and spasmodic for all those years. In late August, the second estimate for Q2 U.S. GDP growth was revised up to 3% and the final estimate in late September raised that to

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1 Akin Oyedele, "*Consumer spending propels economic growth in the 2nd quarter — but by less than expected*", Business Insider, 28 July 2017, http://www.businessinsider.com/gdp-gross-domestic-product-q2-2017-advance-estimate-2017-7

3.1%.[2] We don't yet know how bad Hurricanes Harvey and Irma will affect the Q3 numbers, but it doesn't look good considering that 25% of U.S. oil refining capacity was shut-down by Harvey, and the Florida orange juice crop took a hit from Irma. But, those GDP reductions could be minor compared to the reduced sales of Lone Star beer (to the cowboys in Houston, TX) and the diminished sales of BENGAY arthritis cream (to the retirees in Naples, FL). U.S. GDP growth for all of 2016 was only 1.6% without any hurricanes.

By comparison, European Union (EU) GDP growth came in at 2.2% (annualized) for Q2, up from 2.1% in Q1. China came in at a questionable 6.9% again for Q2. Rather than bore you with numbers from the other major economies, here's a list of the latest GDP growth rates by country. World GDP growth in 2016 was 3.2%. The 2017 forecast is for 3.5% growth.[3]

Let's talk about something more interesting here: the EU's initiatives to tax U.S. technology companies into the same dismal, unimaginative, and oppressed condition as their indigenous companies. Examining the EU's history, an informed person could be cynical and argue that the last great technological innovation that Europe gave to the world was the cuckoo clock in the early 1700's. They haven't invested in technology or produced anything of merit for the last 70 years while the U.S. has produced Apple, Google, Facebook, Qualcomm, Amazon, and Intel. Additionally, the U.S. has created credit default swaps on home mortgages given to people who can't possibly make the payments, introduced hundreds of cryptocurrencies like Bitcoin that finance start-ups without issuing stock or dealing with investment bankers, and we invented the bacon-double-cheeseburger along the way too. Looking at the aging population demographics in the EU, and the births per female per country in Europe (below the 2.1 replacement rate), will give you an idea about why they adopted an "open borders" policy. They need low-paid immigrants to grease their manufacturing machines regularly, and sweep-up at the end of the day. These policies could be seen as a reversion to the caste system of feudal Europe. Just look at Japan's recent fate: they have the world's oldest population, low birth rates, a restrictive immigration policy, and terrible economic numbers. This gives you a general idea about Europe's systemic problems.

How can the EU get more money? They can do what they have done best in the past: colonization. Except this time, they won't take over another nation's resources with soldiers wielding spears, swords, and muskets. They are sending-in overweight, pâté-eating, wine-slurping lawyers in ill-fitting suits and ugly shoes.

The EU fined Apple $14.5 billion in 2016 for their tax deal with Ireland.[4] They fined Google $2.7 billion in June for antitrust violations.[5] They fined Qualcomm 10% of their total revenue (about a $2.4 billion in fines) for antitrust violations in 2015, and now say Qualcomm must pay $600,000 per day until they deliver certain documents and evidence in the court case.[6] In May of 2017, the EU fined Facebook $120 million over issues with the WhatsApp acquisition.[7] Intel was fined $1.2 billion for their business practices in 2009, and that case is under review.[8] In early October, the EU fined Amazon $250 million for their tax deal with Luxembourg.[9] And recently, the EU is considering

2 Lucia Mutikani, "*U.S. economy accelerates in second quarter; hurricanes expected to slow growth*",
   Reuters, 28 September 2017, http://www.reuters.com/article/us-usa-economy-gdp/u-s-economy-
   accelerates-in-second-quarter-hurricanes-expected-to-slow-growth-idUSKCN1C31QR

3 Brian Wang, "*World GDP growth projected to be 3.5% in 2017 and 3.6% in 2018*," NextBigFuture.com, 8 June 2017,
   https://www.nextbigfuture.com/2017/06/world-gdp-growth-projected-to-be-3-5-in-2017-and-2-6-in-2018.html

4 Michael Mchugh, "*Ireland to accuse European Commission of exceeding powers in Apple tax dis-
   pute*", Independent, 19 December 2016, http://www.independent.co.uk/news/business/news/
   ireland-apple-tax-ruling-appeal-european-commission-exceeded-powers-a7483861.html

5 Foo Yun Chee, "*EU fines Google record $2.7 billion in first antitrust case*", Reuters, 27 June 2017, http://www.reuters.
   com/article/us-eu-google-antitrust/eu-fines-google-record-2-7-billion-in-first-antitrust-case-idUSKBN19I108

6 Foo Yun Chee, "*Qualcomm loses appeal against EU threat of daily fin*", Reuters, 17 July 2017, https://www.reuters.com/
   article/us-eu-qualcomm-antitrust/qualcomm-loses-appeal-against-eu-threat-of-daily-fine-idUSKBN1A219J

7 Reuters Staff, "*EU fines Facebook 110 million euros over WhatsApp deal*", Reuters, 18 May 2017, http://www.reuters.com/
   article/us-eu-facebook-antitrust/eu-fines-facebook-110-million-euros-over-whatsapp-deal-idUSKCN18E0LA

8 James Kanter and Amie Tsang, "*Intel's $1.3 Billion Fine in Europe Requires Review, Court Says*", Business Day, 6 September 2017,
   https://www.nytimes.com/2017/09/06/business/intel-eu-antitrust-fine.html?mcubz=3

9 Robert-Jan Bartunek, "*EU orders Amazon to repay $295 million in Luxembourg back taxes*", Reuters, 4 October 2017,
   http://www.reuters.com/article/us-eu-amazon-taxavoidance/eu-orders-amazon-
   to-repay-295-million-in-luxembourg-back-taxes-idUSKCN1C913S

changing their copyright laws, implementing a "link tax" on any website that extracts a brief quote from copyrighted text, and then provides a link to the article.[10] Think about the payments this tax would extort from Google, Yahoo, and Facebook.

Let's add-up these fines. They come to about $21 billion, give or take a few hundred million, without considering what the link tax would add to the pile. France, Germany, Italy, and Spain say they want their part of these settlements, since they are the primary economies of the EU and most of the collected fines and taxes are theirs. But, the European Commission wants to keep this new-colonial money in the Brussel's coffers. These four countries are now demanding new rules that dictate mandatory high corporate tax rates across all EU members, so that countries like Ireland and Luxembourg can't attract major U.S. technology corporations with lower tax rates. Another demand is that U.S. corporations pay taxes on sales (not profits) in each country, regardless of where their main EU offices might be located.[11]

What we have here is similar to the taxes forced upon American colonists by Europeans back in the 1770's, but the tax is now on imported technology rather than exported tea. The EU has already taxed their citizens and companies to the edge of intolerance. On the surface, it seems like they are employing ways to fine and tax American companies and U.S. citizens to keep their faulty economic game, and flawed political structure, going for a while longer. A brief look at the unemployment rates across EU countries will give you another idea about why they desperately need money.[12]

The U.S. administration is about to get involved in these nefarious EU tax-grabbing new-colonialist antics against U.S. corporations, and it's not going to end well for the unelected officials in Brussels. One proposal I might suggest to U.S. authorities is that the fines, revenue tax, and link taxes collected from U.S. technology companies be mandated for expenditure on defense. That would bring those country's military spending up to the 2% of their GDP required by the NATO Treaty but they'll never agree to such conditions, not with the overwhelming liabilities to fund their aging populations with healthcare and government payments to immigrants. Only five countries meet the NATO defense spending requirement today: the U.S., Greece, United Kingdom, Estonia, and Poland.[13]

U.S. companies could just raise the prices of their products by the amount of the new EU levies, and European citizens in each country would pay. Apple, Google, Facebook, Intel, Amazon, and Qualcomm could then take that money and buy military hardware from Boeing, General Dynamics, Northrop-Grumman, Raytheon, and Lockheed, and then get Amazon (who has the best logistics system in the world) to deliver those military products to each EU country not spending 2% of their GDP on defense, in lieu of the tax payments and fines. The Pentagon would then spend less American money defending Europe. That's one way I can see to get the EU countries to live-up to their NATO obligations, help the Pentagon's budget, comply with any new EU taxes levied on U.S. companies, raise U.S. GDP growth to 4%, and increase the sales of VITA member's products substantially, all at the same time.

Europe is about to cover the same muddy economic ground that Japan has trod for 20 years, and the EU needs American money to postpone the effects of that inevitable journey. Japan, however, is depending on automation and robotics to increase their productivity and GDP, to avoid the heavy social cost associated with uneducated and unskilled immigrants. If you take the EU's financial, unemployment, low military spending, immigration, low birthrates, and aging demographic conditions into

"One proposal I might suggest to U.S. authorities is that the fines, revenue tax, and link taxes collected from U.S. technology companies be mandated for expenditure on defense."

"Europe is about to cover the same muddy economic ground that Japan has trod for 20 years."

10 Jeremy Malcolm, "*How Europe's changes to copyright law will affect America*", TechCrunch.com, 26 September 2017, https://techcrunch.com/2017/09/26/how-europes-changes-to-copyright-law-will-affect-america/

11 Jon Stone, "*EU states propose 'turnover tax' to fight back against tech giants' corporation tax dodging*", Independent, 11 Sept 2017, http://www.independent.co.uk/news/world/europe/eu-turnover-revenue-tax-corporation-tax-avoidance-a7941116.html

12 "*Unemployment rate in member states of the European Union in May 2017 (seasonally adjusted)*", Statista, May 2017, https://www.statista.com/statistics/268830/unemployment-rate-in-eu-countries/

13 Ian Bremmer, "*The Only 5 Countries That Meet NATO's Defense Spending Requirements*", Time, 24 February 2017, http://time.com/4680885/nato-defense-spending-budget-trump/

consideration, viewing their recent actions as a despicable and underhanded way to tax Americans is certainly one of the conclusions you can reach without any significant leaps of faith.

Now, wasn't that more fun and informative that digging through all the boring and laborious economic numbers by country?

Markets

Military and Aerospace

There's a lot going on in the military segment, so let's start from the top. In the past, there were three domains of warfare: Land, Sea, and Air, handled by the Army, Navy, and Air Force (respectively). In the 1960's, we added the Space domain. That was integrated into the Air Force's dominion. A few years ago, we added Cyberspace and that domain was assigned to NSA (signals intelligence). Today, those last two domains and where they were placed, are creating significant discussions and concerns.

The Army Air Corps was broken-off from the Army in 1947, as an independent service, but with resistance from both the Army and the Navy. If it has wings and flies from fixed air fields today, it belongs to the Air Force. So, it would be a natural extension for anything flying in Space to come under the jurisdiction of the Air Force, right? Not according to the U.S. Navy. In June, members of the strategic forces subcommittee of the Armed Services Committee, passed a bill to establish the Space Corps under the U.S. Air Force, much like the Marines were placed under the jurisdiction of the U.S. Navy.[14] But, the Navy claims that space is their domain, since most space law, operations, and rules are based on maritime law.[15] It's going to be interesting to watch this inter-service rivalry play-out.

Initially, the U.S. Cyber Forces were formed under the National Security Agency (NSA) and has two divisions: global network operations (GNO) has the defensive mission, and network warfare (NW) has the offensive missions. President Trump and others have been discussing moving the cyber group out from under NSA, naming it Cyber Command, and putting it on even footing with the other military services (Army, Navy, Air Force, and maybe Space Command). [16] This makes some sense, because NSA is considered an intelligence collection service, with no offensive missions. With NSA launching worms and viruses against enemy computer networks that could destroy targets and kill combatants, their mission would change.

However, the Central Intelligence Agency (CIA), with the mission of collecting actionable intelligence, has their Special Activities Division (SAD), charged with offensive paramilitary operations. The CIA flew the first missions in the Middle East with armed drones, hitting high-value targets regularly. So, keeping Cyber Command under NSA, and giving them offensive military authority would not be unusual. We don't have the room to debate the pros and cons here, so read the *"The U.S. Air Force, Not the Navy, Should Lead America in Space War"* and *"Much Ado about Nothing? Cyber Command and the NSA"* articles in the footnotes. We will have to wait and see how this conflict is resolved too.

In 1899, the most powerful military nations on earth signed a treaty banning the use of aircraft in war, but it expired five years later with no support to renew it. Aircraft were first used offensively in early WWI.[17] In July 2017, 122 nations signed a UN treaty banning nuclear weapons in war. None of the nine nations that presently have nuclear weapons signed the treaty.[18] Today, we are seeing amazing developments in artificial intelligence applied to autonomous

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14 Rebecca Kheel, *"Government debates need for military Space Corps"*, The Hill, 15 July 2017,
http://thehill.com/policy/defense/342040-government-debates-need-for-military-space-corps

15 Brent Ziarnick, *"The U.S. Air Force, Not the Navy, Should Lead America in Space War"*, War is Boring, 24 July 2017,
https://warisboring.com/the-u-s-air-force-not-the-navy-should-lead-america-into-space/

16 Michael Sulmeyer, *"Much Ado about Nothing? Cyber Command and the NSA"*, War on the Rocks, 19 July 2017,
https://warontherocks.com/2017/07/much-ado-about-nothing-cyber-command-and-the-nsa/

17 Tom Simonite, *"AI Could Revolutionize Was as Much as Nukes"*, Wired, 19 July 2017,
https://www.wired.com/story/ai-could-revolutionize-war-as-much-as-nukes/

18 Ian Sample, *"Treaty banning nuclear weapons approved at UN"*, The Guardian, 7 July 2017,
https://www.theguardian.com/world/2017/jul/07/treaty-banning-nuclear-weapons-approved-un

military weapons systems. In July, Russia's Kalashnikov announced their new Artificial Intelligence (AI) powered gun that can find and kill targets without human guidance.[19] China is developing autonomous cruise missiles.[20]

In 2012, the Secretary of Defense, Ash Carter issued Directive 3000.09, for the development and use of autonomous and semi-autonomous weapons systems. It basically says we can't use fully autonomous weapons against humans, but that directive can be modified or rescinded by the DoD at any time. If our enemies develop and deploy AI-weapons, then the U.S. will do the same. The UN is holding meetings this year on Lethal Autonomous Weapons Systems (LAWS). But, the UN doesn't make the rules. They create treaties, and countries must sign them to be bound. You can expect the same result on the LAWS treaty that we saw on the UN ban of nuclear weapons: only the countries without AI-powered killer robots will sign it.

China has been moving troops and equipment to their border with North Korea, in preparation for an economic and political collapse of the country, or an attack by U.S. and South Korea forces.[21] In late July, Iran launched another missile capable of sending satellites into space. But the payload of that missile is only about 550 pounds. Primitive nuclear warheads weigh more than twice that amount.[22] North Korea launched ICBM-class missiles on July 4 (that could hit Alaska) and July 28 (that could hit U.S. east coast cities).[23]

In June, the DoD released their new Electronic Warfare Strategy plan, but it is only available to government employees and DoD contractors.[24] The basics of the plan are to make our EW systems agile, adaptive, and integrated into all the services and appropriate platforms.

The U.S. is the world's largest arms exporter with about 33% of the market, followed by Russia and then China. India was the world's largest military arms importer, followed by Saudi Arabia and United Arab Emirates.[25] There are some good interactive charts in the footnote on this topic.

On July 21, President Trump issued an Executive Order for the DoD to do a complete study of the military industry supply chain.[26] Over the years of reduced military spending and budget reductions by previous administrations, a number of defense supplier divisions have been merged or sold off.

Outer Space Treaty

You really should read the United Nations' Outer Space Treaty, the rules for exploring or mining extraterrestrial objects. If an American trades a cellphone to an extraterrestrial alien for a reverberating carbonizer weapon with mutate capacity, and the cellphone is considered by the IRS to have more value, then the alien must pay U.S. taxes on the difference. A short list of laws are on the books that apply when you meet an alien life form. I have proposed that VITA consider modifying our policies and procedures to comply with these laws, considering that some of the people coming to VITA meetings show undeniable signs of being aliens.

19 Patrick Tucker, "*Russian Weapons Maker To Build AI-Directed Guns*", Defense One, 14 July 2017, http://www.defenseone.com/technology/2017/07/russian-weapons-maker-build-ai-guns/139452/

20 Dave Majumdar, "*Is China Getting Ready to Build Its Own Lethal Tomahawk Cruise Missiles?*", The National Interest, 19 August 2016, http://nationalinterest.org/blog/the-buzz/china-getting-ready-build-its-own-lethal-tomahawk-cruise-17410

21 David K. Li, "*China preparing for crisis along North Korean border*", New York Post, 24 July 2017, http://nypost.com/2017/07/24/china-preparing-for-crisis-along-north-korean-border-report/

22 Reuters Staff, "*U.S. says Iran rocket test breaches U.N. resolution*", Reuters, 27 July 2017, http://www.reuters.com/article/us-iran-satellite-idUSKBN1AC1YY

23 Tom Phillips, "*North Korea missile test shows it could reach New York, say experts*", The Guardian, 28 July 2017, https://www.theguardian.com/world/2017/jul/28/north-korea-fires-missile-japan-reports-say

24 Sean D. Carberry, "*DOD releases electronic warfare strategy to stakeholders*", FCW, 22 June 2017, https://fcw.com/articles/2017/06/22/ew-strategy-pentagon-carberry.aspx

25 Dr Kate Blanchfield, Pieter D. Wezeman and Siemon T. Wezeman, "*The state of major arms transfers in 8 graphics*", Stockholm International Peace Research Institute, 22 February 2017, https://www.sipri.org/commentary/blog/2017/state-major-arms-transfers-8-graphics

26 Sandra Erwin, "*Trump Executive Order Directs Major Study of U.S. Defense Industrial Base*", RealClear Defense, 24 July 2017, http://www.realcleardefense.com/articles/2017/07/24/trump_directs_major_study_of_us_defense_industrial_base_111874.html

The 2018 National Defense Authorization Act (NDAA) is awaiting approval.[27] This bill eliminates the Quadrennial Defense Review (QDR) replacing it with the National Defense Strategy (NDS) from the Pentagon, that is created from the National Security Strategy (NSS) from the President, from what I can tell.[28] Look at this source for better explanations.[29]

Obviously, technology is moving much faster than the DoD and the legal systems ability to keep up. There are many papers and reports on multi-domain warfare and cross-domain warfare on the web that are worth reading. The Pentagon is also working on a "war algorithm", that plans and executes battles against enemy forces faster than human commanders.[30]

"Obviously, technology is moving much faster than the DoD and the legal systems ability to keep up."

Technology

Before I get into the details here, let's look at a little history to help explain what is going on in technology today. When microprocessors came out in the 1970's, they were based on the von Neumann model of subsystems: memory, processing, I/O, storage, etc. They were used as sequencers, to replace relays and relay ladder logic in control systems. Another word for these machines is "samplers". The software program implemented a linear progression of instructions that polled the I/O (i.e., read the registers of the I/O chips and then react to those values). You can easily identify a sequencer program: the last instruction is "go to the top". These machines were all CPU-bound: the I/O could deliver more data than the CPU could process.

Better von Neumann microprocessors in the 1980's allowed us to implement event-driven systems, using interrupts. And advancements in real time operating systems efficiently scheduled the CPU cycle utilization. But, it was still a CPU-bound von Neumann architecture. Even though the CPU spent most of its time waiting for interrupts, performance went up dramatically. An interrupt-driven machine can handle much more I/O traffic than a sampling machine.

In the 1990's, advances in microprocessor technology allowed us to implement data-driven machines, still based on the von Neumann architecture. We now had gigahertz processors, that could handle more data than the I/O devices could provide. We became I/O-bound, and have been ever since. Von Neumann architectures only worked when we were CPU-bound. To feed the CPU's today, we need optical links, not speed-limited copper traces and wires.

In the last few years, Moore's Law died: we couldn't get a doubling of transistors and clock frequency every 18 months. And Dennard's Law died too: power density no longer stays proportional to chip area. So, with these points in mind, let's look at what is happening:

- *In April, Fujitsu announced their new 12-core SPARC XII processors, for Unix customers not wanting to transition to commodity servers and Microsoft code.[31]*

- *Sometime this fall, IBM will release their new POWER9 Processor chips.[32] They are aimed at data center applications and incorporate AIX, CAPI, NVLink, and Gen-4 PCIe links.*

27 Shawn Brimley, "*Getting the Pentagon's Next National Defense Strategy Right*", War on the Rocks, 24 May 2017,
   https://warontherocks.com/2017/05/getting-the-pentagons-next-national-defense-strategy-right/

28 John Kummer, Brenton Ramsey & Michael Padgett, "*National Military Strategy Development—Time for a Revolutionary Approach*", RealClear Defense, 17 March 2017,
   http://www.realcleardefense.com/articles/2017/03/17/national_military_strategy_revolutionary_approach_110985.html

29 Peter Feaver, "*The Hardest Part of Trump's National Security Strategy to Write*", Foreign Policy, 14 June 2017,
   http://foreignpolicy.com/2017/06/14/the-hardest-part-of-trumps-national-security-strategy-to-write-russia-hacking-disinformation/

30 Colin Clark, "*The War Algorithm: The Pentagon's Bet On The Future Of War*", Breaking Defense, 31 May 2017,
   https://breakingdefense.com/2017/05/the-war-algorithm-the-pentagons-bet-on-the-future-of-war/

31 Timothy Prickett Morgan, "*Fujitsu Takes on IBM Power9 with SPARC 64-XII*", The Next Platform, 5 April 2017,
   https://www.nextplatform.com/2017/04/05/fujitsu-takes-ibm-power9-sparc64-xii/

32 Eve Daniels, "*POWER9 Is Next Stop on IBM Power Road Map*", IBM Systems, November 2016,
   http://ibmsystemsmag.com/power/businessstrategy/competitiveadvantage/power9-plans/

- *In June, AMD announced their EPYC server processors, new CPUs to challenge Intel's Xeon line at the data center.[33] The four cores in the CPU communicate over their new "Infinity Fabric" internally, in a mesh architecture. Infinity goes off-chip to other EPYC processors, creating a Non-Uniform Memory Access (NUMA) architecture. Originally implemented by Sequent Computer back in 1995. The chips also have multiple paths to memory, something we were doing back in my mainframe computer days of the 70's. So, we are seeing some 1975 and 1995 ideas implemented in silicon here.*

- *In July, Intel announced their new Xeon scalable server CPU chips.[34] If memory serves, previous cores in Intel multicore CPUs were connected with two counter-rotating rings. The new Xeon cores are connected with a mesh architecture, using some variation of OmniPath links. These new chips supposedly increase the performance of encryption and AI applications with new instructions. This new Xeon product line also fragments the server CPU market into multiple segments, based on number of cores, cache sizes, and other characteristics. For those of you of the low-power/low-performance persuasion, Intel released their 8th generation desktop/laptop processor chips in August.[35]*

However, Intel has missed a lot of markets in the recent past (cellphones, tablet computers, etc.) and seem to be filling the gaps in their product line instead of doing something interesting. Samsung took the crown as the world's largest semiconductor maker in Q2.[36] With the PC market declining since 2011, Intel has focused on servers as their primary market while they studied other markets opportunities. They moved into the IoT market with big fanfare, but that doesn't seem to be working out for them: they recently dumped 140 people in that group and terminated their IoT development board products.[37] Intel's financials are still good, but financial analysts are starting to question their technical and business decisions lately.[38] They bought Movidius in 2016, to get into AI with video processing units (VPUs).

AMD continues to expand their push with Cache-Coherent Interconnect for Accelerators (CCIX), their Gen-Z fabric, and OpenCAPI (Open Coherent Accelerator Processor Interface).[39] While Intel and AMD fight for the data center and server market, ARM continues their hegemony in the mobile market through Samsung and Qualcomm chips. What ARM is doing with cores and interconnects is much more interesting than what Intel and AMD are doing. For good measure, ARM is also creating CPUs for the data center market.[40]

The good people at MIT have created a cache-hierarchy algorithm that dynamically allocates cache blocks across multiple cores. Their Jenga algorithm takes up where a previous methodology, Jigsaw, left off.[41] Jenga looks at each core's cache utilization, and reallocates those memory resources every 100ms. In their tests, this technique has increased CPU performance by 20-30%.

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33 Ian Cutress, "*AMD's Future in Servers: New 7000-Series CPUs Launched and EPYC Analysis*", AnandTech, 20 June 2017,
http://www.anandtech.com/show/11551/amds-future-in-servers-new-7000-series-cpus-launched-and-epyc-analysis/2

34 Eric Jhonsa, "*Why Intel's Dominant Server Chip Position Remains on Pretty Solid Ground*", the Street, 16 July 2017,
https://www.thestreet.com/story/14223174/1/intel-s-big-server-chip-launch-will-help-
it-fend-off-amd.html?puc=yahoo&cm_ven=YAHOO&yptr=yahoo

35 Joel Hruska, "*Intel's 'New' 8th Generation Processors are Built on Kaby Lake, Add Additional Cores*", Extreme Tech, 21 August 2017,
https://www.extremetech.com/computing/254492-intels-new-8th-generation-processors-built-kaby-lake-add-additional-cores

36 Chris Neiger, "*Intel Is About to Lose Its Semiconductor Crown*", The Motley Fool, 30 June 2017,
https://www.fool.com/investing/2017/06/30/intel-is-about-to-lose-its-semiconductor-crown.aspx

37 Richard Chirgwin, "*Intel axes 140 IoTers in California, Ireland*", The Register, 5 July 2017,
https://www.theregister.co.uk/2017/07/05/intel_laying_off_140_in_california_and_ireland/

38 Ashraf Eassa, "*An Unfortunate Mistake by Intel Corporation Management*", The Motley Fool, 6 July 2017,
https://www.fool.com/investing/2017/07/06/an-unforgiveable-mistake-by-intel-corporation-mana.aspx

39 Brad Benton, "*CCIX, GEN-Z, OpenCAPI: Overview and Comparison*", Open Fabrics Alliance, March 2017,
https://www.openfabrics.org/images/eventpresos/2017presentations/213_CCIXGen-Z_BBenton.pdf

40 James Vincent, "*This Little USB Stick is Designed to Make AI Plug-and-Play*", The Verge, 20 July 2017,
https://www.theverge.com/2017/7/20/16002682/movidius-ai-neural-compute-stick-intel

41 Larry Hardesty, "*Using chip memory more efficiently*", MIT News, 7 July 2017,
http://news.mit.edu/2017/using-chip-memory-more-efficiently-cache-hierarchies-0707

At the data center, Amazon, Facebook, and Google are moving to 100GbE, and then to 400GbE in 2019, along with faster, better routers.[42] They moved to optical links several years ago to gain more network bandwidth. But, there's even more weirdness going on here. Google has been working furiously on their Quantum computer.[43] Nvidia has created a cube topology, connecting eight Tesla GPUs with their NVLink fabric, for deep learning and AI applications.[44] Consider for the moment that data centers consume 2% of all power generated in the U.S. today, and pay huge power bills. They want to do more computing with less power when they upgrade their server farms in the future.[45] My reading reveals that the actual CPU utilization in data center servers today is only about 10-15%. For the remaining 85-90% of the time, the CPU is waiting for data from memory or I/O.

In July, Fujitsu announced their new Deep Learning Unit (DLU) CPU chips. Each DLU contains 16 Deep Learning Elements (DLE's) and eight execution units, connected in six dimensions with their "Tofu Interconnect" (another variation on Gen-Z, Infinity Fabric, OmniPath, and NVLink).[46] Inside the chip, these elements are connected with a mesh architecture to form a modified 3D cube. Therefore, you have a 3D cube, operating inside a 3D Torus architecture, and that gives you a 6D architecture. Hundreds or thousands of these chips can be connected in this mesh-Torus structure.[47]

But, that's not all. Google just made 1,000 of their Tensor Processing Units (TPUs) available for developers of machine learning software.[48] Engineers at UC Berkeley have created a RISC-V open architecture and started the RISC-V Foundation to promote and distribute the open source hardware code for free.[49] DARPA gave $80 million to five companies, to develop the new Hierarchical Identify Verify Exploit (HIVE) processor to more efficiently process graphical information.[50] The U.S. Department of Energy has given $258 million to six companies in the Exascale Computing Project to develop a supercomputer based on HP's "The Machine" architecture.[51] HP's "The Machine" is a memory-centric architecture, not a CPU-centric architecture.[52] Not to be outdone, Facebook started the Telecom Infra Project (TIP) under
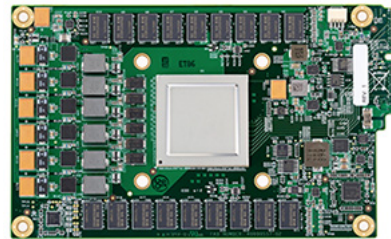
Google's first Tensor Processing Unit (TPU) on a printed circuit board (left); TPUs deployed in a Google datacenter (right)

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42 Mohit Gupta, "*The SerDes – Terabit Ethernet Connection*", Semiconductor Engineering, 11 May 2017, http://semiengineering.com/the-serdes-terabit-ethernet-connection/

43 Tom Simonite, "*Google's New Chip Is a Stepping Stone to Quantum Computing Supremacy*", MIT Technology Review, 21 April 2017, https://www.technologyreview.com/s/604242/googles-new-chip-is-a-stepping-stone-to-quantum-computing-supremacy/

44 Mark Harris, "*NVIDIA DGX-1: The Fastest Deep Learning System*", NVIDIA, 5 April 2017 https://devblogs.nvidia.com/parallelforall/dgx-1-fastest-deep-learning-system/

45 Ann Steffora Mutschler, "*Cloud Computing Chips Changing*", Semiconductor Engineering, 19 April 2017, http://semiengineering.com/cloud-computing-chips-changing/

46 Hilbert Hagedoorn, "*Fujitsu releases details of new AI processor*", The Guru of 3D, 17 July 2017, http://www.guru3d.com/news-story/fujitsu-releases-details-of-new-ai-processor.html

47 Tomohiro Inoue, "*The 6D Mesh/Torus Interconnect of K Computer*", Fujitsu, http://www.fujitsu.com/downloads/TC/sc10/interconnect-of-k-computer.pdf

48 Kaz Sato, Cliff Young, and David Patterson, "*An in-depth look at Google's first Tensor Processing Unit (TPU)*", Google Cloud Big Data and Machine Learning Blog, 12 May 2017, https://cloud.google.com/blog/big-data/2017/05/an-in-depth-look-at-googles-first-tensor-processing-unit-tpu

49 Ann Steffora Mutschler, "*RISC-V Pros And Cons*", Semiconductor Engineering, 29 May 2017, https://semiengineering.com/risc-v-pros-cons/

50 "*Extracting Insight from the Data Deluge Is a Hard-to-Do Must-Do*", DARPA, 2 June 2017, http://www.darpa.mil/news-events/2017-06-02

51 Mariella Moon, "*US funds tech giants' efforts to build next-gen supercomputers*", Yahoo! Finance, 16 June 2017, https://finance.yahoo.com/news/us-funds-tech-giants-apos-082000880.html

52 Dean Takahashi, "*HP Enterprise unveils The Machine, a single-memory computer capable of addressing 160 terabytes*", Venture Beat, 16 May 2017, https://venturebeat.com/2017/05/16/hp-enterprise-unveils-single-memory-160-terabyte-computer-the-machine/

the Open Compute Project for open networking gear.[53] And, the telecom industry is undertaking the new OpenCord activity, to transition the old central offices into data center operations.

The Open Compute Project is doing a specification for networked central office racks called CG-Openrack 19 [54], and there's a new organization, the Open19 Foundation, developing a rack specification, with the goal of moving the telecom central offices into the 21st century. There are now several open rack initiatives with common goals, none of which look promising to me.

Finally, there's Graphcore's new Intelligence Processing Unit (IPU), named "Colossus", set for release later this year. Details on the architecture are sketchy, but they claim 1,000 processing cores and an all-to-all interconnect.[55] They also claim that their IPU can outperform GPUs and general-purpose CPUs by 10x to 100x.[56]

There are both hardware and software efforts ongoing to bring artificial intelligence concepts into reality in many applications, including the military. However, running AI software on Intel CPUs with their new instructions, or on GPUs for that matter, is like trying to run a 1975 Chevy Vega on rocket fuel. That's why DARPA has invested a pile of money in new materials, architectures, and ideas.[57] But, all is not lost. Running AI software on our present inefficient von Neumann processors will show us how to design the next generation of AI processors.

The real solution to many computing problems are totally new non-von Neumann architectures like hardware neural networks, Quantum machines, DNA computers, and bacterial-organic computers. But the *intelligentsia* of the entire semiconductor and software industries are all bogged down in the financial and technical mud of the von Neumann model. Consequently, we're going to see more and more of these projects and efforts, each one costing millions of dollars and millions of man-hours of engineering, yielding horribly inefficient incremental trivial insignificant mundane inconsequential negligible and disappointing increases in performance. If you doubt me, watch this 2-part series about the five von Neumann bottlenecks.

"But the intelligentsia of the entire semiconductor and software industries are all bogged down in the financial and technical mud of the von Neumann model."

I could go on and on here. There are many good articles on all these topics on the web. What we are seeing here is the beginning of broader fragmentation in the CPU market, to AI-CPUs, Neural-Net-CPUs, Quantum-CPUs, and DNA-Bacterial-Organic-CPUs, tailored for specific end applications. And concurrently, we are on the cusp of the declining use of general purpose von Neumann processors like Xeon, Epyc, ARM, RISC-V, and GPUs. Even the military wants to migrate to application-specific processors (ASP's) like HIVE for graphical analysis. While this situation might be perplexing and discomforting, the mess we have now is much better than the mess that's coming.

How could all this activity affect our high performance embedded computing markets? Surely, some of these new AI-specific CPU's will filter down to us. For many years now, I have been encouraging the members of VITA to abandon copper backplanes and copper connectors, and focus on optical interconnects. They have ignored my warnings, claiming that I am a greying alarmist suffering from age-related technological dementia, and they have purposely continued their path of copper traces and von Neumann madness. Now, I expect they will ignore my call to focus on AI-based computing.

53 Julie Bort, "*Inside Facebook's plan to eat another $350 billion IT market*", Business Insider, 21 May 2017, http://www.businessinsider.com/inside-facebooks-telecom-infrastructure-project-2017-5

54 Andrew Alleman, "*New Open Rack Spec Hits the Sweet Spot for Telecom*", Electronic Design, 3 May 2017, http://www.electronicdesign.com/industrial-automation/new-open-rack-spec-hits-sweet-spot-telecom

55 Nicole Hemsoth, "*An Early Look at Startup Graphcore's Deep Learning Chip*", The Next Platform, 9 March 2017, https://www.nextplatform.com/2017/03/09/early-look-startup-graphcores-deep-learning-chip/

56 Natasha Lomas, "*Graphcore's AI chips now backed by Atomico, DeepMind's Hassabis*", Tech Crunch, 21 July 2017, https://techcrunch.com/2017/07/21/graphcores-ai-chips-now-backed-by-atomico-deepminds-hassabis/

57 Brian Wang, "*DARPA funding reconfigurable structures and new materials to go beyond Moore's law*", Next Big Future, 24 July 2017, https://www.nextbigfuture.com/2017/07/darpa-funding-reconfigurable-structures-and-new-materials-to-go-beyond-moores-law.html

What the VITA technologists don't see is that once the AI HW and SW becomes adequate, those technologies can replace embedded board and systems designers: AI-based computer automated design (AiCAD) systems can autonomously design boards and systems, do the signal integrity analysis of the interconnects, optimize the packaging for minimum space and cooling requirements, route the board, backplane, and cable layouts, and simulate the overall performance of the end application on the target embedded system in just a few hours.

Here's what I think the future looks like: an engineer uses the new AiCAD software to design yet another VPX-compliant CPU card based on Intel's latest von Neumann architecture chip, that plugs into a backplane with copper traces through copper connectors. The AI software will do a quick analysis and tell the engineer that the product is incredibly stupid, and then refuse to run the design algorithms for moral reasons. When I am finally retired, or dead and gone, I will live on through AiCAD and haunt those VITA members who disparaged my ideas.

Even at the low end of the AI spectrum, we are seeing amazing advances. A $200 robot running some small algorithms took only 30 minutes to open a locked high-security safe.[58] But, we have a long way to go before AI is truly reliable. "Steve", the mobile security robot at a DC office building, plunged to his death in a lobby fountain recently. His algorithm failed to recognize the uneven surface by the pool and he lost his footing.[59] RIP, Steve.

Changes in computing technology will occur faster than you think, since huge piles of money are being poured into AI hardware, software, and optical interconnects. But for the next few years, your job is safe as you struggle to make PCIe Gen-5.0 work on copper backplane traces with copper connectors. The specification was fast-tracked by the PCI-SIG with revision 0.3 announced in June.[60] However, if you run your PCIe/5.0 board and backplane design through AiCAD, it would probably tell you not to waste your time.

There are over 1300 companies spending over $9 billion on AI research and products this year, too many activities to document here. With this many smart people, and this much money going into AI technology, we will surely see some of it come down to our embedded segment soon.[61]

> *"What the VITA technologists don't see is that once the AI HW and SW becomes adequate, those technologies can replace embedded board and systems designers."*

> *"With this many smart people, and this much money going into AI technology, we will surely see some of it come down to our embedded segment soon."*

Mergers and Acquisitions

As the telecom industry has become more commoditized, and mistreated like a utility by the FCC, we have seen ATT buy Time-Warner and then Direct TV, to get into content. That forces Verizon, Sprint, and T-Mobile to look at buying declining cable TV companies and Dish TV. That, in turn, is causing old-technology telecom companies like Ericsson to explore dumping their telco equipment and services divisions on unsuspecting and uninformed buyers before they go bankrupt like Nortel did in 2009.[62] The telecom industry continues to destroy jobs, retirement plans, and component suppliers, after devastating many large board companies in our industry segment in the past.

In early September, United Technologies bought Rockwell-Collins, giving them a substantial position in avionics and aircraft electronic systems. Remember when GE tried to purchase Honeywell back in 2000? That got shot down in

58 "*Cheap robot cracks high-end combination safe*", MyBroadband, 31 July 2017, https://mybroadband.co.za/news/security/222321-cheap-robot-cracks-high-end-combination-safe.html

59 Jasper Hamill, "'*NEVER FORGOTTEN' 'Heartbroken' humans set up memorial to Steve the 'suicidal' security robot who drowned in a fountain*", The Sun, 20 July 2017, https://www.thesun.co.uk/tech/4060554/heartbroken-humans-set-up-memorial-to-steve-the-suicidal-security-robot-who-drowned-in-a-fountain/

60 "*PCI-SIG® Fast Tracks Evolution to 32GT/s with PCI Express 5.0 Architecture*", Business Wire, 7 June 2017, http://www.businesswire.com/news/home/20170607005351/en/PCI-SIG®-Fast-Tracks-Evolution-32GTs-PCI-Express

61 Michael Krigsman, "*Practical AI for the enterprise: Getting past vendors blowing smoke*", ZD Net, 12 September 2017, http://www.zdnet.com/article/practical-ai-for-the-enterprise-getting-past-vendors-blowing-smoke/

62 Andrés González and Sophie Sassard, "*Ericsson scouts for mergers for lower margin businesses*", Reuters, 4 October 2017, http://www.reuters.com/article/us-ericsson-restructuring/ericsson-scouts-for-mergers-for-lower-margin-businesses-idUSKBN1C91TJ

flames by the EU antitrust people in 2001, so this proposed union could also see similar challenges.

In mid-September, Northrop-Grumman bought Orbital ATK, to expand into missiles. The nice thing about missiles is that they only fly once and the customer must buy another one. That sure beats selling airplanes.[63]

In early October, Boeing bought Aurora Flight Systems, expanding their footprint in unmanned and autonomous aircraft. Boeing was good at making big expensive fuel-inefficient airplanes, but not at making small cheap fuel-efficient drones.[64]

Image courtesy of Aurora Flight Systems

In October, BAE systems announced they would lay-off about 1,000 people because they couldn't give away Typhoon Eurofighters.[65] Just remember that BAE has been trying to merge with anybody for many years now. They tried to merge with EADS back in 2012, but the Germans nixed that deal, fearing that the work done on the Eurofighter in Germany would move to the UK and France.[66] Germany and France have announced a joint project to develop and build the next generation European fighter jet.[67] I suspect this new Franco-Deutsch alliance is payback for Brexit.

Recently, we saw Honeywell announce that they are spinning-off their automotive and home security divisions for sale, and keeping their core aerospace division.[68] However, speculation abounds that GE Aviation will buy Honeywell's aviation division, but that move didn't work well back in 2001, when the EU blocked a GE/Honeywell merger, as previously noted.

Obviously, we are seeing a new wave of consolidation among the defense primes in the U.S., and ostracizing of BAE and the UK in the EU. We'll have to wait and see where each of these events lead in the future.

On a topic closer to home, I have merged my collected history of industry M&A activity since 1989 with more recent data into a spread sheet. We will soon be able to reveal and chart the purchase prices and exit multiples of board companies, across industry segments, and give the first authentic and reliable view of this industry's history. This extensive data will also test my empirical theory, that a board company is worth 5 times its operating gross profit margin. If you know the exit multiple (the selling price of the company divided by its annual sales), and divide number that by 5, you will know the operating gross product margin of the selling company, within a percent or two. When you look at these numbers across industry segments (industrial, telecom, military), you will have a very comprehensive perspective of the history, health, successful and failed business models, and some idea about the future of our industry.

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63 Arunima Banerjee, "*Northrop Grumman to buy missile maker Orbital for $7.8 billion*", Reuters, 18 September 2017, https://www.reuters.com/article/us-orbital-atk-m-a-northrop-grumman/northrop-grumman-to-buy-missile-maker-orbital-for-7-8-billion-idUSKCN1BT0ZZ

64 Andrew Moseman, "*Boeing Buys Autonomous Drone-Maker Aurora Flight Systems*", Popular Mechanics, 5 October 2017, http://www.popularmechanics.com/flight/news/a28514/boeing-buys-autonomous-drone-maker-aurora/

65 "*BAE Systems 'to axe more than 1,000 jobs'* ", BBC News, 9 October 2017, http://www.bbc.com/news/uk-england-lancashire-41556207?yptr=yahoo

66 "*BAE-EADS merger cancelled amid political impasse*", BBC News, 10 October 2012, http://www.bbc.com/news/business-19897699

67 Pierre Tran, "*France and Germany agree to jointly build new generation fighter jet*", Defense News, 14 July 2017, https://www.defensenews.com/air/2017/07/14/france-and-germany-agree-to-jointly-build-new-generation-fighter-jet/

68 Alwyn Scott and Arunima Banerjee, "*Honeywell seeks M&A as it keeps aero, spins off two units*", Reuters, 10 October 2017, http://www.reuters.com/article/us-honeywell-intl-aerospace/honeywell-seeks-ma-as-it-keeps-aero-spins-off-two-units-idUSKBN1CF0CO
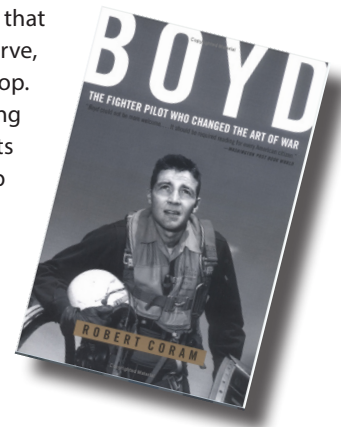
Summary

We have plowed a lot of ground in this report, and some of the furrows might be a little crooked. But what is straight is that significant changes are coming to our industry. We are in a cusp, between event-driven architectures and data-driven architectures. Between antiquated von Neumann computer architectures like Intel Xeons and GPUs, and Neural Network machines. Between CPU-centric architectures and memory-centric architectures. Between sequential processing and parallel processing. These changes will develop sporadically, leaving companies with a false sense of security in the old paradigm during the calmer periods, only to be blind-sided by the speed of change these new ideas will bring.

The world is not getting any safer as Russia and China try to become regional powers, and as North Korea and Iran continue to act-up. Those countries are putting pressure on the U.S. to create better intelligence systems and more lethal weapons to defend the U.S. and our allies. This situation will get worse before it gets better and the answer to our defense lies in the new technologies mentioned in this report.

I have been a bit tough on the EU and their leaders here, but something is motivating them to target successful U.S. companies for cash. How can they possibly justify huge back-tax penalties on U.S. companies because their tax laws are so loosely defined? How can they make up the tax laws as we go along? They could also be motivated by the "Cycle" that Tom Wu talks about in his book, "The Master Switch". He says that economies go from scattered with many companies exploiting new opportunities, to a gathered oligopoly of companies that control a large portion of the economy. That happened with the internet and mobile communications in the past decade: Google, Apple, Facebook, Amazon, and Qualcomm certainly fit that scatter-gather model. The EU companies have no products or ideas to compete with them. Advantages in AI concepts and products in the U.S. will make the technological and financial division between the EU and the U.S. even wider in the future. And that will make the political division wider by default.

In 1995, Col. John Boyd gave a presentation to top military commanders, including a model that became the foundation for the military's "kill chain": the OODA Loop. It has four phases: Observe, Orient, Decide, and Act. Reports like this help with the observation part of the OODA loop. Technology decision makers at companies developing and using critical embedded computing technology must be aware of the technologies and market trends that are discussed in reports like this so that they can then orient, decide and act on the information. My goal is to keep our industry ahead of the curve. Read Robert Coram's book, "Boyd", to understand why we must speed-up the adoption of new ideas, concepts, architectures, and technology in VITA's standards efforts.

VITA
Open Standards, Open Markets