



2022 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](http://www.VITA.com/Market_Reports). (www.VITA.com/VITA_Technology_Industry)

Introduction

Russia's invasion of Ukraine threatens the economic recovery from the COVID-19 lockdowns. But COVID-19 is still with us in a different form now and seems to be driving the Canadian authorities crazy. Analysis of Russia's military capabilities and weapons used in Ukraine are feeding into Pentagon plans for new weapons, systems, tactics, and strategies. Looking at all the problems with EVs (electric vehicles) is getting boring, so let's look at Web 3.0 and the Metaverse. A couple of nascent interconnect standards might filter down to our markets, so we need to be aware of what they do. The semiconductor supply chain is still a mess, and it might get worse in some industry segments. It looks like we're just moving from one crisis to another.

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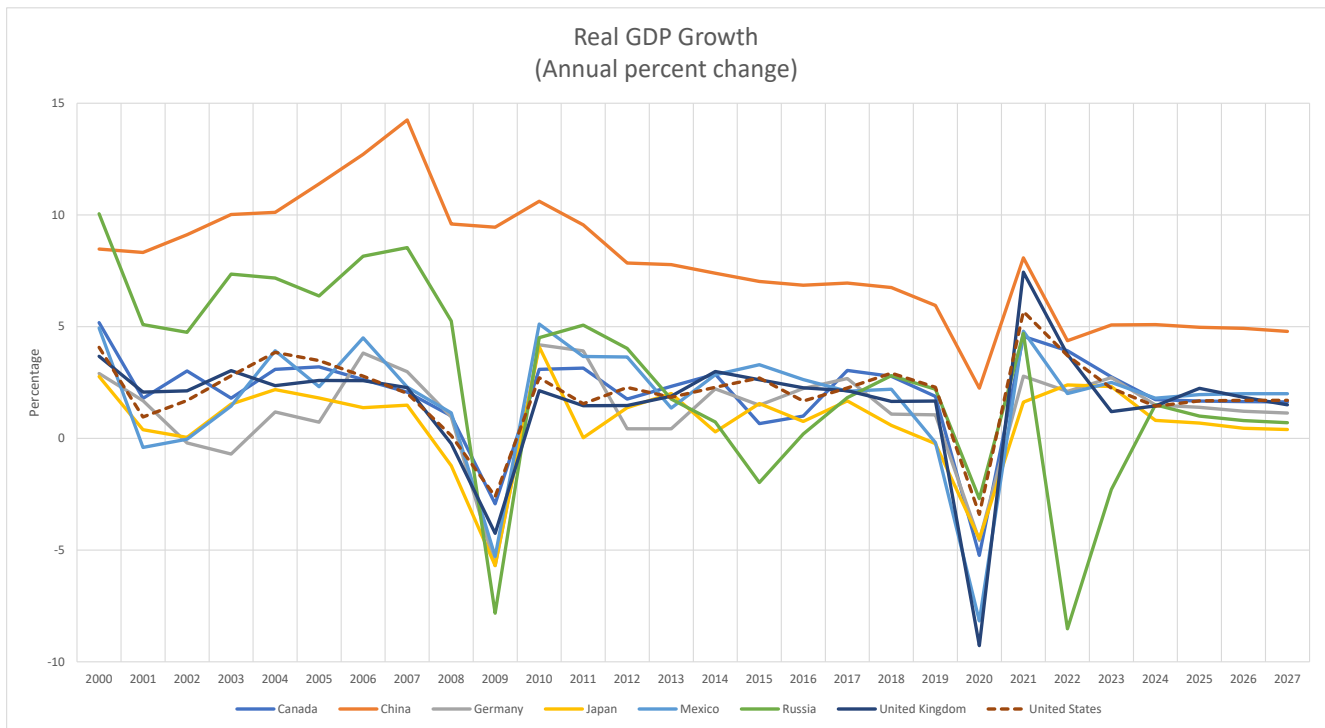
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Economic Conditions

In 2021, U.S. GDP grew at 5.7% after declining by 3.4% in 2020 due to the COVID-19 lockdowns according to the Bureau of Economic Analysis. Forecasts for 2022 were for 3.6% growth, but that number will be negatively impacted by the war in Ukraine and inflation. The U.S. inflation rate for 2021 was 4.7%. In February 2022, U.S. inflation rose to 7.9% driven by increases in food and energy prices.¹ The Federal Reserve is raising interest rates possibly damping U.S. GDP growth. U.S. unemployment declined to 3.8% in February and there are still more jobs available than people wanting to work. Things are uncertain going forward, even with COVID-19's economic influence declining.

¹ "United States Inflation Rate", Trading Economics, <https://tradingeconomics.com/united-states/inflation-cpi>

The EU grew at 5.3% in 2021, after declining 5.9% in 2020.² Forecasts for 2022 growth was 4%, but that number has been revised down to 2.5%. In 2021, EU inflation was 5% but that number rose to 5.8% in February due to high energy prices. The unemployment rate in the EU in January was 6.2%. The European Central Bank (ECB) is considering interest rate increases and that might negatively affect their GDP growth



Source: IMF, April 2022

In the United Kingdom, 2021 GDP rose by 7.5% after falling by 9.4% in 2020 when all the pubs were forced to close during the COVID-19 pandemic.³ 2022 forecasts are for 3.25% growth, but that number is also in jeopardy. Inflation in the UK was 4.9% in 2021. In January, inflation rose to 5.5% due to high energy, food, and beer prices.⁴ The Bank of England raised interest rates by 0.25% in January. The unemployment rate in the UK was 4.1% in January.

China's GDP grew by 8.1% in 2021 after growing by 2.2% in 2020.⁵ Forecasts for 2022 growth have been revised down to 4.2% but inflation and the Ukraine war could drive that number down further. China's inflation rate was about 2.4% in 2020 and is expected to rise to 3.9% in 2022. The Peoples Bank of China has been lowering interest rates recently, to promote economic growth. Unemployment in China rose to 5.3% in January.

Just for fun, let's take a look at Russia. They grew at 4.7% in 2021 after declining 3.1% in 2020.⁶ Forecasts for 2022 growth are all out the window now, considering their invasion of Ukraine in February and the host of economic sanctions levied against them. The latest predictions say that Russia's GDP will decline by 15% or more in 2022, depending on how long the Ukraine war goes on. In 2021, Russia's GDP was about the same as Spain's GDP. For 2022, they could

2 "European Union Full Year GDP Growth", Trading Economics, <https://tradingeconomics.com/european-union/full-year-gdp-growth>

3 Elliot Smith, "UK economy grew 7.5% in 2021, mostly recovering from its pandemic plunge", CNBC, February 11, 2022, <https://www.cnbc.com/2022/02/11/uk-economy-grew-7point5percent-in-2021-mostly-recovering-from-its-pandemic-plunge.html>

4 Isabella Boneham, "UK beer prices could rise to £7 a pint as pubs set to hike prices by 50p due to soaring inflation", National World, February 2, 2022, <https://www.nationalworld.com/lifestyle/money/uk-beer-prices-could-rise-to-ps7-a-pint-as-pubs-set-to-hike-prices-by-50p-due-to-soaring-inflation-3542037>

5 "China GDP Annual Growth Rate", Trading Economics, <https://tradingeconomics.com/china/gdp-growth-annual>

6 "Russia GDP Annual Growth Rate", Trading Economics, <https://tradingeconomics.com/russia/gdp-growth-annual>

drop out of the top 25 world economies.⁷ While they are actively destroying Ukraine's economy, they are passively destroying their own.

Even if the Russian Army left Ukraine today, the sanctions would stay in place for many years to come, to punish them for their aggression. Russia's economy could collapse again, like it did in 1991, unless China helps them out. As Senator John McCain once said, "Russia is a gas station masquerading as a country."

World GDP declined by 3.6% in 2020, grew by 5.5% in 2021, and is forecast to grow at 4.2% in 2022. But the war in Ukraine, inflation, and supply chain disruptions will hammer that 2022 number down further. The top 25 countries contribute about 84% to world GDP while the bottom 168 countries only contribute about 16%. So, any GDP growth in those smaller countries just can't offset the declines in the top 25.

COVID-19 is still with us, but in variants that are not as virulent as the original strain. We are mostly dealing with Omicron and BA.2 in the U.S., but another strain has been found in Europe and Asia: Deltacron. Thankfully, the symptoms of the latest variants are milder than the original. At first, we all had to get two injections (just one for the Johnson & Johnson vaccine) to be considered vaccinated. Then, we all needed a booster shot. Now, they say we all need a fourth shot to be considered fully vaccinated. It's beginning to look like we will need COVID-19 shots every year, just like the flu shots. However, the latest data says that last year's flu vaccine was worthless.⁸ COVID-19 booster shots do not offer complete immunity either. COVID-19 has baffled the medical experts and the statisticians for three years now.

Just as the world's economies were recovering from the COVID-19 lockdowns and things were getting better, Russia decided to attack Ukraine. That event has introduced more uncertainty into economic conditions for 2022. Rising energy prices are fueling inflation: every product or commodity has an energy component, especially food and materials. Supply chains are still disrupted, amplifying inflation. And COVID-19 is still causing severe restrictions in places like China, Europe, and Canada.

Going forward, economic conditions will get worse for a while. When the Canadian government sends the Mounties into Ottawa, armed with harsh words and arrest warrants for the trucker-protesters, and when a pint of beer in England costs 7 pounds (that's \$9.13 in U.S. dollars), those are signs that things are deteriorating. The bright spot in all this turmoil is that European and Pacific Rim countries are arming up. They are increasing their military budgets and spending on weapons to prepare themselves against Russian and Chinese aggression. The military equipment markets worldwide should experience robust growth over the next few years.

Technology

For the last several reports, I have been on a quest studying the pros and cons of electric vehicles (EVs). So, let's continue that tradition here. According to some recent analysis, EVs are more expensive to buy than gas-powered vehicles, more expensive to operate (even with gas at over \$4 per gallon), more expensive to fix, and more costly to insure.⁹ Both Tesla and General Motors have announced that they will sell car insurance for their EVs in states where allowed. Apple is developing their autonomous EV without a steering wheel or pedals (no brakes or accelerator). I wonder who will insure that car?

The range (miles of travel) of an EV battery declines in cold weather (like Minnesota in winter) and the life of the battery declines in hot weather (like Arizona in summer).¹⁰ But you know this if you are familiar with the Arrhenius Equation. He explained that reaction rates in chemistry are directly proportional to temperature, and batteries are just chemical reaction boxes. Here in Arizona a lead-acid car battery, guaranteed for four years, will die in about 2 years.

7 "GDP Ranked by Country 2022", World Population Review, <https://worldpopulationreview.com/countries/countries-by-gdp>

8 Ed Cara, "This Year's Flu Vaccine Was Basically Worthless", Gizmodo, March 11, 2022, <https://gizmodo.com/this-years-flu-vaccine-was-basically-worthless-1848642686>

9 Rachel Koning Beals, "As prices top \$4 a gallon, should you consider an electric vehicle?", Market Watch, March 8, 2022, <https://www.marketwatch.com/story/tesla-will-sell-car-insurance-but-electric-vehicle-insurance-and-repairs-are-more-expensive-than-for-traditional-cars-heres-why-11646665823?mod=home-page>

10 Liz Najman, "How Temperature Affects EV Range", Recurrent, March 30, 2021, <https://www.recurrentauto.com/research/how-temperature-affects-ev-range>

Thomas Katainen of Finland bought a Tesla Model 3 in 2013. After the 8-year, 150,000-mile warranty expired, he started getting error codes on his dash screen. He took it to a repair station and was told he needed new batteries. The price? \$22,600, about half the price of the car when new. So instead of replacing the batteries, he blew it up with 66 pounds of dynamite.¹¹ So think about the value of used EVs: they decline to zero as the warranty nears expiration.

"So think about the value of used EVs: they decline to zero as the warranty nears expiration."

Now let's talk about battery fires. GM recalled all 141,000 Chevy Bolts they have built due to defective batteries that started fires. It will cost them about \$2 billion to replace all those batteries. In February, a cargo ship carrying 4,000 luxury cars (Bentley, Audi, Porsche, Lamborghini, and some new Volkswagen EVs) from Germany to Rhode Island caught fire, burned for 13 days, and sank in the Atlantic.¹² The suspected cause of the fire is a faulty battery in one of the EVs onboard, but we'll never know.

All of the EV makers have been losing money on their vehicles. It took 18 years for Tesla to have its first profitable quarter in 2Q 2021, without the help of government emission credits. They sold over 200,000 cars in that quarter.¹³

As a sidebar here, the "Build Back Better Act" stuck in Congress has a provision that all cars made in the U.S. after 2027 must have a "vehicle kill switch" installed. The vehicle will have onboard intelligence that monitors how the driver is operating the vehicle. That data can be sent to authorities so they can disable the vehicle for dangerous driving offenses from a remote location. The bill also allows other third parties to receive the data, like your insurance company (when you are speeding) or your bank (when you miss a payment) so they can disable your vehicle remotely. This provision violates most of our privacy and constitutional rights.¹⁴

The smartphone wars are over. Google and Apple won. Now, those companies are focusing on how they can expand their cellphone market into the electronics inside EVs. Google has their "Android Auto" program and Apple has their "CarPlay" program, and they are making deals with the EV makers to supply all the dashboard entertainment and connectivity functions.¹⁵ Those projects are raising a lot of legal/antitrust issues. If you have Apple's CarPlay dashboard in your vehicle, you'll have to pay extra for access to Google Maps. If you have Android Auto, you'll have to pay extra for access to Apple's services. EVs are becoming a cellphone, a laptop computer, and a flat-screen TV on wheels. In January, Sony (maker of TVs and entertainment equipment) and Honda (maker of cars) announced a joint venture to make EVs. Sony will supply the dashboard entertainment, connectivity, and other electronics while Honda will build the car.

All traditional carmakers are taking their profits from selling gas-powered vehicles, and desperately pouring those billions of dollars into EV models. In early March, Ford reorganized their company into 3 divisions: Ford Pro (commercial and government vehicles), Ford Blue (gas powered vehicles), and Ford Model E (electric vehicles) to keep track of what they are spending and getting back on electric vehicles. According to Wall Street analysts, what Ford might be doing is setting-up the Model E (EV) division to be spun-out as a separate public company. That way, Ford Model E would be financed by money from the sale of stock, not by the profits from gas-powered vehicles. The CEO of Stellantis (the old Fiat-Chrysler group) recently said that building an EV is 50% more expensive than building a comparable gas-powered vehicle. He's basically saying that none of the EV makers have any economies of scale (except Tesla).¹⁶ In Q4 2021, GM sold 26 EVs. Tesla sold 308,600.

11 Emma Roth, "Tesla owner blows up Model S instead of footing \$22,600 repair bill", The Verge, December 26, 2021, <https://www.theverge.com/2021/12/26/22853573/tesla-model-s-explosion-repair-bill>

12 Cristian Agatie, "Volkswagen Loses Almost 4,000 Cars As the Felicity Ace Cargo Ship Sinks in Rough Seas", AutoEvolution, March 1, 2022, <https://www.autoevolution.com/news/volkswagen-loses-almost-4000-cars-as-the-felicity-ace-cargo-ship-sinks-in-rough-seas-182877.html>

13 Sean O'Kane, "Tesla finally made a profit without the help of emission credits", The Verge, July 26, 2021, <https://www.theverge.com/2021/7/26/22594778/tesla-q2-2021-earnings-revenue-profit-credits-emissions-bitcoin>

14 Lauren Fix, "Biden's 'Infrastructure' Bill Contains Backdoor 'Kill Switch' for Cars", Newsmax, April 26, 2022, <https://www.newsmax.com/finance/laurenfix/kill-switch-legislation-for-cars-privacy/2021/12/10/id/1048218/>

15 Leah Nysten, "Big Tech's Next Monopoly Game: Building the Car of the Future", Politico, December 26, 2022, <https://www.politico.com/news/magazine/2021/12/27/self-driving-car-big-tech-monopoly-525867>

16 Hazel Southwell, "Stellantis CEO Says Suppliers Need to Brace for Huge EV Costs", The Drive, <https://www.thedrive.com/news/44482/stellantis-ceo-says-suppliers-need-to-brace-for-huge-ev-costs>

GM is watching Ford's reorganization with interest and may do the same. In January, they announced their new online used car sales website: CarBravo. They will include the used cars sitting on their dealer's lots across the U.S. and compete with Carvana and Carmax for online sales.¹⁷ This way, GM can take a cut on the sales of used cars at their dealers and use that money to fund their EV investments. In 2021, 41 million used cars were sold in the U.S. while 15 million new cars were sold. CarBravo could also be a collection website for prospects for new cars in the future and GM could sell directly to them online, eliminating the dealerships.

This discussion of EV problems reveals a bigger problem. Green energy sources can't overcome the fundamental laws of nature: they cannot scale efficiently.¹⁸ We are spending billions of dollars chasing solar, wind, ocean waves, and batteries while the laws of physics clearly limit the collection efficiency of those sources. That brings us to the empirically derived "Alderman's Law of Green Energy": the most abundant energy sources have the least efficient collection methods.

Governments pushing green energy sources seem to be ignoring this reality. The most efficient production of energy on this planet (so far) are big nuclear reactors, but they have drawbacks. Small modular molten-salt nuclear reactors would be more efficient and deserve consideration. With them, we can eliminate the problems associated with the present power grid and build a more distributed and resilient power distribution system. But having a small nuclear reactor a few blocks away from your home might be a concern.

"But having a small nuclear reactor a few blocks away from your home might be a concern."

In a contrarian view, another article states that even with the low collection efficiencies, there are simple ways to reduce energy usage and make green energy more attractive. Building design (to capture more solar energy), plumbing and HVAC design (to reduce the power needed to move water and air), and increased insulation could overcome the limitations. In other words, we need to reduce our overall energy consumption to match the low efficiencies of green energy collection.¹⁹ But this idea violates Kardashev's Scale: as a civilization becomes more technologically advanced, it uses more energy.

Now, let's look at some even crazier stuff. A Japanese professor has created a "lickable" TV screen, where you can taste the food being displayed. There are hidden canisters of flavors that spray on the screen so you can taste the food being prepared on the Food Channel or in fast-food commercials.²⁰ If he can do this, then Smell-o-Vision should be very simple.

After getting bored with researching EV problems, I have a new quest topic: Web 3.0. That's a combination of the Metaverse, Blockchain, crypto currencies, interactive gaming, non-fungible tokens (NFTs), virtual reality (VR), augmented reality (AR), Las Vegas, and a Ponzi scheme all merged together. Web 1.0 was where dumb browsers accessed static web pages with shopping carts and different payment methods. Web 2.0 was when browsers got smarter and interacted more with users through centralized websites like YouTube, Instagram, and Facebook (now Meta) sharing user-created and other media content. Web 3.0 is a decentralized (distributed) network where users can interact with each other directly, create content, and make money instead of the big tech companies making all the money.²¹

Basically, Web 3.0 replaces your browser, TV, cellphone, and gaming console with a VR/AR headset and some software. You can roam around in different environments (like a video game), visit friends or attend meetings (like Zoom), go

17 Joseph White, "GM challenges Carvana with CarBravo online used car marketplace", Reuters, January 11, 2022, <https://www.reuters.com/technology/gm-challenges-carvana-with-carbravo-online-used-car-marketplace-2022-01-11/>

18 Iddo Wernick, "Green Technologies Have a Glaring Problem of Scale", RealClear Science, https://www.realclearscience.com/articles/2021/11/27/green_technologies_have_a_glaring_problem_of_scale_805367.html

19 "Energy efficiency guru Amory Lovins: 'It's the largest, cheapest, safest, cleanest way to address the crisis'", The Guardian, <https://www.theguardian.com/environment/2022/mar/26/amory-lovins-energy-efficiency-interview-cheapest-safest-cleanest-crisis>

20 Cheryl Teh, "A Japanese professor has created a lickable TV screen that can imitate the flavors of the food it displays", Insider, December 24, 2021, <https://www.insider.com/japanese-professor-creates-lickable-tv-screen-imitate-food-flavors-2021-12>

21 Brian Wang, "An Introduction to the Billion-Dollar Web 3.0 Industry", NextBigFuture, February 20, 2022, <https://www.nextbigfuture.com/2022/02/an-introduction-to-the-billion-dollar-web-3-0-industry.html>

shopping (like Amazon), watch videos (like Netflix and YouTube), and pay for things with crypto currencies. You can pay for access to an online game and then make money on how well you do (like Las Vegas). Guess who owns some of the patents on the Metaverse? It's Walmart.²²

Today, you can buy an avatar, its clothes, capabilities, and its weapons (like buying on Amazon) to represent you when roaming around in different games and digital environments. You can also buy digital real estate in virtual spaces. You can buy and sell original digital artwork as NFTs. The most popular NFTs are "Crypto Punks" and the "Bored Ape Yacht Club" images. Some of this digital art has sold for hundreds of thousands of dollars (a Ponzi scheme).²³ Eventually, you will be able to send your well-dressed avatar to the store, with a list of groceries you need. The avatar will do the shopping, pay for it, and have it delivered to your home while you are working in your office. I think this is why Walmart has some pertinent patents on the Metaverse.

"The avatar will do the shopping, pay for it, and have it delivered to your home while you are working in your office."

Another Japanese company has created a wristband, so you can feel pain when your avatar is getting pummeled by miscreants in the Metaverse. It delivers electric shocks to the wearer during certain virtual reality experiences.²⁴ Obviously, companies are trying to duplicate the five senses (sight, sound, smell, taste, and touch) to make your digital adventure more realistic. The Metaverse might be able to duplicate how it feels to be attacked and eaten by a great white shark while virtually surfing in Australia.

But these new primitive digital worlds are attracting thieves, crooks, and criminals. While Meta (Facebook) was beta-testing their virtual space (Horizon World), a female avatar was molested (groped) by another avatar.²⁵ Somehow, over \$1.7 million worth of NFTs were stolen from the primary website (OpenSea) where they are bought and sold.²⁶ And we know that billions of dollars of Bitcoin have been stolen, even though Blockchain validates all transactions to and from your digital wallet.

In March, President Biden issued an Executive Order (XO) for the Treasury Department to study crypto currencies and make recommendations for new rules and laws. They will also explore the possibility of a government-issued crypto currency and other digital financial assets.²⁷ So, the federal government is looking at getting into Web 3.0.

I am still trying to get my head around how Web 3.0 works and what it does. It just might knock many of the top tech companies (Apple, Google, Meta-Facebook, Netflix, and Amazon) off their centralized perches since the Metaverse is a distributed model. To understand it, you must follow the money. There are 18,000 crypto currencies in circulation today, and over 106 million people are using them. When mature, the Metaverse is predicted to handle billions or possibly trillions of dollars' worth of transactions.

We will see a surge in mergers, acquisitions, and start-ups as Web 3.0 develops. In February, Microsoft bought Activision Blizzard (a game developer) for \$68.7 billion.²⁸ Sony bought Bungie, another game maker, in January for \$3.6 billion. To

22 Thomas Hum, "Metaverse barriers to entry are 'rather high.' CoinDesk Global Macro Editor", Yahoo!Finance, January 19, 2022, <https://finance.yahoo.com/news/metaverse-barriers-to-entry-are-rather-high-coin-desk-global-macro-editor-191654235.html>

23 Natasha Dailey, "Crypto isn't decentralized.", Business Insider, March 20, 2022, <https://markets.businessinsider.com/news/currencies/crypto-isnt-decentralized-nft-bored-ape-yacht-club-buys-cryptopunks-2022-3>

24 Lucas Nolan, "Virtual Insanity: Japanese Startup Makes Electric Shock Bracelet So You Can Experience Pain In The Metaverse", Breitbart, March 26, 2022, <https://www.breitbart.com/tech/2022/03/26/virtual-insanity-japanese-startup-makes-electric-shock-bracelet-so-you-can-experience-pain-in-the-metaverse/>

25 Paul M. Barrett, "The metaverse is the world's strongest argument for social media regulation", The Hill, March 23, 2022, <https://thehill.com/opinion/technology/595333-the-metaverse-is-the-worlds-strongest-argument-for-social-media-regulation>

26 Russell Brandom, "\$1.7 million in NFTs stolen in apparent phishing attack on OpenSea users", The Verge, February 20, 2022, <https://www.theverge.com/2022/2/20/22943228/opensea-phishing-hack-smart-contract-bug-stolen-nft>

27 J. Fingas, "Biden's executive order on cryptocurrency opens the door for a US coin", Engadget, March 9, 2022, <https://www.engadget.com/president-biden-executive-order-cryptocurrency-strategy-142547135.html>

28 Jay Peters, "Read exactly how Microsoft's \$68.7 billion deal for Activision Blizzard came together", The Verge, February 18, 2022, <https://www.theverge.com/22941636/microsoft-activision-blizzard-acquisition-sec-filing-came-together>

complicate matters, a new bill has been introduced in Congress, to outlaw mergers and acquisitions greater than \$5 billion. That will hamper M&A activity in the tech industry if it passes.²⁹

In Europe, they are working on the "Digital Markets Act", that outlaws certain behaviors by the big tech companies, and bans them from using data analytics to gain market advantages in Web 3.0. In July of last year, President Biden issued an XO, tasking the Federal Trade Commission (FTC) and the Department of Justice (DoJ) to investigate the tech industry (along with 3 other industry segments) for potential antitrust violations.³⁰ I may need to include a "legal section" in my next report, to keep up with all the investigations and new laws targeted at the tech industry as Web 3.0 develops.

On the semiconductor front, Intel announced that they are spending \$36 billion on two new fabs in Madgeburg, Germany, along with design and manufacturing facilities in France, Ireland, Italy, and Spain.³¹ The semiconductor supply chain is still a mess, and things could get worse. Russia's attack on Ukraine has shuttered plants that make about 50% of the neon gas used in advanced chip manufacturing.³²

In January, the University of Manchester, under a program called SpiNNaker-1, connected 1 million cellphones together, running neural network software, creating a neuromorphic computer with the power of a mouse's brain. With the participation of Technische Universitat-Dresden, they are running enhanced algorithms on SpiNNaker-2, a more powerful neuromorphic computer based on cellphones with the latest advanced processors. Obviously, the upper-case NN in each name stands for "neural network".³³

The PCI-SIG finalized the specifications for PCIe 6.0 (PCI Express) in January. If you have a tough time remembering the bandwidth for the number of lanes for each version like I do, here's a handy chart that lists them all.³⁴

PCIe® Speeds/Feeds - Pick Your Bandwidth

- Flexible to meet needs from handheld/client to server/HPC
- ~Max Total Bandwidth = Max RX bandwidth + Max TX bandwidth
- 30 Permutations yielding 10 unique bandwidth profiles
- Encoding overhead and header efficiency not included

Specifications	Lanes				
	x1	x2	x4	x8	x16
2.5 GT/s (PCIe 1.x +)	500 MB/S	1 GB/S	2 GB/S	4 GB/S	8 GB/S
5.0 GT/s (PCIe 2.x +)	1 GB/S	2 GB/S	4 GB/S	8 GB/S	16 GB/S
8.0 GT/s (PCIe 3.x +)	2 GB/S	4 GB/S	8 GB/S	16 GB/S	32 GB/S
16.0 GT/s (PCIe 4.x +)	4 GB/S	8 GB/S	16 GB/S	32 GB/S	64 GB/S
32.0 GT/s (PCIe 5.x +)	8 GB/S	16 GB/S	32 GB/S	64 GB/S	128 GB/S
64.0 GT/s (PCIe 6.x)	16 GB/S	32 GB/S	64 GB/S	128 GB/S	256 GB/S

+ = data rate supported by this and subsequent spec revisions.

29 Tim de Chant, "Antitrust bill would bar mergers over \$5B, allow regulators to unwind others", ARS Technica, March 17, 2022, <https://arstechnica.com/tech-policy/2022/03/antitrust-bill-would-bar-mergers-over-5b-allow-regulators-to-unwind-others/>

30 Thomas A. Hemphill, "Big Is Bad: Unpacking Biden's Economic Executive Order", The National Interest, July 15, 2021, <https://nationalinterest.org/blog/politics/'big-bad'-unpacking-biden's-economic-executive-order-189789>

31 Sam Shead, "Intel commits \$36 billion to making chips in Europe", CNBC, March 15, 2022, <https://www.cnn.com/2022/03/15/intel-commits-36-billion-to-making-chips-in-europe.html>

32 "Russia's Attack on Ukraine Halts Half the World's Neon Output for Chips", NewsMax, March 13, 2022, <https://www.newsmax.com/finance/streettalk/russia-ukraine-semiconductor-chip-neon/2022/03/11/id/1060761/>

33 Charlotte Christopherson, "SpiNNaker: Next-level thinking", ARM Community, January 31, 2022, <https://community.arm.com/arm-research/b/articles/posts/spinnaker-next-level-thinking>

34 Andrew Cunningham, "PCIe 5.0 is just beginning to come to new PCs, but version 6.0 is already here", ARS Technica, January 12, 2022, <https://arstechnica.com/gadgets/2022/01/pci-express-6-0-spec-is-finalized-doubling-bandwidth-for-ssds-gpus-and-more/>

Today, we have the latest PCIe versions and Compute Express Link (CXL) interconnects to deal with. Add to those two new interface concepts to consider, that seek to solve different problems. The first is Open Memory Interconnect (OMI), released last year. It's a high-speed serial low-latency memory interface for memory pooling and sharing. CXL has memory sharing capabilities (with cache coherence) and a more efficient interface for data storage, but nothing associated with memory pooling.³⁵ Rumors are that OMI will merge into CXL at some point, solving the near-memory, far-memory, memory-sharing, and memory-pooling challenges.

Next is Universal Chiplet Interconnect Express (UCIe). That's a new interface standard for connecting chiplets together inside 2D and 3D chip packages.³⁶ This one is mostly for the semiconductor guys, but you never know what mechanisms and concepts from these two new standards could find their way into chip-to-chip and board-to-board interconnect standards in the future. Just be aware that they exist.

Advances in technology are outpacing the old industrial-revolution antitrust laws, consumer protection laws, labor laws, and business models. This is setting-up a huge conflict between tech companies and the legal system as Web 3.0 develops. Technology dramatically changes yearly, while the law changes over 25 to 50 years. New reactive laws (on data collection, the use of analytics, and restricted mergers and acquisitions) could retard the development of new concepts, ideas, and algorithms bringing negative economic effects upon the tech industry.³⁷ I recommend that you read Klaus Schwab's book, "*The Fourth Industrial Revolution*" for a better understanding of how technology is affecting the world we live in. You won't sleep for a week if you are more than 10 years from retirement.

Military

The entire world is watching how Russia's strategy, tactics, weapons, and troops are performing in their invasion of Ukraine. So far, their planning has been poor, and their execution terrible against Ukrainian forces. As Sun Tzu said, overconfidence is a swift way to defeat. When the invasion started, U.S. semiconductor companies stopped all shipments of chips to Russia since they could be used to build or maintain weapons. Russia's chip purchases only account for 0.1% (\$560 million) of the total semiconductor market of \$556 billion. From what we have seen in Ukraine, Russia doesn't have many precision weapons.³⁸

As of March, the Pentagon has 685 artificial intelligence (AI) projects underway.³⁹ The Army and Navy both have over 200 of them. The rest are associated with Space Force, Air Force, and the Joint All-Domain Command and Control (JADC2) program. Of the 88 major weapons systems in the Pentagon's inventory, 17 of those have AI projects in progress. One of those new projects is OSCAR (open-source cloud-based AI-enabled reporting). That's a system that takes publicly available information from across the world, analyzes it, and makes predictions about geopolitical and military events in different countries.⁴⁰

Every spring, the Stockholm International Peace Research Institute (SIPRI) releases their report on all military arms transfers worldwide.⁴¹ They show the countries selling arms and the countries buying from them. In 2021, the U.S. was

35 Byron Moyer, "Improving Memory Efficiency And Performance", Semiconductor Engineering, March 28, 2022, <https://semiengineering.com/improving-memory-efficiency-and-performance/?cmid=554e4eff-d9b2-4ab8-9643-82c8603e46c1>

36 Paul Alcorn, "New UCIe Chiplet Standard Supported by Intel, AMD, and Arm", Tom's Hardware, March 2, 2022, <https://www.tomshardware.com/news/new-ucie-chiplet-standard-supported-by-intel-amd-and-arm>

37 Thomas A. Hemphill, "U.S. Chamber of Commerce Report Gets It Right on Proposed Antitrust Legislation", The National Interest, February 18, 2022, <https://nationalinterest.org/blog/techland-when-great-power-competition-meets-digital-world/us-chamber-commerce-report-gets-it>

38 Wallace Witkowski, "Semiconductor sales to Russia banned, but that shouldn't hurt Intel, AMD and other chip makers", Market Watch, March 1, 2022, https://www.marketwatch.com/story/semiconductor-sales-to-russia-banned-but-that-shouldnt-hurt-intel-amd-and-other-chip-makers-11646079584?cx_testId=22&cx_testVariant=cx_1&cx_artPos=6&mod=home-page-cx#cxrecs_s

39 Colin Demarest, "Congress wants new \$200 million program to strengthen AI at combatant commands", Defense News, March 16, 2022, <https://www.defensenews.com/artificial-intelligence/2022/03/16/congress-wants-new-200-million-program-to-strengthen-ai-at-combatant-commands/>

40 Patrick Tucker, "New Report Offers Glimpse Of How AI Will Remake Spywork", Defense One, January 18, 2022, <https://www.defenseone.com/technology/2022/01/new-report-offers-glimpse-how-ai-will-remake-spywork/360872/>

41 "Trends in International Arms Transfers, 2021", SIPRI, March 2022, <https://www.sipri.org/publications/2022/sipri-fact-sheets/trends-international-arms-transfers-2021>

the primary arms dealer to the world, Russia was second, France was third, and China fourth. In 2022, we are seeing the shipment of weapons shift away from the Middle East and move to the Pacific and European countries. While threats in the Middle East are falling, they are rising in Europe and in the Pacific. Sanctions are decreasing Russia's arms sales, and distrust of China are depressing their exports of weapons.

After two Continuing Resolutions, Congress finally passed the federal spending bill in March. That included \$728.5 billion for the defense budget, a 5% increase over 2021.⁴² Money for new platforms and programs will start flowing soon.

In October and November, the Army conducted their Project Convergence-2021 exercises here in Arizona. Their enhanced AI algorithms (Rainmaker, Prometheus, FIRESTORM, and SHOT) performed exceptionally well. Rather than getting into the details here, my article "How Rainmaker, Prometheus, FIRESTORM, and SHOT AI algorithms enable the Kill Web" has a summary of what they did and how they worked.⁴³

In February, the Navy conducted their IMX-22 (International Maritime Exercise-2022) in the Middle East. Unlike the Army, the Navy does not talk about their AI algorithms and what they do. Rather than get into the details of what they accomplished in this exercise, my article "The Navy, CEC, Project Overmatch, and the Kill Web" has a recap of IMX-22 and other Navy experiments.⁴⁴

For more on the Space Force, I recommend that you read chapter 14 of George and Meredith Friedman's book, *"The Future of War"* (1996). You'll learn that space may look empty, but it has a specific topography with strategic locations in cislunar space and at the earth-moon libration points (L-1 through L-5) where we must position our satellites in the future.

Since we surveyed EV's in the technology section, it's mandatory that we explore what the Army is thinking about for their fleet of 225,000 vehicles in the future. As part of the Next Generation Combat Vehicle program (NGCV), the Army has created a "Power Transfer Cohort" committee of six companies to identify the technologies needed for electric military vehicles to operate under austere battlefield conditions.⁴⁵ That's a more challenging environment than where consumer EVs operate. Charging rate, battery range, battery life, and reliability are much more demanding for military vehicles.

The Army is connecting all their weapons and sensors together under their Integrated Battle Command System (IBCS) program. The Air Force is connecting all theirs with the Advanced Battle Management System (ABMS) program. The Navy is connecting their platforms under the Cooperative engagement Capability (CEC). The Space Force doesn't have a name for their program to connect all their satellites and ground stations together, so we'll use SF-ABMS for now since they operate under the Air Force.

Each of these services have older systems that were never designed to talk on a common network. Replacing those communications systems with new ones would eat into their budgets. So, each service is creating "black boxes", to translate (bridge) those old data structures and protocols so they can operate on a common mesh network. Newer platforms, and upgraded platforms, will contain the latest in communications capabilities for the mesh. Then, each services' network of sensors and weapons must connect to the Pentagon's Joint All-Domain Command and Control (JADC2) network to create the COP (common operating picture) for senior military leaders managing a war.⁴⁶

42 Leo Shane III and Joe Gould, "Congress passes budget with defense boost, \$13.6 billion in Ukraine aid", Defense News, March 11, 2022, <https://www.defensenews.com/congress/2022/03/11/congress-passes-budget-with-defense-boost-136-billion-in-ukraine-aid/>

43 Ray Alderman, "How Rainmaker, Prometheus, FIRESTORM, and SHOT AI algorithms enable the Kill Web", Military Embedded Systems, Dec 23, 2021, <https://militaryembedded.com/radar-ew/sensors/how-rainmaker-prometheus-firestorm-and-shot-ai-algorithms-enable-the-kill-web>

44 Ray Alderman, "The Navy, CEC, Project Overmatch, and the Kill Web", Military Embedded Systems, February 26, 2022, <https://militaryembedded.com/unmanned/isr/the-navy-cec-project-overmatch-and-the-kill-web>

45 Jen Judson, "US Army picks 6 companies to tackle how to power electric combat vehicles in the field", Defense News, April 22, 2022, <https://www.defensenews.com/land/2021/04/22/us-army-picks-6-companies-to-tackle-how-to-power-electric-combat-vehicles-in-the-field/>

46 Theresa Hitchens, "JADC2 Implementation Plan has targeted funding in 2023, focus on data sharing: Crall", Breaking Defense, March 18, 2022, <https://breakingdefense.com/2022/03/jadc2-implementation-plan-has-targeted-funding-in-2023-focus-on-data-sharing-crall/>

There are 5 sequential phases to the JADC2 program. The first was the formation of the Cross-Functional Team (CFT) who were tasked with identifying the details about what must be accomplished to put the entire network together. That phase is complete. The second phase was the approval and release of the JADC2 comprehensive strategy document. SECDEF Austin did that back in June. The third phase was “gap analysis”: finding things that have been overlooked. That has also been completed. The fourth phase is the release of the JADC2 Implementation Plan, which tells each of the services what to do but not how to do it. Deputy Secretary of Defense Kathleen Hicks signed and distributed the Implementation Plan (a classified document) in March, and an unclassified summary has been released to the public. After that, the Pentagon will create the Joint Warfighting Strategy (JWS) document in the fifth phase.

Connecting everything together on a network might look simple, but it is not. Access to certain data must be controlled by need-to-know and classification. When platforms or people come into the mesh network, they must “comply-to-connect” using some extraordinarily complex and secure user-verification processes to keep enemy cyber-hackers out. All data stored on the network and transmitted between nodes must be encrypted for security. The network must have back-up and recovery capabilities using the 3-2-1-1-0 rule (3 copies of all data on at least two distinct types of media, 1 copy stored away from the main network servers, and one immutable copy stored in some super-secure location).

Now, let’s take a look at the testing and experiments being conducted for JADC2. In the Global Information Dominance Experiments 1 (GIDE1), historical enemy IMINT, SIGINT, and ELINT data was fed into an AI algorithm in a table-top exercise. That algorithm then generated possible enemy courses of action and recommended certain responses from our combat commands and weapons platforms in the area.

In the GIDE 2 exercise in last March, radar data from both military and FAA sources in Canada and the U.S. were fused together into one radar picture of a simulated attack against the U.S. mainland with a software tool called Pathfinder. That tool then feeds the data into another algorithm that calculates which fighter planes in what locations should be launched to intercept those enemy planes, based on time-to-intercept, fuel requirements, and weapons loads.

The GIDE 3 exercise took place last July. It used the tools in the first two exercises, plus added another tool to integrate data from satellites, surface ships, and aircraft to create a 3-D picture of the situation. That picture was then shared with operational commanders around the world. So, lots of pieces are coming together, but there’s a lot of work left to do.

All of these networks (JADC2, IBCS, ABMS, SF-ABMS, and CEC) are coming together to create what is called the “Kill Web”, where any sensor that has identified a target can connect to any weapon anywhere in the world, and fire that weapon at that target in just a few seconds.

The Russian invasion of Ukraine has inspired many EU countries to increase their military budgets and acquire new advanced ISR and weapons systems. Those increased budgets are creating problems. There are many projects underway in the EU, to design and build their own weapons systems: the Eurotank, the nEUOn drone, the 6G fighter planes from France, Germany, and Spain (FCAS), and the Tempest fighter plane from the UK, Italy and Sweden. Those projects will take decades to complete. If EU countries buy existing advanced weapons from the U.S. prime contractors, that will take jobs and tax revenue away from EU countries. It will also endanger the funding and commitments to those new EU platform initiatives.⁴⁷

As an example, eight countries (UK, Canada, Norway, Denmark, Italy, Netherlands, Australia, and Germany) have bought F-35 fighter planes. They can’t wait a decade for FCAS or Tempest aircraft, to replace their aging fighter planes. UAVs like the Predator and Reaper are operated by numerous countries in Europe and Asia now. The airframes are easier to build for advanced countries, but the sensors, communications subsystems, and software are difficult. Smaller short-range drones, with a camera and an RF link, are easy for any country to build (from commercially available parts). Most industrial countries can build their own ground combat vehicles and small patrol boats. So, we will see an increase in demand for larger U.S.-made platforms and more sophisticated ISR systems from Europe and Asia, primarily for defensive purposes.

⁴⁷ Tom Kington, "Budget hikes test shared European Union spending goals", Defense News, March 25, 2022, <https://www.defensenews.com/global/europe/2022/03/25/budget-hikes-test-shared-european-union-spending-goals/>

Since we talked about Web 3.0 and the Metaverse in the technology section, it's appropriate to apply those concepts here. The Metaverse will become a new domain of warfare. That's where augmented reality is layered on top of the physical world on the battlefield. Commanders can walk through a battlefield virtually, moving troops and weapons to confront an enemy simply by moving icons around on a screen. When the tactical commanders see their icon move on their screen, they know where to go and what to do. I suspect that's where some of the AI projects mentioned above are being focused.⁴⁸

If you want to see how a military version of the Metaverse might work, read P. W. Singer and August Cole's book, *"Burn-In"* (2020). If you think fully autonomous fighter planes, bombers, tanks, and missile-firing ships are amazing, they are just small components in the concept of a military Metaverse.

Mergers and Acquisitions

I've mentioned the flurry of acquisitions in the video game sector and the potential new laws and restrictions coming to the tech industry. The FTC blocked Nvidia's acquisition of ARM in February. In January the Federal Trade Commission (FTC) stopped Lockheed's acquisition of Aerojet Rocketdyne (maker of missiles).⁴⁹

The Pentagon has voiced concerns about mergers among military suppliers. In 1990, there were 51 major defense contractors. Today, there are 5.⁵⁰ The primary market ripe for M&A is the hypersonic missile segment. The second area is artificial intelligence software.

Another area worth watching is the small satellite segment of the military market. There are 94 makers of cube/micro/nano satellites and subsystems today. In late March, European satellite maker SES Government Solutions bought the satellite communications division of Leonardo DRS.⁵¹

On our industry, Mercury Systems bought Avalex Technologies last September and Atlanta Micro in November.⁵² Our segment of the defense industry doesn't seem to be a target of acquisition restrictions. We make components (boards) and integrate some systems, so our companies don't have the revenues or market share to attract much attention from the authorities.

Summary

Let's look at all the transitions we are experiencing. Fentanyl became the new crack cocaine. Social media and virtual reality are now becoming the new fentanyl. Oil is the new coal. Data is the new oil. AI (artificial intelligence) is the new solar energy (collecting something that's basically available for free). Using energy is bad and we need to use less, even though energy is the primary source for economic growth. Cows and pigs are bad (they create greenhouse gases), so we need to eat only plant-based foods. Electric vehicles limit our range of travel, so we need to stop using petroleum-powered vehicles and travel less.⁵³ Science, medicine, economics, and education are the new politics. Big tech companies are bad for our economy and mental health so they must be severely restricted or broken apart. Globalization (trade among countries) is bad and needs to be replaced with economic nationalism (making everything domestically to create local jobs and tax revenue). Cryptocurrency is the new money. The Metaverse is the new reality.

48 Aaron Bazin, "The Metaverse: A New Domain of Warfare?", Small Wars Journal, March 4, 2022, <https://smallwarsjournal.com/jrnl/art/metaverse-new-domain-warfare>

49 Josh Boak, "Mergers of Defense Companies Are Risking National Security, Pentagon Warns", Military.com, February 15, 2022, <https://www.military.com/daily-news/2022/02/15/mergers-of-defense-companies-are-risking-national-security-pentagon-warns.html>

50 Joe Gould, "Pentagon worried about mergers, especially among hypersonic weapons suppliers", Defense News, February 15, 2022, <https://www.defensenews.com/pentagon/2022/02/15/pentagon-worried-about-mergers-especially-among-hypersonic-weapons-suppliers/>

51 Theresa Hitchens, "SES CEO: Leonardo DRS buy, new sats all about growing US government business", Breaking Defense, March 24, 2022, <https://breakingdefense.com/2022/03/ses-ceo-leonardo-drs-buy-new-sats-all-about-growing-us-government-business/>

52 Mercury Systems, <https://www.mrcy.com/company/mergers-and-acquisitions#acquisitions>

53 Jeremy Beaman, "Lifestyles must change to help keep warming in check, IPCC says", Washington Examiner, April 4, 2022, <https://www.washingtonexaminer.com/policy/lifestyles-must-change-to-help-keep-warming-in-check-ipcc-says>

European and Asian nations are buying swords instead of plowshares. And while chaos is replacing stability, fear is replacing optimism.

Let's look at the end of globalization. As Russia continues to decline economically and militarily, they will become a vassal state when China bails them out. That will force the world into a bipolar power structure (the U.S. vs the China-Russia coalition). Democratic countries could bond together into a single trading block, and communist-dictatorship countries could bond together into another. That's not likely to hold for long, considering that Europe needs Russia's gas and oil to survive, and other democratic countries are dependent on China for trade. Loyalties will be tested and oscillate over the next few years.

The breakdown of supply chains, associated with COVID-19 and the war in Ukraine, is revealing a bigger problem: a rising world population during a period of world resource depletion. We are seeing a shortage of energy, food, fertilizer, minerals, and water that has been ignored by world governments for decades.⁵⁴ Our problems are much bigger than just broken supply chains.

Are there positive longer-term effects from COVID-19 and the war in Ukraine? Yes, it will inspire countries who import many of their needs to develop their own domestic sources. They will subsidize the development of new mines and new processing capabilities for commodities (if they have natural resources). They will subsidize the development of more food production (of both plants and animals) and energy production (through solar, hydroelectric, wind, and maybe nuclear). Worldwide inflation will justify new investments in those areas because the payback period will be shorter as food, energy, and commodity prices rise. Many new jobs will be created domestically, and new tax revenues will arise from those new domestic industries. Countries exposed to the supply chain disruptions seen during COVID-19 and the war in Ukraine will become more economically independent as a result.

A pessimist once said, "... the mess we have now is better than the mess that is coming." An optimist once said, "... this too shall pass." What we will see is probably somewhere in the middle of these two statements, depending on where you are located. Weak economies with poor leadership will suffer more than stronger economies with strong leadership. Countries who have abundant natural resources will do better than those who don't. Companies with industrial-age business models will do poorly compared to those who take risks, innovate, adapt, and change. Apple and Google killed Nokia and Motorola. Now, we are watching Tesla kill GM, Ford, VW, Mercedes, Renault, BMW, Stellantis, and others.⁵⁵

The surprise in all this is that the market for military weapons and platforms is becoming a growth market as European and Asian countries prepare to defend themselves against Russian and Chinese aggression (respectively). Going forward, we will experience more uncertainty until things calm down in Ukraine and supply chains recover to some degree. Read Elliot Ackerman and Admiral James Stavridis' book "2034" (2021). You'll understand why we need to evolve the multi-domain Kill Web into a Military Metaverse populated with physical world unmanned autonomous weapon platforms.

54 Gail Tverberg, "Putin's War Is A Disaster For The Global Economy", OilPrice.com, April 3, 2022, <https://oilprice.com/Energy/Energy-General/Putins-War-Is-A-Disaster-For-The-Global-Economy.html>

55 Brian Wang, "Legacy German Auto Sales Down 30% but Tesla Up 300%", NextBigFuture, April 6, 2022, <https://www.nextbigfuture.com/2022/04/german-car-sales-show-tesla-and-porsche-growth.html#more-175390>