



2018 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://MarketReports). (www.VITA.com/MarketReports)

Introduction

In this report, we'll explore Europe again. But this time, from a military perspective. Then, we'll review the market research reports on the predicted volumes of the different military platforms to be bought and deployed in the future, worldwide. Additionally, some new technology developments are examined. And finally, we'll evaluate the latest M&A activity in our industry.

Financial Conditions

The big news for this report is that U.S. GDP growth hit 4.2% in Q2/2018 (second estimate).¹ This number was revised up from the first estimate of 4.1%. In Q1, U.S. GDP grew by a lackluster 2.2% (final estimate).² According to the Atlanta Federal Reserve, Q3 growth will be about 3.8%.³ The last time we saw U.S. GDP grow at 4% was in 2014.

China grew at 6.7% in Q2, declining a little from their 6.8% rate over the past year.⁴ EU GDP growth was 2.5% in Q1, declining to 2.1% in Q2.⁵ Forecasters say Europe will be

- 1 Jeffrey Bartash, "Second quarter even stronger than it first looked: GDP raised to 4.2% from 4.1%", MarketWatch, August 29, 2018, <https://www.marketwatch.com/story/second-quarter-was-even-stronger-than-it-first-looked-gdp-raised-to-42-from-41-2018-08-29>
- 2 Jeffrey Bartash, "U.S. GDP revised lower for the first quarter on inventories", MarketWatch, May 30, 2018, <https://www.marketwatch.com/story/us-economy-grew-slightly-slower-22-in-first-quarter-revised-gdp-figures-show-2018-05-30>
- 3 "Atlanta Fed cuts U.S. third-quarter GDP view below 4 percent", Reuters, September 11, 2018, <https://www.reuters.com/article/us-usa-economy-atlantafed/atlanta-fed-cuts-u-s-third-quarter-gdp-view-below-4-percent-idUSKCN1LR20Z>
- 4 "China Q2 GDP growth slows to 6.7 pct y/y, in line with expectations", Reuters, July 15, 2018, <https://www.reuters.com/article/china-economy-gdp/china-q2-gdp-growth-slows-to-6-7-pct-y-y-in-line-with-expectations-idUSL4N1U92TK>
- 5 Angela Bouzanis, "Eurozone: Growth falls to two-year low in Q2", Focus Economics, July 31, 2018, <https://www.focus-economics.com/countries/eurozone/news/gdp/growth-falls-to-two-year-low-in-q2>

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lucky to see 2% growth for all of 2018. The U.S. has pending trade complaints against the EU, so things could get interesting for them going forward. Here's the big picture: U.S. GDP is growing while China and EU economies are shrinking a little.

Let's move on to more interesting topics. In a previous report, I chastised the EU for not being innovative, compared to the U.S. Previous EU innovators like Nokia and Ericsson are shadows of their former selves, but so is the entire telecom equipment industry. Citing these companies as failed examples might be unfair. My comments were not backed up by analysis, so I did some reading and research.⁶ One of the most glaring reasons for the low innovation rate in the EU is a lack of venture capital. Another is that Europeans think locally and act locally: across Europe, nobody knows about the products and services from a successful tech start-up company in Netherlands. Once that Netherlands tech company does well locally, they sell-out because they can't get the capital to expand. That's what happened to Booking.com (Amsterdam). They sold out to Priceline.com (Norwalk, Connecticut) for \$113 million in 2005. Booking.com now accounts for 80% of Priceline.com's \$11 billion in revenue today. Spotify Technology S.A. (Stockholm) is the EU's hope for a home-grown successful tech company, unless they become cash-strapped and sell out to Amazon or Apple or Google or Facebook.

Europe has the talent and the skills to be a leader in tech, but they can't attract venture capital because of their economic models and bureaucratic governments' lack of innovation. There are other reasons: a culture of risk aversion, aging demographics, multiple languages to deal with, and local economic loyalties. However, governmental obstruction tops the list.⁷

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Recent comments about America's discontent with NATO's financial arrangements alerted the EU leaders that they have both a defense problem and an innovation problem. So, Europe has created PESCO (Permanent Structured Cooperation), a new military initiative containing 17 individual projects.⁸ One of those projects is to design and build three new military ground combat vehicles: an armored infantry fighting vehicle, an amphibious assault vehicle, and a light armored vehicle. With the British leaving the EU (BREXIT), and not part of PESCO, the design committee can safely put the steering wheels on the left side without suffering significant political backlash (except from the previous British colonies of Malta and Cyprus, who still drive on the left).

It's clear that most EU countries will not spend 2% of their GDP on defense, as established by the NATO treaty. Five EU countries are bound to neutrality by their constitutions: Austria, Switzerland, Ireland, Sweden, and Finland. They have all signed-on to PESCO, but none of these five countries are members of NATO. Only Denmark, Malta, and the UK declined to sign-up for PESCO and European Defence Fund (EDF). The UK is on their way out of the EU, so no problem there. Each member country, even the neutrals, will contribute to the EDF. The assumption here is that the rich countries will contribute more, and the collective defense expenditures will get close to 2% of a lower EUGDP, with the UK out of the picture. The countries that do put big money in the EDF will expect to get money back, to fund the equipment and facilities needed to make the components for the common military platforms being designed in Europe. And they want the jobs that go with that investment. Total EU unemployment is 7.1%. Maybe the latest report from the World Economic Forum has them spooked.⁹ This report says that 75 million jobs in developed countries will be eliminated by computers and AI algorithms by 2022. That's only four years.

It would make no sense for EU countries to contribute to EDF, with no local economic benefit, and then be forced to buy those platforms from another EU country. Italy has an 11% unemployment rate, a debt-to-GDP ratio of 132%, and a shaky banking system. Spain has an unemployment rate of 15% and a debt-to-GDP ratio of 99%. They will both want a premier position at the EDF trough. The World Economic Forum report says that AI and computers will create 133 million new jobs by 2025 (in 7 years), but those will be high-skill jobs. So, the EU is facing a possible gap where unemployment of low-skill

6 Jeremy Kahn, "Why Can't Europe Do Tech?", Bloomberg Businessweek, August 15, 2018, <https://www.bloomberg.com/news/features/2018-08-16/inside-europe-s-struggle-to-build-a-truly-global-tech-giant>

7 James Pethokoukis, "Why can't Europe create its own Facebook, Apple, Netflix, or Google? Here's what Europeans think", AEIdeas, April 25, 2016, <http://www.aei.org/publication/why-cant-europe-create-its-own/>

8 "Permanent Structured Cooperation (PESCO) first collaborative PESCO projects - Overview", European Council, <https://www.consilium.europa.eu/media/32079/pesco-overview-of-first-collaborative-of-projects-for-press.pdf>

9 Jamey Keaten, "Machines to handle over half workplace tasks by 2025", Associated Press, September 17, 2018, <https://www.apnews.com/78c17567c24b48c3b67be095ae0db99c>

workers rises rapidly in the next few years. If you want a better understanding of this prediction, read Klaus Schwab's book, "The Fourth Industrial Revolution". He is the chairman of the World Economic Forum.

Outside of PESCO, France and Germany have proposed a new European Main Battle Tank (EMBT) for all the EU countries to buy. It's a hybrid made with the chassis and engine from the existing German Leopard-2 tank, and the turret and gun from the French Le Clerc tank.¹⁰ Reporters in Europe use an undiplomatic but amusing appellation for it: the "Frankentank". And, it looks like the jobs and revenue benefits from this project will accrue to France (9.2% unemployment) and Germany (3.2% unemployment).¹¹



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France and Germany have agreed, independent of PESCO, to co-design Europe's next-generation fighter jet, to replace the aging Dassault Rafales, Saab Gripen, and the Eurofighter Typhoons.¹² On average, it takes the Europeans about 16.5 years to design, test, manufacture, and deploy low-tech fighter planes. The F-35 took about 24 years from design-start to deployment. The reason for the extra 8 years might be software: the F35 contained 8 million lines of code when it went into service. The Block-3 upgrades, presently being implemented, increase that to 10 million lines of code. FYI, the stealthiest jet fighter in the world, the F-22, contains 2 million lines of code. And that plane took 19 years from design-start to operational status.

As you ponder this new Franco-German fighter jet, consider the disappointing results from the EU's most recent military project: the over-budget and under-performing A400M military transport plane.¹³ The wings are built in the UK, the fuselage in Germany, the cockpit in France, and final assembly is done in Spain. Right off the production line, the engines had major problems. Now, they are removing some high-tech systems from the plane because they can't make them work.¹⁴

The Swedes are not happy about being snubbed in the Franco-German fighter plane alliance. Their major defense company (Saab) makes the Gripen fighter jet. And as you already know, the Brits are persona non grata in the EU. So, the Brits and the Swedes are in discussions to design and build their version of the next-generation Eurofighter.¹⁵ In July, the Brits unveiled a mock-up of their new 6G Tempest fighter jet at the Farnborough Air Show. BAE (UK) will build the plane, Rolls Royce (UK) will provide the engines, MBDA (UK, France, Italy, and Germany) will supply the weapons, and Leonardo (Italy) will contribute the sensors and electronic warfare equipment.¹⁶ How the Swedes fit into the Tempest project, or a different fighter design, is perplexing. The Brits have 4.1% unemployment and Sweden has 6.2% unemployment

10 Sebastian Sprenger and Jeff Martin, "French and German armor makers test the waters with a 'Euro-tank'", Defense News, June 11, 2018, <https://www.defensenews.com/digital-show-dailies/eurosatory/2018/06/11/french-and-german-armor-makers-test-the-waters-with-a-euro-tank/>

11 "Unemployment rate in member states of the European Union in June 2018", Statista, June 2018, <https://www.statista.com/statistics/268830/unemployment-rate-in-eu-countries/>

12 Pierre Tran, "We are not dupes: France takes step away from US with fighter program", Defense News, September 7, 2018 <https://www.defensenews.com/air/2018/09/07/we-are-not-dupes-france-takes-step-away-from-us-with-fighter-program/>

13 Pierre Tran, "Airbus cutting 3,700 jobs across Europe, slashing A400M aircraft production", Defense News, March 7, 2018, <https://www.defensenews.com/industry/2018/03/07/airbus-cutting-3700-jobs-across-europe-slashing-a400m-aircraft-production/>

14 Tim Hopher and Andrea Shalal, "Europe's A400M army plane may see some features axed", Reuters, February 12, 2018, <https://www.reuters.com/article/us-airbus-a400m-exclusive/exclusive-europes-a400m-army-plane-may-see-some-features-axed-idUSKBN1FW1TR>

15 Rachel Millard, "Britain could team up with Sweden to build a new fighter jet after being snubbed by France and Germany", Daily Mail, July 5, 2018, <http://www.dailymail.co.uk/news/article-5923349/Britain-build-new-fighter-jet-Swedes.html>

16 Kyle Mizokami, "U.K. Introduces New Fighter Jet: The Tempest", Popular Mechanics, July 16, 2018, <https://www.popularmechanics.com/military/research/a22168844/uk-new-fighter-jet-tempest/>

Meanwhile, the wealthy EU countries are looking at the 5G F-35 fighter jet from Lockheed-Martin. But the price tag of \$100 million per plane is causing apprehension.¹⁷ So, Boeing has released their new F/A-18 Super Hornet for about \$70 million. They have also proposed a new version of the F-15 Eagle, the new F-15x.¹⁸ Lockheed started pitching an F-22/F-35 hybrid fighter to the U.S. Air Force, Japan, and probably our EU allies. It will use the F-22 airframe and the F-35 electronics.¹⁹ No price tag has been revealed. However, this hybrid could run into some problems. In 1997, congress passed the “Obey Amendment”, proposed by Representative Dave Obey from Wisconsin. It states that the U.S. cannot sell stealthy F-22 fighter planes to any other country.²⁰ This proposed aircraft looks like it would fall under those restrictions. According to recent reports, the U.S. Air Force has no interest in a new F-15 or the F-22/F-35 hybrid.²¹

But, back to the point here. After years of neglect, the EU wants to rebuild their military-industrial base instead of buying advanced platforms from U.S. military contractors. They want the jobs, the revenue, and the taxes on the profits from building their own military hardware. The EU wants to become a major exporter of military equipment. And, they need to put low-skilled people to work over the next four years. Since the rest of the world can't afford advanced platforms like the F-35, making low-tech military hardware is perfect for bootstrapping their military-industrial infrastructure as well as spurring some level of innovation. Low-budget EU countries and third-world countries in Africa, South America, and Asia can only afford cheap low-tech weapons. On the surface, the NATO spat might be the catalyst that inspires some innovation in Europe. But it will occur in the military segment and not in the consumer markets. EU government spending, through the EDF, will substitute for venture capital to get the wheels turning. I'll discuss the forecasts for military planes, ground vehicles, helicopters, and other platforms in detail in the Military section of this report.

“After years of neglect, the EU wants to rebuild their military-industrial base instead of buying advanced platforms from U.S. military contractors.”

The observations above raise some interesting questions. Why would EU countries pay into PESCO and the EDF, but not meet NATO requirements? Even the neutral countries are onboard with this EU defense project, except for Denmark and Malta. So, let's look at possible reasons. First, they want to keep their defense money at home and not subsidize America's economy. The U.S. shoulders about 67% of the cost of NATO today and that situation must change.

Secondly, the EU needs jobs and revenue, so the military equipment markets look attractive to them. We've already seen that they don't have the venture capital to compete in the consumer and high-tech markets. Their governments cannot easily move tax money over to commercial companies in those segments. They can move government money to companies in the military segment, under the guise of “national defense”. Third, it takes billions of dollars for the R&D, tooling, and infrastructure to manufacture military platforms. To create the volumes to justify that investment, they need to export their military products. If you look at the 2017 arms export report from SIPRI, you will see that the U.S. supplied 34% of all global arms exports in 2017, followed by Russia (22%), France (6.7%), Germany (5.8%), and China (5.7%).²² France and Germany figured this out long before the EU bureaucrats did, and the EU wants a bigger piece of the world defense equipment pie. If you want to see the top 100 companies making and selling military hardware, here's your chance. Count the number of companies in the EU on the top 100 list and look at their sales.²³

It's nice to see the EU put money into innovation, even if it is in the military segment. It's nice to see them take more responsibility and pay for their own defense too, through the creation of PESCO and the EDF. The bigger question is

17 Kyle Mizokami, “The F-35 Is About To Get Cheaper. Now Here's the Bad News.”, Popular Mechanics, April 12, 2018, <https://www.popularmechanics.com/military/aviation/a19757413/f-35-production-price-drop/>

18 Kyle Mizokami, “Boeing's Newest F-15 Packs More Than Two Dozen Missiles”, Popular Mechanics, July 18, 2018, <https://www.popularmechanics.com/military/aviation/a22355833/boeing-new-f-15x/>

19 Marcus Weisgerber, “Lockheed Pitching F-22/F-35 Hybrid to US Air Force”, Defense One, August 30, 2018, <https://www.defenseone.com/business/2018/08/lockheed-pitching-f-22f-35-hybrid-us-air-force/150943/>

20 Robert Farley, “Imagine: F-22 Raptors For Export”, The Diplomat, May 8, 2015, <https://thediplomat.com/2015/05/imagine-f-22-raptors-for-export/>

21 Dave Majumdar, “Why the Air Force Won't Buy the F-15X or 'New' F-22 Raptor”, The National Interest, September 17, 2018, <https://nationalinterest.org/blog/buzz/why-air-force-wont-buy-f-15x-or-new-f-22-raptor-31442>

22 “Trends in International Arms Transfers, 2017”, SIPRI, March 2018, https://www.sipri.org/sites/default/files/2018-03/fssipri_at2017_0.pdf

23 “Top 100 for 2018”, DefenseNews, <http://people.defensenews.com/top-100/>

whether PESCO and the EDF will replace NATO in the future. That can't happen for many years. It will take a decade or more for them to design their own military hardware. And, it will take billions of Euros to build their military-industrial infrastructure. Finally, I have concerns about how PESCO and the EDF will work. They are governed by a committee of representatives from 25 different countries, and that reminds me of the definition of a camel. It's a horse designed by a committee.

Military

In this section, I will review the forecasts for the different military platform markets. The openly available data is muddled, confusing, and deficient in many areas, so I am compelled to adopt the Dionysian principles of synthesis, passion, and intuition as the appropriate tools for our examination here. Unfortunately, the information on this topic does not lend itself to the Apollonian process, that favors pure logical analysis with a dispassionate weighting of the evidence. However, to remove any bias and attempt to balance these two methodologies, I will apply the Odyssean conventions, that seek to find common elements that connect many ambiguous ideas into a logically explicit structure. After reading this section, I am sure that you will agree with this approach.

Fighter Planes

New aircraft won big in the 2019 defense budget, so let's start by looking at fighter planes.²⁴ Over the next 14 years (2018-2032), 8,063 fixed-wing military aircraft will be built and put into service world-wide.²⁵ Fighter jets will be 54% (4,354), trainers will be 25% (2,015), military transports at 13% (1,048), and special purpose aircraft at 8% (645). For comparison, Boeing's researchers say that 42,730 commercial airliners will be built worldwide over the next 20 years (2018-2037). If things were linear, that's 2,136 commercial airliners per year.²⁶

Another report says that 3,243 fighter jets will be produced worldwide over the next 10 years (2018-2027).²⁷ The difference between the two reports (4,354 - 3,243 = 1,111) is the production difference for four years. Annually, the reports show worldwide production rates peaking at 380 fighters in 2021, declining to 269 in 2027.

Russia built about 10 of their new 5G SU-57 fighters, but the Russians have not mastered stealth design. Maybe that was a factor when their only export customer (India) cancelled future cooperation and purchases.²⁸ China has built 8 of their 5G J-20 fighters, and 2 of their 5G J-31 fighters so far. While the Chinese have mastered elements of stealth, they can't design and build jet engines. They buy their engines from the Russians. China ordered 24 of the Russian 4.5G SU-37 fighters. They took delivery of four in 2016, ten in January 2017, and Russia says they will deliver the last 10 by the end of this year. So, don't count on Russia or China having a large percentage of the fighter jet market over the next 10 years.



5G SU-57, Source: Wikipedia

24 Sydney Freedberg, "Aircraft Win Big In FY19 Appropriations: Munitions, Space, Marines Hammered", Breaking Defense, September 14, 2018, <https://breakingdefense.com/2018/09/aircraft-win-big-in-fy19-appropriations-munitions-space-marines-hammered/>

25 "Military Aircraft Forecast Overview", Forecast International, https://www.forecastinternational.com/fistore/prod.cfm?FISSYS_RECNO=23&title=Military-Aircraft-Forecast

26 Tim Hepher and Victoria Bryan, "Boeing lifts 20-year industry demand forecast to \$6 trillion", Business Insider, June 20, 2017, <https://www.businessinsider.com/r-boeing-lifts-20-year-industry-demand-forecast-to-6-trillion-2017-6>

27 "Fighter Aircraft Market Worth \$249B Over Next 10 Years", Forecast International, May 23, 2018, <https://globenewswire.com/news-release/2018/05/23/1510577/0/en/Forecast-International-Fighter-Aircraft-Market-Worth-249B-Over-Next-10-Years.html>

28 Alex Lockie, "Russia admits defeat on its 'stealth' F-35 killer by canceling mass production of the Su-57 fighter jet", Business Insider, July 12, 2018, <https://www.businessinsider.com/russia-admits-defeat-su-57-not-going-into-mass-production-2018-7>

Here's where things get fuzzy. As of January 2018, Airbus seems to have orders for 99 Eurofighter Typhoons (to be delivered by 2023, over five years, or about 20 per year).²⁹ Dassault has orders for 48 Rafale fighters, from what I could find. It looks like Saab has orders for about 36 Gripen fighter planes. These planes were ordered by countries with small budgets in Asia, Eastern Europe, South America, the Middle East, and Western Europe. So, if you add these up and look at the timeframes, the numbers suggest that the EU aerospace industry has the capacity to build about 30-40 fighter jets per year.

Comparatively, the U.S. and 9 partner nations plan to buy 3,100 of the 5G F-35 fighters by 2035. The production rate is expected to reach 17 planes per month in 2020 (about 200 per year). So far, Lockheed has delivered 310 F-35 fighter planes since 2011 (in 7 years, or 44 per year on average).³⁰ From what I could find on the web, U.S. defense contractors are building 1.25 F-15's per month, two of the F/A-18 Super Hornets per month, and one F-16 per month. And there are pending orders for these planes from allies in Asia and the Middle East. Additionally, there are two Unmanned Combat Air Systems (UCAS) on the drawing boards from Kratos Defense & Security Solutions: the XQ-58A Valkyrie, and the UTAP-22 Mako.³¹ It's too early to forecast demand for these autonomous wingman platforms.

Helicopters

There's a big transition happening in helicopters. The Navy is using the tilt-rotor V-22 Osprey instead of traditional overhead rotor aircraft. The Army wants to transition from the Blackhawk, Apache, and Chinook to the Bell (Textron) V-280 Valor tilt-wing aircraft. There are two old sayings among pilots: (1) "airplanes want to fly, but helicopters don't", and (2) "a helicopter is 50,000 parts flying in a close formation". Overhead rotor aircraft are the worst shock-and-vibration and contaminant environments of any aircraft. And, they are tough to maintain: they beat themselves to death.

Nevertheless, market researchers say that 26,238 helicopters will be built over the next 14 years (2018-2032). That number includes commercial and military aircraft.³² About 5,714 of that total will be medium/heavy military helicopters (>15,000 lbs.).³³ Based on unit volume, the Russians will ship about 40% (2,285), Sikorsky at 24% (1,371), China at 9% (514) and Boeing at 8% (457). Together, these four helicopter manufacturers produce about 450 aircraft per year. This rate could accelerate in the 2020's as the U.S. Army transitions to the Future Vertical Lift aircraft (FVL). That's the V-280 Valor.

Another market report predicts that 1,600 light military helicopters (<15,000 lbs.) will be built worldwide over the next 15 years.³⁴ Airbus will build 420, China's Avicopter will build 301, Hindustan Aeronautics (India) will build 257, and Bell Helicopter (Textron) will build 225. Worldwide production rates will come down from 217 in 2017, to 87 units in 2024. Obviously, the market for light military helicopters is declining.

In 2017, Boeing received multi-year orders for 268 AH-64 Apaches from the U.S. Army, with 24 going to Saudi Arabia. Fifteen countries fly Apaches, and 40% of Apache production has been going to foreign allies.³⁵ Boeing can produce about 6 units per month (72 per year). The Apache is an attack helicopter with over 2,000 built since 1986.

29 Tony Osborne, "Typhoon Production Nudges to 2023", Aviation Week, June 18, 2017, <http://aviationweek.com/paris-air-show-2017/typhoon-production-nudges-2023>

30 James Langford, "Lockheed adds 1,800 workers to ramp up F-35 fighter production", Washington Examiner, July 23, 2018, <https://www.washingtonexaminer.com/business/lockheed-adds-1-800-workers-to-ramp-up-f-35-fighter-production>

31 Stew Magnuson, "New Age of Autonomous Jet Fighters on Horizon", National Defense, September 14, 2018, <http://www.nationaldefensemagazine.org/articles/2018/9/14/the-future--of-air-power>

32 "Rotorcraft Forecast Overview", Forecast International, https://www.forecastinternational.com/fistore/prod.cfm?FISSYS_RECNO=33&title=Rotorcraft-Forecast

33 "Medium/Heavy Military Rotorcraft Market Stabilizing", Forecast International, February 26, 2018, <https://globenewswire.com/news-release/2018/02/26/1387020/0/en/Forecast-International-Medium-Heavy-Military-Rotorcraft-Market-Stabilizing.html>

34 Richard Tomkins, "Airbus expected to lead light military helicopter market, report says", United Press International, October 25, 2017, <https://www.upi.com/Airbus-expected-to-lead-light-military-helicopter-market-report-says/6101508953732/>

35 James Bach, "Boeing's Apache deal could be worth more than \$7 billion", Washington Business Journal, March 23, 2017, <https://www.bizjournals.com/washington/news/2017/03/23/boeing-s-apache-deal-could-be-worth-more-than-7.html>

Over 4,000 Sikorsky UH-60 Blackhawk utility helicopters have been built since 1979 and 27 countries fly them today. In 2017, they got an order for 257 Blackhawks from Saudi Arabia.³⁶ I could not find their production rate anywhere. Sikorsky is working on their next generation overhead-rotor helicopter now, the SB>1.³⁷

Then, there's the Boeing CH-47 Chinook heavy transport helicopter. The U.S. Army flies about 475 of them today. The V-280 is predicted to replace the Chinook in the future.³⁸

Unmanned Aerial Vehicles (UAV)

This market is very hard to quantify. The U.S. military may buy 5,000 UAVs, but only 50 of them are real aircraft. The other 4,950 are mini-UAVs or micro-UAVs (little quadcopters that cost <\$10,000). So, we must sort out the small stuff.³⁹ UAVs are divided into seven categories, by their prices, so it's best that you read the report. It says that U.S. manufacturers built 1,179 fixed-wing UAVs in 2017 and will build 2,530 in 2026. U.S. makers built 2,530 mini-UAVs in 2017 and will build 4,439 in 2027. There are other reports out there, but they all have trouble counting things, and they segment the market into a dizzying array of classes. The 2019 DoD budget did increase spending on drones, but the bulk of the volume will be in smaller models.⁴⁰

Looking at the big stuff, the Air Force ordered 36 new MQ-9 Reaper drones in 2017, for delivery through 2020.⁴¹ Over 160 Reapers have been built since its debut in 2007. In March of 2018, the Air Force retired the MQ-1 Predator drones. About 360 have been built since 1994.

In 2005, six EU countries agreed to finance and build a next generationUCAV (Unmanned Combat Air Vehicle): France, Greece, Italy, Spain, Sweden, and Switzerland.⁴² The nEUROn made its first flight in 2014. At this point, the artistically creative handling of the name (Neuron) is more impressive than the actual aircraft.

In yet another EU project, France, Germany, Italy, and Spain agreed to work together on a new medium-altitude long-endurance remotely piloted aircraft system (MALE RPAS).⁴³ A mock-up of the aircraft was unveiled at the Berlin Air Show in early 2018. In this instance, the aircraft is more creative than its name.



Bell V-280 Valor, Photo courtesy of Bell Helicopter Textron Inc.



Dassault nEUROn, Photo courtesy of Dassault

36 Jonathan Weber, "The Black Helicopters Are Coming", Seeking Alpha, July 5, 2017, <https://seekingalpha.com/article/4085908-black-helicopters-coming>

37 "SB>1 DEFIANT™ JMR Technology Demonstrator", Lockheed Martin, <https://www.lockheedmartin.com/en-us/products/sb1-defiant-technology-demonstrator.html>

38 Sydney Freedberg, "Bell V-280 Vs. Sikorsky-Boeing SB>1: Who Will Win Future Vertical Lift?", Breaking Defense, October 2, 2017, <https://breakingdefense.com/2017/10/bell-v-280-vs-sikorsky-boeing-sb1-who-will-win-future-vertical-lift/>

39 Dee Ann Divis, "Military UAV Market To Top \$83B", Inside Unmanned Systems, April 24, 2018, <http://insideunmannedsystems.com/military-uav-market-to-top-83b/>

40 Kelsey Atherton, "After cuts, 2019 drone budget still largest ever for Pentagon", C4ISR Net, September 20, 2018, <https://www.c4isrnet.com/unmanned/2018/09/20/after-cuts-2019-drone-budget-still-largest-ever-for-pentagon/>

41 John Keller, "Air Force orders another 36 MQ-9 Reaper UAV attack drones from General Atomics", Military & Aerospace Electronics, May 19, 2017, <https://www.militaryaerospace.com/articles/2017/05/36-new-mq-9-reaper-uav-attack-drones-ordered.html>

42 "nEUROn Unmanned Combat Air Vehicle (UCAV) Demonstrator", Air Force Technology, <https://www.airforce-technology.com/projects/neuron/>

43 Mike Rees, "First Full-Scale Model of European Medium-Altitude Long-Endurance RPAS Revealed", Unmanned Systems Technology, April 30, 2018, <https://www.unmannedsystemstechnology.com/2018/04/first-full-scale-model-of-european-medium-altitude-long-endurance-rpas-revealed/>

In 2013, BAE (UK) flew their Taranis UCAS (unmanned combat air system), nicknamed “Raptor”, for the first time. BAE is now working on a new UAV called “Magma” which uses its propulsion system for control rather than moving control surfaces.⁴⁴ Something hard to do with human aboard.

Since 2013, Boeing has been installing “autonomy kits” on numerous old F-16 fighter jets, and the Air Force is using them as target drones for fighter pilot gunnery training.⁴⁵ Today, they are enhancing those autonomy kits to make older fighter jets into UCAS platforms (Unmanned Combat Air Systems).⁴⁶ One F-35 could control 4 or 5 of these unmanned fighter planes on combat missions. With advanced AI algorithms onboard, these modified old planes can fly themselves, find targets, and destroy those targets autonomously. Adding more confusion, these planes blur the distinction between UAVs and fighter planes.

Long Range Bombers

Only three countries fly long-range bomber aircraft today: the U.S., Russia, and China. There are three next-generation bombers on the drawing boards: the U.S. B-21 Raider, the Russian PAK-DA, and the Chinese Xian H-20. They are all flying-wing designs, much like the present B-2 Spirit bomber. On average, it takes about 15 years to design, build, and deploy new strategic bombers. Russia doesn’t have the economy to build-up their bomber force, and the Chinese can’t design and build jet engines, so don’t look for them to produce many over the next 10 years. However, the U.S. Air Force originally wanted 100 of the new B-21’s, to replace the aging B-1 and B-52 bombers. That total was recently increased to 172.⁴⁷ Taking a guess, the Air Force could probably take 10 new B-21’s per year, once the design and testing phase are completed. Maybe the Russians and Chinese can build a few, so the worldwide total for new bombers is about 12 per year, in another 3-4 years.

In 2015, Germany announced that they will undertake a new project, to design the EU’s next-generation bombers, to replace their aging Tornado aircraft. But the Tornado looks more like a fighter plane with some bombs strapped under its wings, and not a strategic long-range bomber. So, you can discount this announcement and just add this plane to the lengthy list of next-generation EU fighter jet projects. Of all the military platform markets, the lowest volumes are in bombers.

Combat Ground Vehicles and Tanks

If you like volume, you’ll love this market segment. Over the next 10 years, the market researchers say that a total of 453,000 military ground vehicles will be bought, built, and deployed.⁴⁸ That’s 45,300 per year, if the markets were linear. Of the 453,000, about 108,000 will be armored fighting vehicles. Self-propelled artillery accounts for 11,300 vehicles. Logistics support will see 307,000 vehicles bought. The air and missile defense total is 3,400 vehicles. The U.S. will buy 107,000 vehicles over 10 years. China will buy 44,100. Western powers want medium to heavy vehicles. Smaller nations want light vehicles. And, 3,800 new tanks will be bought by 2023.⁴⁹ Many small Asian countries are buying tanks, to defend against China. All the countries bordering Russia want more tanks, and all the European NATO countries are in the market for new tanks these days. This is why the EU is starting-up numerous projects to build tanks, ground combat vehicles, and troop carriers.

44 Craig Hoyle, “BAE ignites unmanned interest with Magma”, *FlightGlobal*, January 9, 2018, <https://www.flightglobal.com/news/articles/bae-ignites-unmanned-interest-with-magma-444720/>

45 Clay Dillow, “The Pentagon Wants Autonomous Fighter Jets to Join the F-35 in Combat”, *Tech Defense*, March 30, 2016, <http://fortune.com/2016/03/30/autonomous-fighter-jets-join-the-f-35/>

46 Darrell Etherington, “U.S. Air Force and Lockheed demonstrate autonomous F-16 strike capabilities”, *Tech Crunch*, <https://techcrunch.com/2017/04/11/u-s-air-force-and-lockheed-demonstrate-autonomous-f-16-strike-capabilities/>

47 Colin Clark and Sydney Freedberg, “What Will New Bomber Squadrons Mean For Air Force? 75 More B-21s?”, *Breaking Defense*, September 18, 2018, <https://breakingdefense.com/2018/09/what-will-new-bomber-squadrons-mean-for-air-force-75-more-b-21s/>

48 Vivienne Machi, “Analyst: Burgeoning Weight of Military Ground Vehicles ‘Unsustainable’”, *National Defense*, June 15, 2018, <http://www.nationaldefensemagazine.org/articles/2018/6/15/analyst-burgeoning-weight-of-military-ground-vehicles-unsustainable>

49 “Main Battle Tank Market – Segmented by Generation, and by Geography - Growth, Trends, and Forecast (2018 – 2023)”, *Mordor Intelligence*, May 2018, <https://www.mordorintelligence.com/industry-reports/main-battle-tank-market>



Oshkosh JLTV Family of Vehicles, Photo courtesy of Oshkosh Defense

The U.S. Army just bought 473 new Bradley Fighting Vehicles, to use as test beds for all the new C4ISR systems coming into service.⁵⁰ The older Bradleys and M113 Armored Personnel Carriers can't generate enough electricity to power all the new electronic gear. The Army has pulled some older Bradleys and Abrams tanks out of storage and outfitted them with "autonomy kits". One new Abrams tank can control several of these "wingman" combat ground vehicles.⁵¹

Oshkosh Defense just received a new order for 1,574 JLTV (Joint Light Tactical Vehicles).⁵² They have delivered over 2,000 since initial production started in 2016. And, the U.S. Army says they want a total of 55,000 of those vehicles.⁵³

C4ISR

Researchers say the market for C4ISR (command, control, computers, communications, intelligence, surveillance, and reconnaissance) equipment will be \$132 billion by 2026.⁵⁴ They break these systems down by land, sea, air, cyber, space, and then by function (radar, sonar, secure communications, infrared sensors, electronic warfare, signals intelligence, etc.), but you'll have to buy the report to get the details. Without doubt, this is our biggest market opportunity for electronic systems. Many of those ground vehicles mentioned above will need advanced C4ISR electronics onboard.

Ships

We build one aircraft carrier about every 5 years, one new submarine about every 3 years, a few LCS (Littoral Combat Ships) every 18 months, and a new destroyer now and again. The Chinese and the Russians produce even less. So, there's not enough volume here to get excited about.

Upgrades

Now, let's inject some reality into these platform forecasts. Before all this new gear gets built and deployed, which will take many years, there will be tons of upgrades to existing platforms. There are no market research reports on that topic, only an article here and there about which platforms are due for new equipment. As an example, I think we will see several upgrades to existing military VME-based systems, before NXP does something weird to their PowerPC product line. The

50 Warren Maven, "Army Makes Massive Bradley Buy", Warrior Maven, August 11, 2018, <https://defensemaven.io/warriormaven/land/army-makes-massive-bradley-buy-up-to-473-vehicles-to-prep-for-major-power-war-tJRL3ZUc80GISK-BMdpeLw/>

51 Kris Osborn, "The Army Is Building Robot Attack Tanks", The National Interest, July 23, 2018, <https://nationalinterest.org/blog/buzz/army-building-robot-attack-tanks-26541>

52 "U.S. Army Places \$484 Million Order for 1,574 Joint Light Tactical Vehicles", Oshkosh Defense, June 29, 2018, <http://mil-embedded.com/news/oshkosh-to-deliver-1574-jltvs-with-recent-484-million-order/>

53 Sydney Freedberg, "Tanks Up, Choppers Down, Artillery WAY Up In Army's Old School 2019 Budget", Breaking Defense, February 12, 2018, <https://breakingdefense.com/2018/02/tanks-up-choppers-down-artillery-way-up-in-armys-old-school-2019-budget/>

54 "C4ISR Market to be worth US\$ 132.26 Billion by 2026", Transparency Market Research, May 4, 2018, <https://globenewswire.com/news-release/2018/05/04/1496777/0/en/C4ISR-Market-to-be-worth-US-132-26-billion-by-2026-Transparency-Market-Research.html>

Qualcomm deal to buy NXP fell apart in July, so NXP is trying to figure out what to do next.⁵⁵ It's much cheaper to upgrade an older platform that's still relevant, than to replace it. Over the next few years, I think we will see more older platforms upgraded than new platforms bought to replace them.

You may need to connect some dots, extrapolate some numbers, and do a little math with the information above. The volumes ramp-up and ramp-down on a curve, over time. They are not linear. Also, consider that the physical volumes predicted in these reports are military budget-driven, adding an element of uncertainty. So, the numbers could jump off that curve with larger increases or decreases in certain years.

Technology

There are two exciting developments on the technology front: Chord signaling and the COBO specification. I have watched the excruciatingly-slow, monotonous, problem-plagued, painfully-incremental performance improvements of differential interconnects on copper traces for years. I got impatient long ago and became a big fan of optical links. VITA members have specified robust and reliable optical connectors for VPX standards, but board vendors are sticking with differential copper links like PCIe. However, we have seen several companies create optical FPGA mezzanine cards (FMC). That's encouraging.

"I got impatient long ago and became a big fan of optical links."

Chord signaling announced by **Kandou Bus** has slightly renewed my interest in copper-based interconnects, at least for now. This is the first substantial improvement in copper-trace-based performance in years. On the surface, it's a multi-wire version of differential signaling. Four traditional two-wire differential links use 8 wires while a four-link Kandou Bus uses five wires (four for the data signals and one for differential parity). The sum of the bits on the five wires always equals zero. Additionally, Kandou Bus' signal integrity issues are much easier to handle. However, the success of this development is dependent upon the semiconductor makers adopting this new concept. Companies like Intel (PCIe) and Nvidia (NVLink) have not-invented-here attitudes, so I doubt they will adopt this innovation. Kandou Bus is close to what a universal copper-trace interconnect standard could be, and it could make our lives much easier at the board and backplane level. This is a great piece of thinking and technology, but I fear that it will be ignored.

Therefore, my fallback position is the **Consortium for On-Board Optics (COBO) specification**. This document specifies 400Gb/s and 800 Gb/s fiber links (x8 and x16 respectively) using 50G PAM-4 signaling. When the 100G PAM-4 signaling standard is complete, the aggregate bandwidth can go up to 1.6Tb/s (x16). In the long run, optical just makes more sense from a performance standpoint.

This takes us into a discussion about processors and memory. As you know from previous reports, von Neumann computer architectures are limiting our performance these days, especially in AI applications.⁵⁶ We move the data too much, consuming lots of power and creating lots of heat. And, while CPU performance over time has gone-up 60%, memory performance has only gone up 7%. That means the CPU is waiting for data most of the time.⁵⁷ Additionally, better algorithms have increased performance thousands of times more than hardware speed-ups.⁵⁸ Obviously, we are on the verge

"von Neumann computer architectures are limiting our performance these days, especially in AI applications."

55 Michael Martina and Stephen Nellis, "Qualcomm ends \$44 billion NXP bid after failing to win China approval", Reuters, July 25, 2018, <https://www.reuters.com/article/us-nxp-semicondtrs-m-a-qualcomm/qualcomm-ends-44-billion-nxp-bid-after-failing-to-win-china-approval-idUSKBN1KF193>

56 Brian Bailey, "AI Architectures Must Change", Semiconductor Engineering, August 13, 2018, <https://semiengineering.com/ai-architectures-must-change/>

57 Joel Hruska, "CPU Utilization Is Wrong on PCs, and Getting Worse Every Year", Extreme Tech, May 2, 2018, <https://www.extremetech.com/computing/268661-cpu-utilization-is-wrong-on-pcs-and-getting-worse-every-year>

58 Brian Wang, "Algorithms provide more performance gain than hardware in many cases", Nex Big Future" August 22, 2018, <https://www.nextbigfuture.com/2018/08/algorithms-provide-more-performance-gain-than-hardware-in-many-cases.html>

of tremendous change in computer architectures.⁵⁹ Maybe that's why Apple says they might be dropping Intel processors in their products and designing their own CPUs.⁶⁰ These new architectures will require much faster board-to-board links than the present fabrics-on-copper-traces can provide. So, I'm keeping one foot solidly planted in the optical realm.

Ray Kurzweil has calculated the maximum number of computations that can be done, and the maximum amount of data that can be stored, in the observable universe. But first, he converts the matter and energy in that universe to "computronium".⁶¹ Two things stand out in his theory: (1) the interconnects are optical (not copper), and (2) the computing architectures are not von Neumann machines. So, he directly supports my observations about what we must do in this industry to improve performance. If you doubt my views on this topic, you are doubting Ray Kurzweil.

Many of us watched the total collapse of the telecom equipment industry a few years ago, with some amusement. The acme of this event was the bankruptcy of Nortel. Now, we get to watch the total collapse of pay TV (cable and satellite TV) markets.⁶² Over 5 million subscribers will cut the cord in 2018, and that rate is accelerating. Streaming is displacing the horrible content and high prices associated cable and satellite TV. Once reliable 5G cellular is deployed, the pay TV business model is toast.

Another massive disruption is developing for the network equipment market. Amazon has made noises that they are going to make their own network switches for their data centers and sell them to businesses online. They are tired of paying high prices to Cisco, ZTE, Huawei, Arista, and Juniper.⁶³ Additionally, there's a government ban on purchases of Huawei and ZTE routers for security reasons.⁶⁴

CVS Health, a drug store company, is making their own home dialysis equipment now.⁶⁵ That zaps some traditional medical device makers and their lucrative prices. The world healthcare market is around \$2 trillion, and it is ripe for disruption.⁶⁶ Many services provided by doctors and nurses today will be replaced by IoT-type devices, artificial intelligence, and cloud services.

This topic fits better in the Military section of this paper, but I will cover it here since it involves technology. In 1972, the UN General Assembly voted to ban the use of incendiary weapons against soldiers in battle. Think napalm. But, this ban also covers directed-energy weapons since lasers are incendiary devices. In 1977, Article 35 was passed by the Geneva Convention. It prohibits the use of weapons that cause "superfluous injury or unnecessary suffering." Think poison gases, deadly biological weapons, and probably laser weapons too. In 1998, the UN passed the "Protocol on Blinding Laser Weapons". It says military forces cannot use lasers to permanently blind enemy soldiers on the battlefield. Despite these Laws of Armed Conflict, progress is being made on anti-personnel laser weapons. You can't permanently blind enemy soldiers, you can't expose them to severe burns, and you can't inflict "superfluous injury or unnecessary suffering". But, the laws don't prohibit vaporizing an enemy soldier in an instant. According to the latest research, it takes about 2 Megawatts of laser energy, for a few milliseconds, to completely disassemble a human body into its atomic components.⁶⁷

59 Ed Sperling, "Big Changes For Mainstream Chip Architectures", Semiconductor Engineering, August 23, 2018, <https://semiengineering.com/big-changes-for-mainstream-chip-architectures/>

60 Ryan Shrout, "Opinion: How Apple dropping Intel would change the future of technology", MarketWatch, April 3, 2018, <https://www.marketwatch.com/story/how-apple-dropping-intel-would-change-the-future-of-technology-2018-04-03>

61 Brian Wang, "Computronium universe – computation limits of computronium and limits to the universe", Next Big Future, August 25, 2018, <https://www.nextbigfuture.com/2018/04/computronium-universe-computation-limits-of-computronium-and-limits-to-the-universe.html>

62 Gerry Smith, "Who Killed the Great American Cable-TV Bundle?", Bloomberg, August 8, 2018, <https://www.bloomberg.com/news/features/2018-08-08/who-killed-the-great-american-cable-tv-bundle>

63 Emily McCormick, "Cisco, Juniper Fall on Report Amazon May Sell Data Switches", Bloomberg, July 13, 2018, <https://www.bloomberg.com/news/articles/2018-07-13/cisco-juniper-fall-on-report-amazon-may-sell-data-switches>

64 Todd Shields, "Huawei and ZTE Targeted While Security Ban Advances at U.S. FCC" Bloomberg, April 17, 2018, <https://www.bloomberg.com/news/articles/2018-04-17/huawei-zte-targeted-as-security-ban-advances-at-u-s-fcc>

65 Emma Court, "CVS is making a medical device, showing how health-care companies are doing more", MarketWatch, April 8, 2018, <https://www.marketwatch.com/story/cvs-is-making-a-medical-device-showing-how-health-care-companies-are-doing-more-2018-04-05>

66 Jeff Dorsch, "Tech Tackles Health Care", Semiconductor Engineering, April 23, 2018, <https://semiengineering.com/tech-tackles-digital-health-care/>

67 Robert Hunter Ward, "The Dawn of Anti-Personnel Directed-Energy Weapons", Real Clear Defense, July 24, 2018, https://www.realcleardefense.com/articles/2018/07/24/the_dawn_of_anti-personnel_directed-energy_weapons_113641.html

In August, the UN Committee on Certain Conventional Weapons (CCW) met in Geneva, to hammer-out a treaty to ban fully-autonomous weapons (killer robots). Five countries blocked the progress of that meeting: the U.S., Russia, South Korea, Israel, and Australia.⁶⁸ This committee could not even come to an agreement on the definition of an autonomous weapon. We already have autonomous defensive weapons. The AEGIS missile defense system has a fully-autonomous mode. We probably have offensive weapons with a fully-autonomous mode too.

In 1911, the Institute of International Law in Madrid proposed banning the use of aircraft in war, except for reconnaissance missions. Many countries signed the proposal, except the major countries that had airplanes just before WWI. In 2017, the UN passed the Ban on Nuclear Weapons. Over 120 nations signed the treaty, except the nations that have nuclear weapons. When portable 2-Megawatt lasers are feasible, expect to see the bans and prohibitions on anti-personnel laser weapons ignored too.

M&A Activity

In January, Celestica bought Atrenne Integrated Solutions, Inc. for \$139 million.⁶⁹ No sales numbers were disclosed, so we can't calculate the multiple. Atrenne makes backplanes and packaging for computers. You might remember that Atrenne bought Hybricon from Curtiss-Wright back in 2015. Some history, Carlo Gavazzi/Mupac was bought by SIE Computing Solutions in 1986 and SIE Computing Solutions was bought by Atrenne in 2014.

In April, Pentair spun-out their Schroff electronic packaging division (along with Hoffman, Raychem, Tracer, Erico, and Caddy groups) into a separate company: nVent.⁷⁰ So, there's been a lot of activity in the electronic packaging sector.

In April, Intel divested their Wind River Systems, Inc. software group to asset manager TPG.⁷¹ They paid \$883 million for Wind River back in 2009. VxWorks was supposed to lead Intel into the embedded computing markets, but that didn't seem to work out. Intel also sold-off their McAfee software group about a year ago. None of that software fits into the data center markets or the developing artificial intelligence chip markets.

In May, Molex bought Bittware, Inc., a maker of FPGA-based boards.⁷² No numbers were disclosed. You might remember that Nallatech, another maker of FPGA-based boards, was bought by Integrated Systems, Inc. back in 2008. Then, Molex bought ISI in 2016.

In late July, Mercury Systems bought Germane Systems for \$45 million.⁷³ Germane makes rugged servers that are installed in Navy submarines. This fits nicely with Mercury's purchase of Themis back in late 2017. Themis made rugged servers and systems for Navy surface vessels.

In August, One Stop Systems (OSS) acquired Concept Development Inc. (CDI) for \$5.9 Million (\$4.9 million in stock, and \$1 million in cash).⁷⁴ According to the press release, CDI will contribute \$4 million to \$6 million to OSS annual revenue. That suggests that CDI was bought for between 0.98- and 1.4-times sales. On average, that's about 1.2 times sales. CDI makes inflight entertainment systems for commercial airliners. Keep this in mind when you read the military section of this report, and the forecast for commercial airliners over the next 20 years.

⁶⁸ Mattha Busby and Anthony Cuthbertson, "Killer robots' ban blocked by US and Russia at UN meeting", Independent, September 3, 2018, <https://www.independent.co.uk/life-style/gadgets-and-tech/news/killer-robots-un-meeting-autonomous-weapons-systems-campaigners-dismayed-a8519511.html>

⁶⁹ "Celestica to Acquire Atrenne Integrated Solutions", Celestica, January 24, 2018, <https://corporate.celestica.com/news-releases/news-release-details/celestica-acquire-atrenne-integrated-solutions>

⁷⁰ "nVent Announces Completion of Separation from Pentair", nVent, April 30, 2018, <https://investors.nvent.com/press-releases/press-release-details/2018/nVent-Announces-Completion-of-Separation-from-Pentair/default.aspx>

⁷¹ "Wind River to be Acquired by TPG", Wind River, April 3, 2018, <https://www.windriver.com/news/press/pr.html?ID=20982>

⁷² "Molex Announces Acquisition of BittWare", Molex, May 14 2018, https://www.molex.com/molex/news/display_news.jsp?channel=New&channelId=-8&oid=2376&pageTitle=Molex+Announces+Acquisition+of+BittWare

⁷³ "Mercury Systems Announces Acquisition of Germane Systems", Mercury Systems, July 31, 2018, <https://www.mrcy.com/press-center/press-releases/press-release-detail/?id=17791>

⁷⁴ "One Stop Systems Signs Agreement to Acquire Concept Development", One Stop Systems, August 28, 2018, <https://ir.onestopsystems.com/press-releases/detail/84/one-stop-systems-signs-agreement-to-acquire-concept>

Summary

If you've gotten this far reading this report, then you know that the EU's solution for their defense situation is partly a jobs, tax, and revenue program. After all, the EU will be losing the economic and defense contributions of the UK, as Brexit approaches, so they need to come-up with a new collective strategy. You also know that it will take decades for the EU to master the technologies they need (like stealth, engines, radar, sensors, etc.), and to build-up their military-industrial infrastructure. In the meantime, they will modify their 4G fighter jets (Eurofighter, Gripen, Rafale) for export to low-budget countries. And, they can build and export some ground combat vehicles and tanks immediately, by mixing and matching parts from exiting platforms from different countries.

You also know, from the research reports, that the entire world will consume about 300 fighter jets, 500 military helicopters, 10 long-range bombers, a few thousand small UAVs, about 50 or so large UAVs, 380 new tanks, and about 45,300 military vehicles per year. The largest volume market, with the fewest technology challenges, is in ground combat vehicles and tanks. So, it's no surprise that PESCO singles-out that market while ignoring ships, UAVs, fighter jets, and long-range bombers. France, Germany, Sweden, and the UK have focused on those platforms independently. After all, again, the EU still sleeps under the blanket of NATO, so they are protected unless the U.S. decides to suspend article 5 of the treaty until they pay-up.

Russia, China, and Iran have serious problems too. If you want to see one possible future of the world over the next few years, you really should watch Peter Ziehan's presentation.⁷⁵ It goes on for about an hour, but is definitely worth your time.

In our industry, things look promising with the new defense budget. We are transitioning from the war on terrorism back to wars against nation states. The market research reports mentioned are also positive in this regard, especially the C4ISR systems forecast. And I suspect we will see many upgrades on existing platforms before all the new stuff comes into service. The Kandou Bus Chord signaling scheme and the Consortium for On-Board Optics (COBO) specifications could add some product opportunities for us too, depending on adoption by the semiconductor makers.

“Additionally, our U.S. overall economy is growing nicely. So, things look good going forward.”

⁷⁵ Brian Wang, “Peter Zeihan lists real problems but then has insane conclusions”, NextBigFuture, September 21, 2018, <https://www.nextbigfuture.com/2018/09/peter-zeihan-lists-real-problems-but-then-has-insane-conclusions.html#more-149573>

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