Department of Defense Emerging Technology Strategy: A Venture Capital Perspective

Silicon Valley Defense Working Group
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ABSTRACT

The purpose of this paper is to assess the DOD's efforts to access new sources of innovation through engagement with venture-backed emerging technology companies. The intended audience is threefold: DOD innovation policy makers, members of innovation units deployed to emerging tech ecosystems, and their overseers and financial backers in Congress.

The paper starts by offering an overview of venture funding trends in areas of DOD interest both generally, and then in the Artificial Intelligence category. The encouraging conclusion is that at least on the surface, DOD efforts have been a stunning success.   Based on publicly available data, venture funding to dual use companies the last five years has tripled from around $5B to nearly $15B.

However, a deeper look as shown in the AI study reveals that the DOD overly focuses on the Early Stage. The corresponding geographic analysis of venture flows in 2018 compared to DOD innovation units shows an incomprehensible lack of engagement in Silicon Valley. The Valley sees nearly 55% of dual use funding but only 2.7% of DOD innovation budgets. The Defense Innovation Unit (DIU) based in Mountain View, California is the most important element of DOD's emerging technology strategy. It's resources should be sharply increased, and its mandate greatly expanded to reflect Silicon Valley's importance as the leading emerging technology ecosystem.

The second section lays out a multi-stage throughput model for dual use venture activity. The goal is to establish a common understanding by all three intended audiences of the VC market's structure and inner workings. Misunderstandings here appear manifold when DOD innovation is viewed from a Silicon Valley perspective. A better familiarization by innovation leaders will effectively calibrate policy, capital and personnel, to the venture market driving stronger outcomes for the warfighter. This section also provides further evidence that the DOD overly targets Early Stage dual use activity and must strengthen its efforts by broadening focus towards the later stages.

The third section offers a set of metrics detailed at each VC funding stage to assess the effectiveness of DOD innovation engagement. Early Stage efforts should focus on increasing the creation of new dual use starts-ups, Mid Stage on attracting higher levels of venture capital, and Late Stage to deploying the new technology on large contracts with the services to support deployment of new technology to the warfighter at scale. The importance of driving for success in the Late Stage, and especially towards enabling exits, is ignored by the DOD innovators yet is of the utmost importance to VC's. However, the two parties are very aligned in their interests here, as the paper shows.

The primary policy recommendations are (1) aim innovation policy towards successful Late Stage partnering, (2) increase focus on Silicon Valley geographically, (3) coordinate the efforts of civilian innovation units with the uniformed services at the local and national levels (4) assign responsibility for managing the entire National Security Innovation Base (NSIB) to DIU under the SecDef, DepSecDef, or Vice Chairman of the Joint Chiefs of Staff , (6) move MD5 under DIU and assign it the mandate for Early Stage engagement nationally at the local ecosystem level, (7) coordinate the Program of Record long term acquisition process through partnership between DIU and the Program Executive Offices, and (8) develop a comprehensive set of metrics to measure outcomes at every sector, stage, and geography.

Finally, the overarching conclusion of the paper is that victory is within grasp: the suggested policy changes will better calibrate DOD innovation engagement to actual venture market dynamics creating a

self-sustaining/funding National Innovation Security Base that enables the deployment of new capabilities to the warfighter at what General Mattis calls the "speed of relevance."

PREFACE

It is generally accepted that the US has entered a new geopolitical phase that equates to a Digital Arms race, primarily with China. Silicon Valley conceptually stands at the front lines. Whoever harnesses the newest technology for geoeconomic purposes wins. So, it would seem natural then that the DOD would send "soldiers to the front" to secure these new technologies for the warfighter.

To that end, a four-star COCOMM commander met with a group of 20 dual use VC's early in 2019 to explore commercial space options for his new multi-decade modernization program. Thirty minutes into the meeting it became apparent, however, that no one in the room had seen his Broad Area Announcement calling for emerging tech ideas. No one, that is, except the VC rep from a prime contractor.

Four-star generals aren't the best choice for foot soldiers in this new digital conflict. The DOD needs a better strategy…

INTRODUCTION

The DOD has officially shifted focus from Counter-terrorism (CT) to Great Power Competition (GPC), as described most prominently in the Trump Administration's 2018 National Defense Strategy: "Inter-state strategic competition, not terrorism, is now the primary concern in U.S. national security." [1] Observers such as the media, industry analysts, and academics have begun talking about the new "Digital Arms Race" with China, or the new "Cold War II" with Russia and China. "US Scrambles to Outrun China in New Arms Race" proclaimed the New York Times newspaper headline on January 27, 2019.[2] Defense leaders speak of the digitization of warfare. The three traditional domains, Air, Sea, and Land have now been expanded to the realms of Space, Cyber, and Information. The Russians refer to the latter as "Hybrid Warfare," a term trumpeted by General Gerasimov, Russia's chief of the General Staff.[3]

Recent DOD strategy documents decry a "digital gap" that has emerged between the US and its adversaries in these new domains. A variety of efforts have begun to work towards closing that digital gap. Much of these efforts center around improving defense innovation and strengthening the National Security Innovation Base. Policy statements, new budget authorizations, and the development of novel DOD innovation outreach units are all aimed at accelerating the closure of this perceived gap.

From the 2018 National Defense Strategy:

> "The security environment is also affected by *rapid technological advancements and the changing character of war.* The drive to develop new technologies is relentless,

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[1] "Summary of the 2018 National Defense Strategy of the United States of America", https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf p1

[2] Sanger, Barnes, Zhong, and Santora, "U.S. Scrambles to Outrun China in New Arms Race", **New York Times**, 27 January 2019.

[3] Muhammad Ali Baig, "Gerasimov Doctrine and Hybrid War", **Daily Times**, 10 March 2019, https://dailytimes.com.pk/295075/gerasimov-doctrine-and-modern-hybrid-war/

expanding to more actors with lower barriers of entry, and moving at accelerating speed. New technologies include advanced computing, "big data" analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology – the very technologies that ensure we will be able to fight and win the wars of the future.

The DOD recognizes that new commercial technologies will change society and, ultimately, the character of war. The fact that many technological developments will come from the commercial sector means that these state competitors and non-state actors will also have access to them, a fact that risks eroding the conventional overmatch to which our Nation has grown accustomed. Maintaining the Department's technological advantage will require changes to industry culture, investment sources, and protection across the National Security Innovation Base."[4]

The implied goal of these efforts is to better facilitate the US in its competition with its Near Peer competitors by developing new sources of emerging technology. Secretary Mattis described this goal succinctly at the 2018 Reagan Defense forum: "Our will to win is not more important than our will to prepare to win. This includes warfighting excellence from our military, steady predictable funding from Congress, and engaged support from our most innovative industry leaders, including Silicon Valley."[5]

Mattis' statement begs the question, then, what exactly is "Emerging Tech," with a $60B R&D budget why does DOD need it, and how does the DOD get more of it from Silicon Valley?
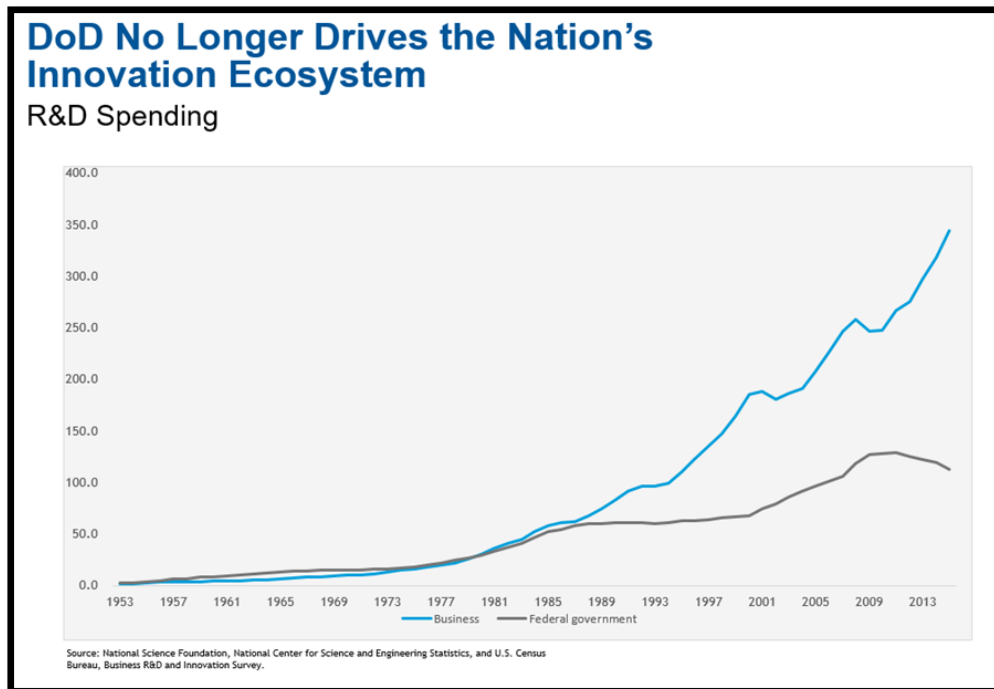
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[4] "Summary of the 2018 National Defense Strategy of the United States of America", https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf p3
[5] "Remarks by Secretary Mattis on National Defense Strategy", 1 December 2018, https://dod.defense.gov/News/Transcripts/Transcript-View/Article/1702965/remarks-by-secretary-mattis-on-national-defense-strategy/, p7

The two most likely new sources, then, would be tech developed by the new "Tech Titans" such as Google, Amazon, and Facebook and/or early stage emerging technology companies backed by venture capitalists. These two sources could reasonably be lumped into the DOD's rhetorical innovation category of "Silicon Valley" given either their geographic HQ locations and/ or their sources of funding originating from Sand Hill Road (the geographic center of the vast preponderance of tech venture capital).

So, the DOD is deploying resources, in terms of "boots on the ground" and dollars, to access these sources of emerging tech that their current/traditional sources of technology don't offer through the establishment of new innovation units such as DIU, AFWERX, and Army Futures Command (AFC).   From the standpoint of a defense technology venture investor based in Silicon Valley, these units' strategy and mission are obvious. Defense innovation policy makers are less sure of these units' mission and strategy. This is obvious considering, for example, that DIU has had three executive directors in two years (four if you count the acting Exec prior to Mike Brown[6]) and seen its funding cut multiple times by the appropriation committees.[7]

From a Silicon Valley investor standpoint, the DOD should drive forward on three line of efforts to effectively engages venture-backed emerging technology companies:

1. Startups: To inspire potential founders to quit their day jobs and start that company they always dreamed of. Also, to develop an initial business model that includes selling to the government (dual use).
2. VC Funding: To help attract venture capital towards these dual (or single) use start-ups across all stages, sectors, and geographies.
3. Policy: To drive policy changes that enable the services to be more effective consumers of these new technologies at each start-up lifecycle stage with ultimate goal of getting Late Stage emerging tech companies on Programs of Record (or the R&D/O&M equivalents).
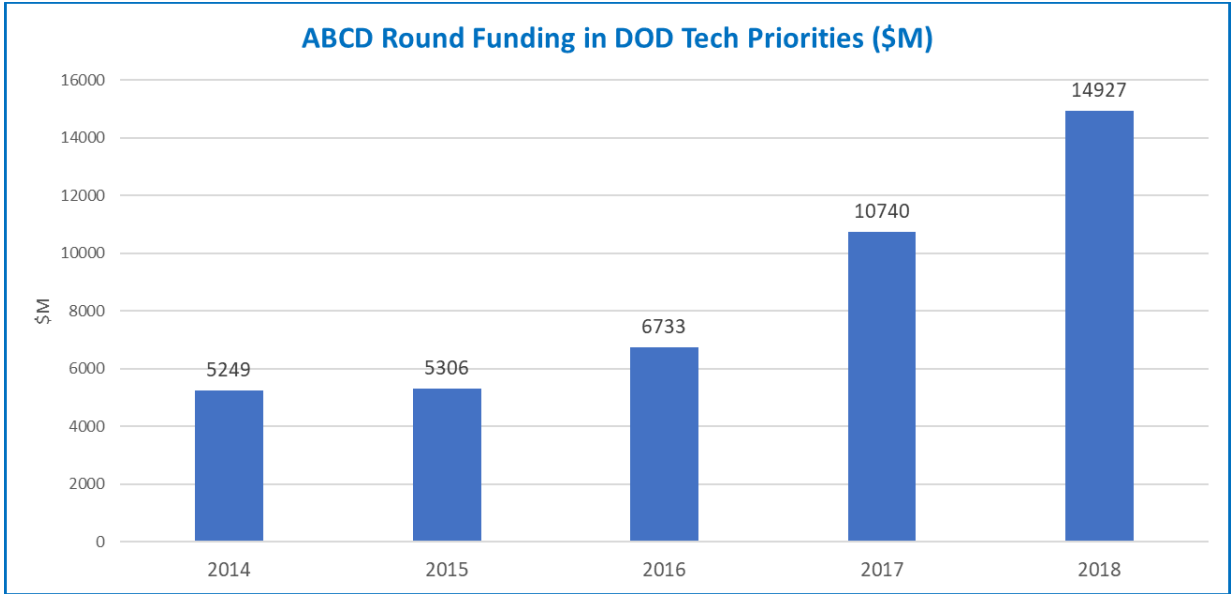
2014-18 DUAL USE VENTURE FUND FLOWS

The effectiveness of DOD innovation engagement is difficult to measure qualitatively. The various outreach units act in an uncoordinated (and often conflicting) manner, no unit has a clear national leadership role, funding levels for the various units are inconsistent, and the uniformed services have yet to fully get involved. Quantitative measurements are much easier. A survey of publicly available venture funding in dual use categories show that despite DOD's miscalibrations, it is succeeding in attracting private capital. The chart below shows excellent growth in dual use funding the last five years.[8]

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[6] Jennifer Elias, "Former Symantec CEO Names to Head Defense Department's Silicon Valley Unit", *Silicon Valley Business Journal*, 24 September 2018, https://www.bizjournals.com/sanjose/news/2018/09/24/dod-diu-silicon-valley-unit-michael-brown-symantec.html
[7] Lauren Williams, "DIUx Gets a Big Boost in FY19 Budget," *FCW*, 12 February 2018, https://fcw.com/articles/2018/02/12/budget-williams-dod.aspx
[8] Unless noted, all venture funding data is source from Pitchbook with full documentation in the appendix.

ABCD Round Funding in DOD Tech Priorities ($M)

Year	$M
2014	5249
2015	5306
2016	6733
2017	10740
2018	14927

Also encouraging is that the DOD has roughly held it's share of VC funding steady at around 20%.

% Share DOD to Total US VC

Year	%
2014	19.7%
2015	16.8%
2016	19.0%
2017	22.9%
2018	21.1%
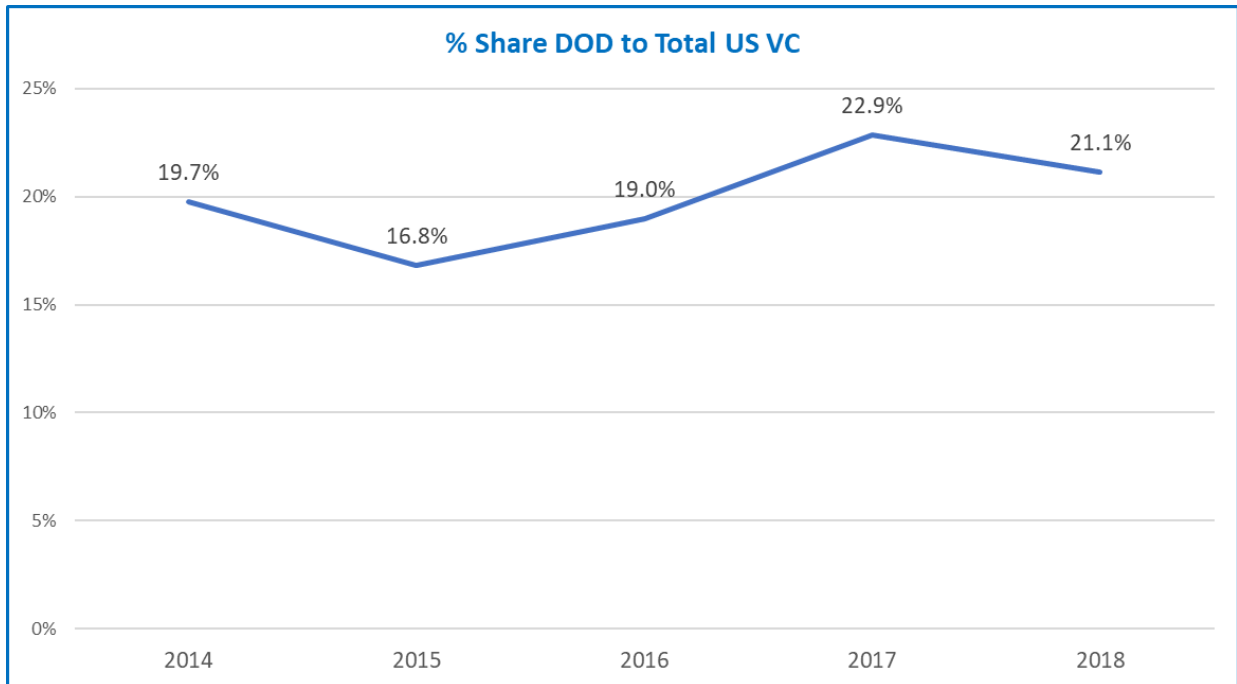
Looking at the 2018 dual use venture funding by round reveals insights that will better shape innovation strategy. As the chart below shows, whether by intent or not, A and B Round funding is rather robust. However, the levels drop in the Late Stage illustrating the need to shift focus.

2018 DOD Tech Priority VC Investment by Series ($M)

2018 DOD Deal Count
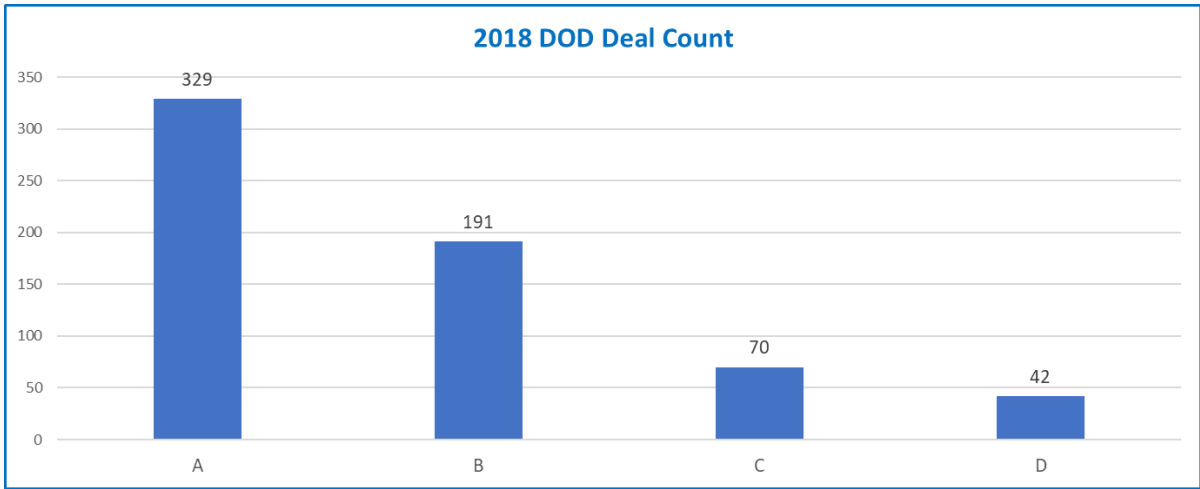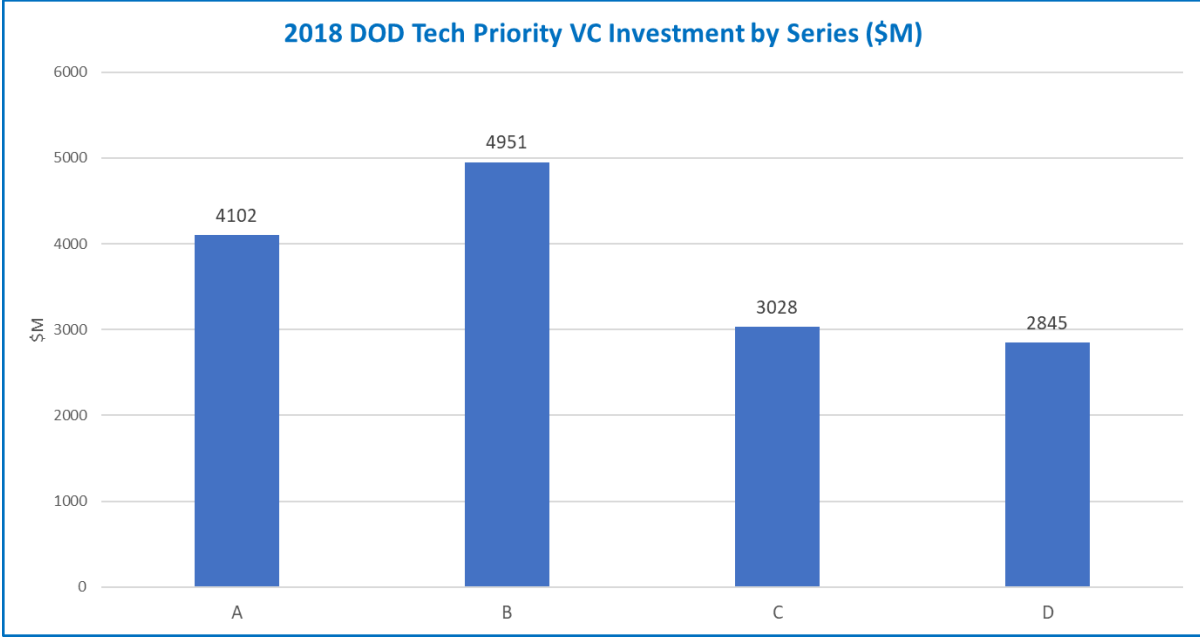
2018 Dual Use Venture Activity by Region

The first chart below shows 2018 dual use venture activity by region and funding stage. The second chart compares DOD innovation unit budgets to venture activity by region.

One immediate conclusion jumps off the page: Silicon Valley completely dwarfs all other regions. Similarly, from the second chart, DOD innovation is significantly over-indexed to the National Capital Region (NCR) and extremely under-indexed to Silicon Valley. SV had 57.5% of 2018 dual use venture flows. However, the DOD only allocates 3.7% of its VC-backed innovation engagement budget there with just a single unit deployed there. DIU needs a massive resource increase as the only unit based in Silicon Valley. The NCR gets 91% of DOD budgets with a mere 2.6% of venture funding. Lastly, AFC's selection of Austin for its HQ implies other priorities for the unit than engagement with venture backed companies. Texas only saw 2.7% of venture funding in dual use categories last year.

2018 Dual Use Venture Activity by Region

					Funding Round			
Region	Dollars (MM)	% of Total $	Deal Count	% of Total #	A	B	C	D
NCR	374	2.6%	24	3.9%	13	9	1	1
Midwest	392	2.7%	24	3.9%	15	5	2	2
New England	1316	9.0%	76	12.4%	42	23	7	4
New York	1825	12.5%	62	10.1%	28	24	7	3
Northwest	53	0.4%	7	1.1%	4	3	0	0
Rocky Mountains	175	1.2%	13	2.1%	6	4	3	0
Silicon Valley	8414	57.5%	290	47.4%	152	76	41	21
Southeast	308	2.1%	18	2.9%	8	8	0	2
Southern California	1102	7.5%	58	9.5%	26	24	6	2
Southwest	287	2.0%	14	2.3%	10	3	1	0
Texas	389	2.7%	26	4.2%	13	8	1	4
Totals	14635		612		317	187	69	39

2018 DOD Innovation Unit Budget by Geography vs VC Funding Flow

|	VC Dollars		DOD Dollars		
Region	Dollars (MM)	% of Total $	Dollars (MM)	% of Total #	Innovation Units (HQ)
NCR	374	2.6%	1755	91.0%	SCO, MD5, JAIC, NavalX
Midwest	392	2.7%	0	0.0%	
New England	1316	9.0%	0	0.0%	
New York	1825	12.5%	0	0.0%	
Northwest	53	0.4%	0	0.0%	
Rocky Mountains	175	1.2%	2	0.1%	CYBERWERX
Silicon Valley	8414	57.5%	71	3.7%	DIU
Southeast	308	2.1%	0	0.0%	SOFWERX (no public budget data avail)
Southern California	1102	7.5%	0	0.0%	
Southwest	287	2.0%	0	0.0%	AFWERX
Texas	389	2.7%	100	5.2%	AFC
Totals	14635		1928		

All the data relating to venture funding in this paper, unless otherwise noted, is targeted at DDRE Griffin's ten tech priorities for the DOD as described in the appendix[9]:

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[9] "USD(R&E) Top 10 Technology Focus Areas," https://aida.mitre.org/top-10-technology-areas/.

CASE STUDY – AI/ML

Artificial Intelligence/Machine Learning (AI/ML) stands as a compelling case study candidate for a variety of reasons. Highest among those is the fact that the White House[10] and DOD[11] just released strategy papers, the Joint Artificial Intelligence Center was recently launched under General Shanahan[12], and the category represents a huge amount of dual use venture funding (65.6% in 2018). This case study illustrates how the analysis of venture funding by stage and source better informs DOD innovation strategy.
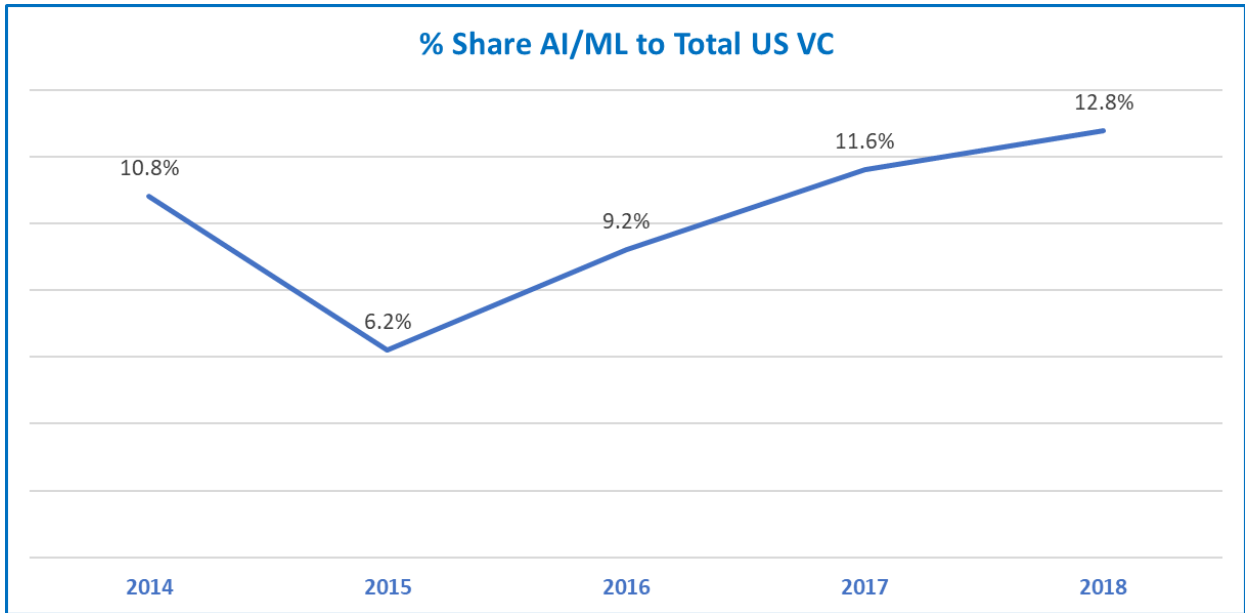
AI/ML funding is showing immense growth and taking a steadily increasing share of venture funding. All good news for the DOD's AI ambitions. Venture investors have poured billions into AI/ML deals. The total from 2014 to 2018 according to Pitchbook stands at $22.6B. This number alone clearly shows the DOD should focus on partnering with existing dual use AI start-ups rather than creating new ones. There are plenty of potential AI start-ups to partner with already. The JAIC would be wasting resources duplicating the work of Early Stage VC's if it focused on start-up hackathons, boot camps, and similar founder recruitment efforts. Rather, the AI unit should focus on building customer relationships with the most promising dual use start-ups.
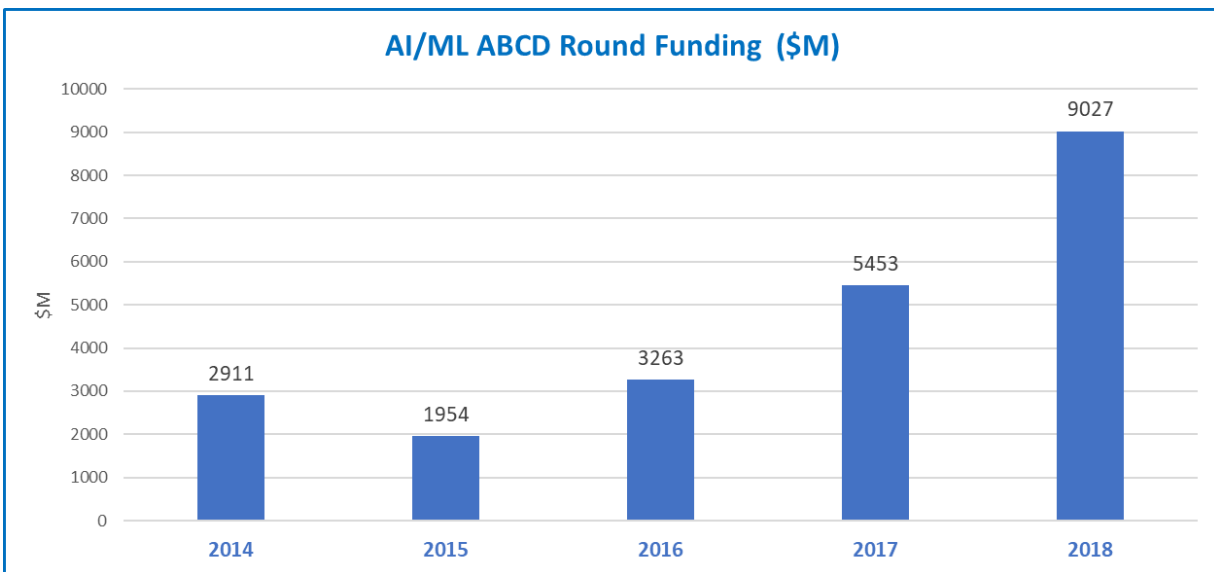

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[10] President Donald Trump, "Executive Order on Maintaining American Leadership in Artificial Intelligence, February 11, 2019, https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/.

[11] Department of Defense, "Summary of the 2018 Department of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity," https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF.

[12] James Cullum, "DOD CIO: Joint Artificial Intelligence Center 'Up and Running'" *Homeland Security Today.us*, 14 December 2018 https://www.hstoday.us/subject-matter-areas/cybersecurity/dod-cio-joint-artificial-intelligence-center-up-and-running/

% Share AI/ML to Total US VC

10.8%

6.2%

9.2%

11.6%

12.8%

| 2014 | 2015 | 2016 | 2017 | 2018 |

However, a closer look at 2018 funding data shows a more nuanced story. While A and B Round funding remains healthy, Late Stage funding drops dramatically. AI technology has yet to find revenue-rich markets making Late Stage funding difficult. This represents an opportunity for the DOD, to aggressively compete for the attention of A and B Round companies with large procurements without onerous compliance and accounting requirements thereby potentially attracting Late Stage funding that is currently sitting on the sidelines.

2018 AI/ML VC Investment by Round ($M)

A	B	C	D
3041	3083	1857	1012

2018 % Share AI/ML vs Total US VC
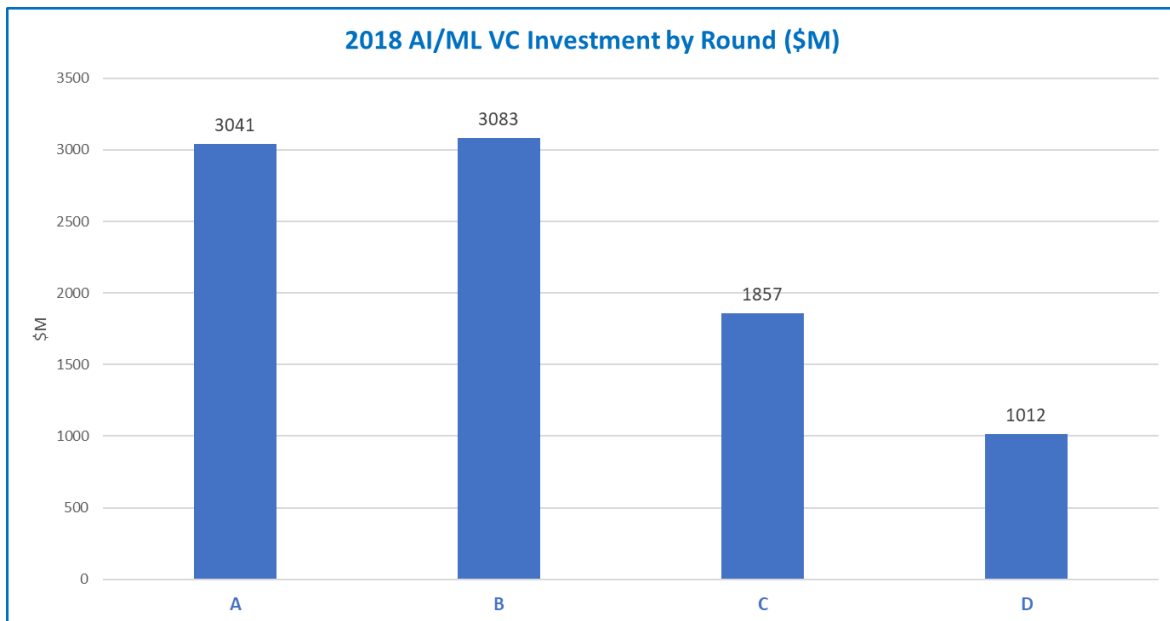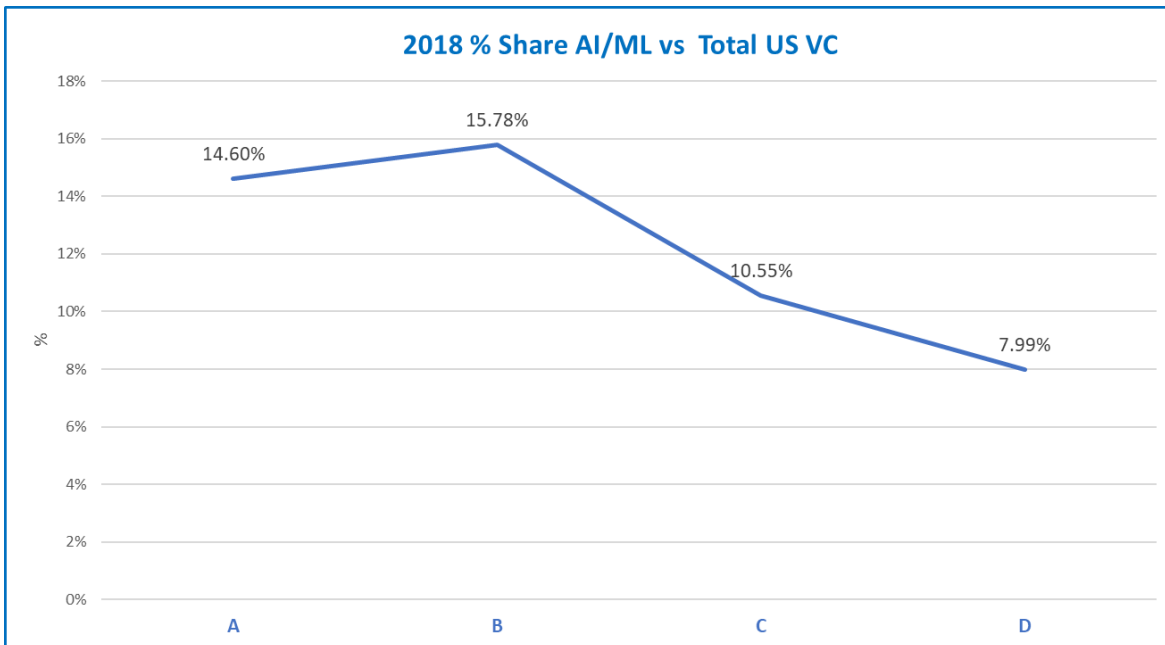
And those efforts to woo capital and start-ups in AI should center around the West Coast. According to CB Insight's 4Q18 Venture Reports, the top five states for AI deals in the quarter were:

1. CA: 53 deals, $1.9B invested.
2. MA: 13 deals, $247M invested.
3. NY: 10 deals, $110M invested.
4. TX: 3 deals, $10M invested.
5. WA: 3 deals, $9M invested.

Again, this illuminates Army Future Command's decision to HQ in Austin. Naturally proximity to testing ranges and resources at Fort Hood supports that move, but the lack of AI/ML start-ups does not. The recent spate of NYC-based DOD AI/ML hackathons also don't make sense from a geographic analysis.

A VENTURE CAPITAL MAP OF THE NATIONAL SECURITY INNOVATION BASE

Better policy and innovation partnerships would flow easier if the DOD side better understood the structure and process of the people (venture being relationship driven) they are trying to partner with. Especially considering that the DOD needs Silicon Valley more than Silicon Valley needs the DOD. The goal of this section, then, is to increase the effectiveness of DOD innovation efforts by decreasing the awkwardness of their efforts to attract innovation. Metaphorically, stop stepping on your dance partner's shoes by actually learning the dance.

Following is a highly simplistic model that captures the life stages of a venture backed dual use start-up as it progresses through the innovation ecosystem, describes the relevant issues for DOD support of that process at each stage, and recommends policies for improvement thereof. In the next section, the

paper will then offer basic framework for measuring the effectiveness of the DOD's efforts in stimulating greater output of dual use companies from this ecosystem.

Many of the terms and acronyms will be defined in the following section. However, a few definitions up front are necessary:

- Start-up Stage - the general timeframe and lifecycle in which the start-up is currently operating. Innovation policy needs to fit each stage; one size does not fit all.
- VC Funding Round – the specific funding round that the start-up either most recently completed or is working to fund. These rounds somewhat fit the start-up stages, but not perfectly. The key is that as the start-ups move through their life stages, their funding round sources and milestones shift. Policy should fit appropriately.
- Sand Hill Road – the geographic location west of Stanford University in Palo Alto, California, where the vast majority of the leading venture capital firms are located, especially those capable of writing large, late stage checks. The term "Sand Hill Road" is also often used as a metaphor for traditional venture funding.
- MVP – Minimum Viable Product, the goal of an early stage start-up, which is to go through multiple customer engagements as they define their MVP then build a business model. Many policy makers mistakenly confuse the order: MVP first, then detailed business model.
- DOD Innovation Units – DIU: Defense Innovation Unit, AFC: Army Future's Command, AFWERX: Air Force innovation outreach unit, SOFWERX: Special Operations Forces innovation, outreach unit, MD5: National Security Technology Accelerator, H4D: Hacking for Defense. This purposely excludes traditional DOD innovators such as DARPA, AFRL, NRO, etc.

DOD Innovation Outreach Ultimate Goal

In the interest of staring with the end in mind, the ultimate goal of DOD innovation efforts should first be defined. As referenced in the introduction, the obvious answer to that question is threefold from the perspective of a Silicon Valley venture investor: to motivate more founders to launch dual use start-ups, attract an increasing amount of private capital to fuel those start-ups' growth, and develop better policy to enable the services to deploy the technology from these companies. Or more simply put, the goal of DOD Innovation is to increase the number of "Dual Use Unicorns[13]" like Palantir, SpaceX, Cloudflare, Tanium, C3IOT etc., by an order of magnitude.

While the DOD may not care about helping start-ups make Unicorn status, only the larger Late Stage companies can handle the onerous requirements of full Federal Acquisition Requirements. And the venture funders will require large exits at the Late Stage to continue finding dual use companies in the long term. Successful exits renew the innovation ecosystem. They are the key to driving the self-funding nature of the venture market. The proceeds of the exit go to the VC's who often re-invest them in earlier stage deals. As the number of successful exits grow, the amount of capital available in that ecosystem grows over time as well. For example, according to Crunchbase, a leading source of start-up financing data, the average successful startup raises $41M in capital and exits for an average of $242.9M[14]. So, the DOD stands to benefit from a growing, self-funded source of new technology.

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[13] A "unicorn" is Silicon Valley vernacular for a private (pre-IPO) venture backed company whose last financing round was conducting at a valuation exceeding $1B.

[14] Issie Lapowsky, "$243 Million: Crunchbase's Very Rosy Picture of the Average Startup Exit," Inc., https://www.inc.com/issie-lapowsky/average-successful-startup-exit.html.

Creating Late Stage winners is easier said than done. In 2018, VC's funded 317 A Rounds but only 39 D Rounds. However, the DOD can boost the number of D Rounds if it properly aligns its current outreach units and budgets more effectively by stage, sector, and geography.

To do that, leadership needs to first understand the unique issues involved in supporting a start-up through its journey from Day 1 to Exit. It's generally understood in the Valley that the average time from start-up Day 1 to Exit is around 7 years[15]. Exact data on that number is difficult to measure with perfect accuracy because much of the data in the early stages is inconsistently self-reported. As discussed later, the data becomes much more reliable around the A Round.

Defining Foundational Venture Stage Concepts

Start-up Lifecycle Stages: The lifecycle of a start-up proceeds in stages. These are generally referred to as Early, Mid, and Late Stage. Venture Capital firms often define their investment strategies by these stages. For example, Bessemer is known as a Mid Stage firm with emphasis on B Rounds whereas Technology Crossover Ventures is very Late Stage focused, writing checks into 5+ year old start-ups near their exits. The stage focus dictates what size of fund these VC's raise.

The average check size of an Early Stage Seed fund in 2018, according to Pitchbook, was $1.8M. A venture fund normally targets 10-15 deals in its 7-10 year life. Thus, a Seed fund would need to raise around $20-50M for the handful of partners to effectively deploy the fund in a timely manner.

Short Funding Stages Enforce Speed: Each stage usually holds 1-3 financing rounds. To move through these rounds, the start-up needs to achieve certain milestones. Funding rounds are usually spaced 12-18 months apart. Investors fund just enough cash in each round for the company to work towards its milestone enabling the solicitation of the next funding round at a higher valuation. This structure drives the impressive speed in technology development which attracts the DOD – the start-up team either hits its milestone or goes "cash out."

Founders' Equity Incentivizes Speed: The other driver of start-up speed is the incentive of the equity ownership. The founders stand to make a tremendous amount of money through their equity holdings if they get to a successful exit. Thus, they are willing to take extremely low cash compensation and run a very lean operation. This second feature of start-ups is also attractive to DOD innovation goals. Traditional DOD R&D development programs are often very slow and end up wasting billions, as was the case with the Army's Future Combat System program.

Key Funding Milestones: For a start-up to obtain its next funding round, it must first achieve the key milestone enabled by its current funding round. DOD innovation policy makers should a have rudimentary understanding to better align resources by stage.

The key milestone in each stage evolves as the company grows. In the Early Stage, according to the work of leading start-up theorist and Stanford professor Steve Blank, the company is searching for its

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[15] For more analysis of average times to exit, see Sammy Abdullah, "How Long Does It Take a Startup to Exit?," Crunchbase, November 25, 2018, https://about.crunchbase.com/blog/startup-exit/.

Minimum Viable Product (MVP),[16] while building out the team beyond the first founders (usually 1-3, with more than 5 being relatively rare). In the Mid Stage, the company raises more money to build the MVP into a full featured product ready for general availability with a full-fledged business plan and revenue model. In the Late Stage, the company raises even more money, often upwards of $100M+ or more, to scale business towards an exit by hiring a large sales force and launching a comprehensive marketing campaign with the goal of ensuring a profitable exit.

The DOD needs to meet start-ups at each of their life stages with the right combination of customer engagement and financial support that helps the company move more effectively towards their next funding round. Yet, this assistance must also be supportive of the ultimate exit.

For instance, the start-ups board of directors will often reject early stage Non-Recurring Engineering money from a DOD source if they don't see a pathway from that activity towards a full Program of Record opportunity. The NRE may seem nice in a vacuum, but investors at the next funding round will not "count" that revenue in their valuation if it's not indicative of a much larger market opportunity later (usually referred to as TAM or Total Addressable Market).

Venture Backed Emerging Tech Ecosystem								
Start Up Stage	Year	VC Funding Round	Average Round Size	VC Funding Sources	Key Funding Milestone	Customer Role	DOD Role	DOD Innovation Units
Early	0	Angel Seed	25K 1.8M	Local	Identify MVP/Build Team	Intros - MVP Feedback, Alpha Product Contracts	Attract & Inspire Dual Use Founders	AFC, AFWERX, MD5, NSA2, H4D
Mid		A B	7M 15M	Regional	Launch Product/Biz Model	Engagement - Proof of Concept, Beta Product Contracts	Help Attract Capital, Guide thru DOD "Market"	??? DOD needs to fill this gap.
Late	7	C D Exit	26M 44M 243M	Sand Hill Road/Wall Street	Scale Business towards Exit	Revenue - Long Term Full Production Contracts	Rapidly Deploy Emerging Tech to Warfighter/ Services	DIU

Early Stage – Funding Stages and Sources

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[16] Steve Blank, "Why the Lean Start-Up Changes Everything," *Harvard Business Review*, May 2013, https://hbr.org/2013/05/why-the-lean-start-up-changes-everything.

The Angel and Seed rounds constitute what is called the Early Stage. Note that Early Stage funding data is less reliable that later stage data due to the self-reporting issue. Therefore, this paper is only analyzing A Rounds and later. The Mid and Late Stage sections will start with a review of 2014-18 dual use funding trends.

Angel Round - On Day 1, when a start-up is first formed through the signing of Articles of Incorporation, it finds financing in one of three ways: either by "bootstrapping," with the help of Friends and Family, or by securing launch funding from an Angel Investor. Bootstrapping is when the founders use their own money to finance operations. An Angel Investor is a professional venture investor who specializes in investing in a start-up's first round by using outside capital. Angels are almost exclusively High Net Worth individuals, though they often group together in networks. The function of the Angel is to partner with the founders to move them from the "cocktail napkin idea" stage to where they can receive their first full VC funding round from a traditional Venture Capital Limited Partnership (or the equivalent thereof like a corporate entity making an early stage minority investment – the nuances are not relevant to the purposes of this paper).   Both sources of funding described above are usually lumped together under the name Angel Round for convenience.

Seed Round – While usually still pre-revenue, here the start-up usually accepts their first capital investment from a professional venture firm. The importance is that the company has somewhat graduated from the "hobbyist" start-up phase to being serious enough to attract investor attention.

Most major cities have an adequate number of Angel and Seed investors that a founder can get all their financing done locally, as shown by the CB Insights chart below. Thus, the DOD does not need a national level function working to organize and attract early stage funding for dual use start-ups. The local innovation units can address that issue organically in their own local venture networks.
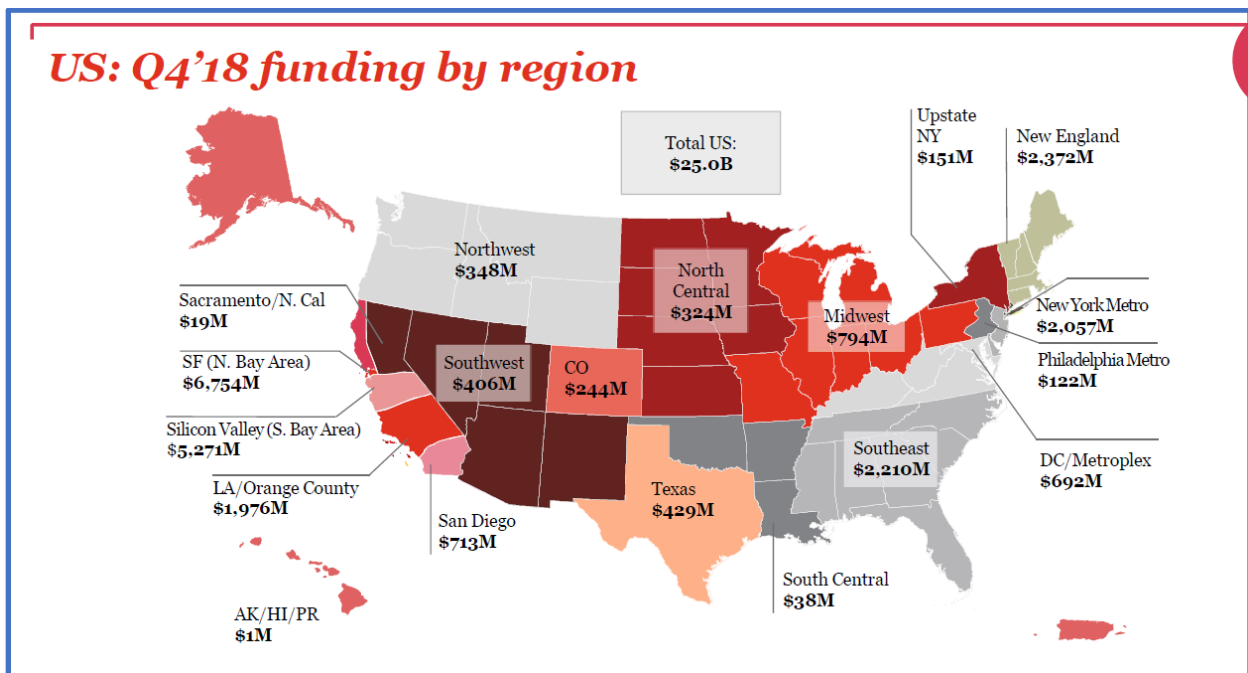
Early Stage – DOD Innovation Units

DOD is heavily resourced in their efforts at the Early Stage. While leaving the details for the DOD Innovation Unit Appendix, a couple units stand out as notable:

- Hacking4Defense: According to the H4D website, "Hacking for Defense ™ is a university-sponsored class that allows students to develop a deep understanding of the problems and needs of government sponsors in the DOD and IC." The DOD funds Hacking4Defense with classes conducted at approximately 20 schools in the fall of 2018[17]. H4D is an extremely well thought out program (if one endorses the Lean Start Up methodology) for launching dual use founders on Day 1 through Day 90 when the three-month course ends. The formal timeline begs the question of what happens next when a start-up graduates…enter MD5…
- MD5: Otherwise known as the National Security Technology Accelerator (and rumored around Silicon Valley to be up for a name and reporting structure change), the mission of MD5 is to "create new communities of innovators that solve national security problems." MD5 is well positioned to provide the "Sherpa" function described above, especially for H4D graduates who need support in their early stage dual use mission from Day 91 through their Seed Round. Well positioned for three reasons.
    1. DOD-Wide: MD5 represents the entire DOD whereas other early stage outreach units like AFWERX are beholden to a specific service.
    2. National Geographic Focus: provides the comprehensive nation-wide network necessary to harness every single state (ie, and more importantly, every Congressional district).
    3. University Focused: a natural hub from which the surrounding innovation ecosystem can be effectively organized whereas other early stage units lack a consistent geographic home in each geography which leads to inconsistent deployments of resources across regions.
- AFC: The Army Futures Command is a vitally important evolution of the DOD innovation outreach strategy. As referenced in the introduction, none of this emerging technology partnering rhetoric matters if it doesn't end up deployed across the services in the hands of the warfighter. Additionally, AFC has the largest budget of any services innovation unit at $100M, a 4-star commander, and responsibility for the Army's entire $30B+ modernization budget.[18]However, at least for now, their geographic choice of Austin positions them as an Early Stage player. The Southern region, including Texas, Oklahoma, Arkansas, and Louisiana, only account for 6.6% of all venture deals and a meager 2.4% of all venture funding in the US in 2018, according to the National Venture Capital Association[19].

Early Stage – DOD Goals

In the simple three phase DOD innovation outreach framework described earlier, here is where DOD innovation outreach efforts should be focused on motivating founders to start a company, and/or direct

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[17] Ryan Johnston, "Hacking for Defense Course to Be Taught in 20 Universities This Year," EdScoop, September 21, 2018, https://edscoop.com/hacking-for-defense-course-to-be-taught-in-20-universities-this-year/.
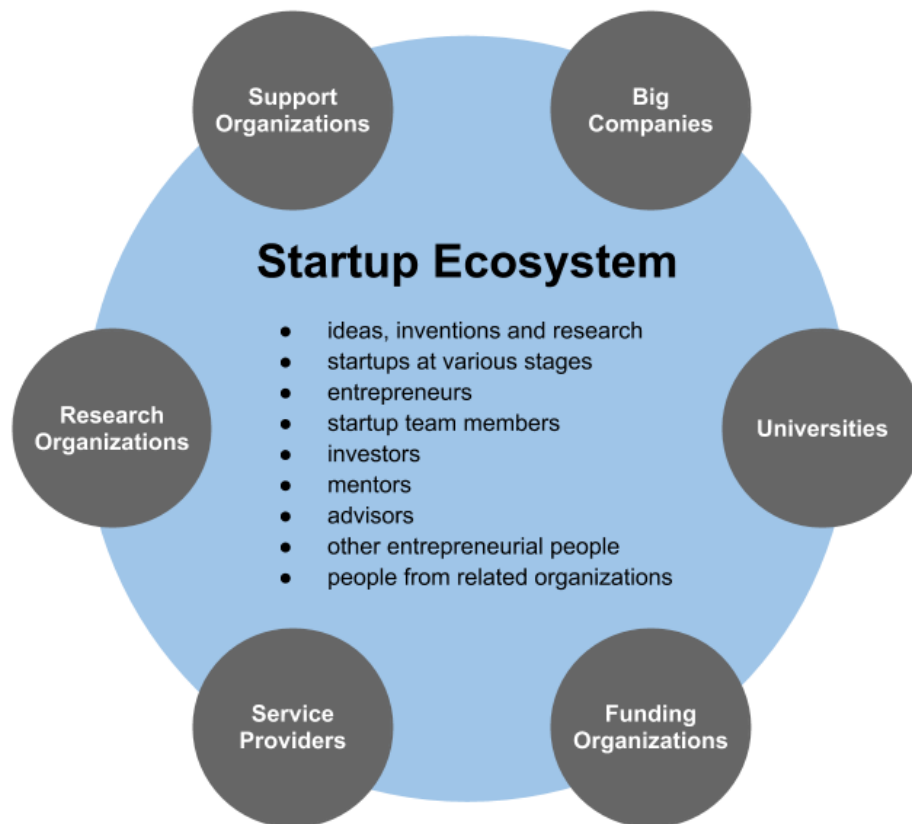
[18] Sydney Freedberg, "Army Futures Command: $100M, 500 Staff, and Access to Top Leaders," *Breaking Defense*, August 29, 2018, https://breakingdefense.com/2018/08/army-futures-command-100m-500-staff-access-to-top-leaders/.

[19] PitchBook and National Venture Capital Association, "Venture Monitor: 4Q 2018," https://nvca.org/research/venture-monitor/, 17.

their start-up towards dual use applications. The earlier a start-up embraces the DOD as a customer or security as a market, the more likely they are to develop technologies of interest. This could be thought of as the "battle for hearts in minds in the garages and dorm rooms." And thus, the Early Stage DOD outreach efforts should be calibrated to this goal.

For example, MD5's new program aimed at University outreach, the National Security Academic Accelerator (NSA2) being piloted at Arizona State University and the University of California at San Diego, appears well calibrated. MD5 has a mandate and DOD funding to conduct innovation "influence operations" aimed at academic institutions.

Mapping the Local Start-up Ecosystem: In addition to founder-oriented outreach, these Early Stage DOD units need to map out their local/regional innovation ecosystem as depicted in the following graphic.[20] They need to identify all the resources in their assigned region that could support their cause, and potentially benefit dual use start-up founders in their company's first years. Of utmost importance are the Angel Investors described above, and the Angel Networks. All the existing university-based incubators, entrepreneurs clubs, innovation leadership, etc, would also need to be mapped out along with supportive military influence groups such as San Diego's Military Advisory Council. These are relationship-based networks such that a traditional military rotational assignment model won't do – another reason that MD5 should serve as the permanent civilian "connective tissue" of the Early Stage.

Startup Ecosystem

- ideas, inventions and research
- startups at various stages
- entrepreneurs
- startup team members
- investors
- mentors
- advisors
- other entrepreneurial people
- people from related organizations

Support Organizations · Big Companies · Universities · Funding Organizations · Service Providers · Research Organizations
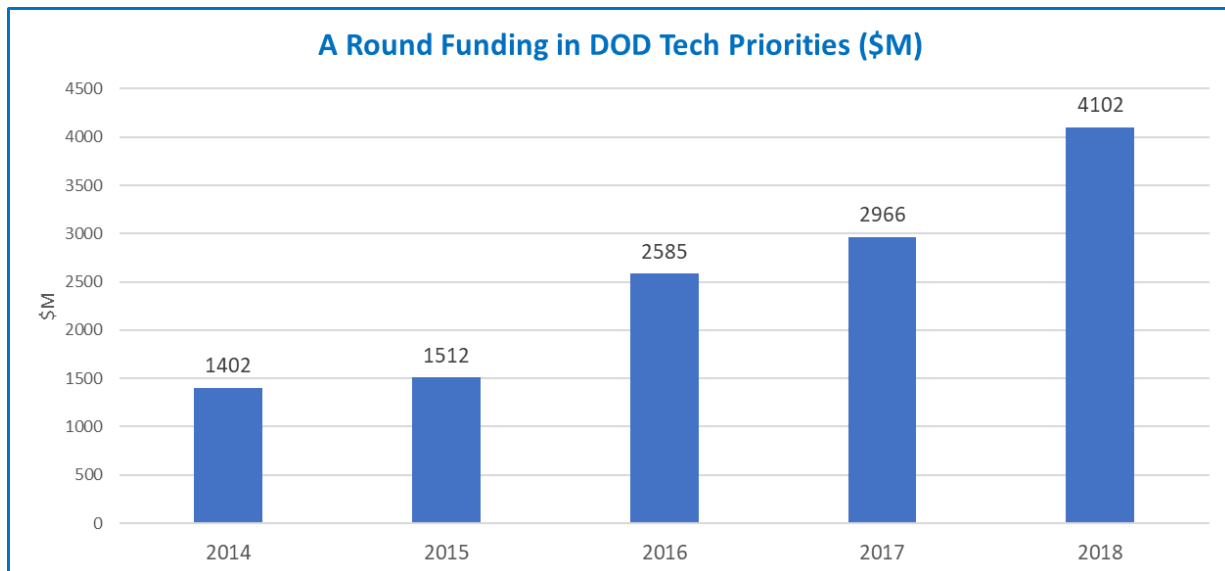
There a few key efforts here that must be effectively conducted, and somewhat in order:

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[20] Figure from "Whitepaper on Startup Ecosystems," courtesy of startupcommons.org, under CC BY 3.0.

1. Founding of the dual use start-up; essentially getting from "cocktail napkin" to Articles of Incorporation (Day 1) with Founder's Equity divvied up among the small number of founders.
2. Incubation (Day 2 through Seed Funding). Many innovation locales have existing incubators. DOD should partner there as much as possible. If adequate and effective local incubators don't exist to serve dual use startups, DOD innovation outreach units may need to start their own. Incubation is where the start-up founders hire employee #1, while beginning the search for their MVP.
3. Customer Intros – The early stage start-up needs as many customer introductions as possible to get input on their MVP. Here the DOD outreach folks can help by providing these introductions to the local DOD units and related agencies. This is probably the single most important function of the DOD outreach units at the early level – to break down barriers between civilian start-ups and local defense entities. Merely getting on base to engage with local military leaders is nearly impossible for civilian founders.
4. Modest Funding – Early Stage start-ups can benefit from small amounts of DOD non-dilutive capital in the form of grants and non-recurring engineering funding. These amounts should probably mirror the practice of commercially-oriented incubators, who often give $50-150K in funding in exchange for small pieces of equity. The funding helps the start-up get through their first 90-365 days. The DOD money should come with no strings attached and even perhaps no deliverables. The funding is to help the start-up engage with potential DOD customers as the founders search for their MVP. Prototyping comes later and marks the beginning of a multi-year journey from OTA style "no-strings" attached defense contracts towards full rate production Program of Record contracts with full FAR12/15 accounting requirements.

Mid Stage – Funding Trends

As the charts below show, funding in the Mid Stages appears healthy and growing. The rough total of $9B in Mid Stage funding ($4.1B A and $4.95B B) is encouraging considering how little the DOD has invested in stimulating this funding. As shown later, FY19 budgets for innovation units focused explicitly on venture backed companies totals less than $2B and is arguably closer to a few hundred million depending on how one views the Strategic Capabilities Office (SCO).

A Round Funding in DOD Tech Priorities ($M)

B Round Funding in DOD Tech Priorities ($M)

Year	$M
2014	969
2015	1318
2016	2148
2017	2774
2018	4951
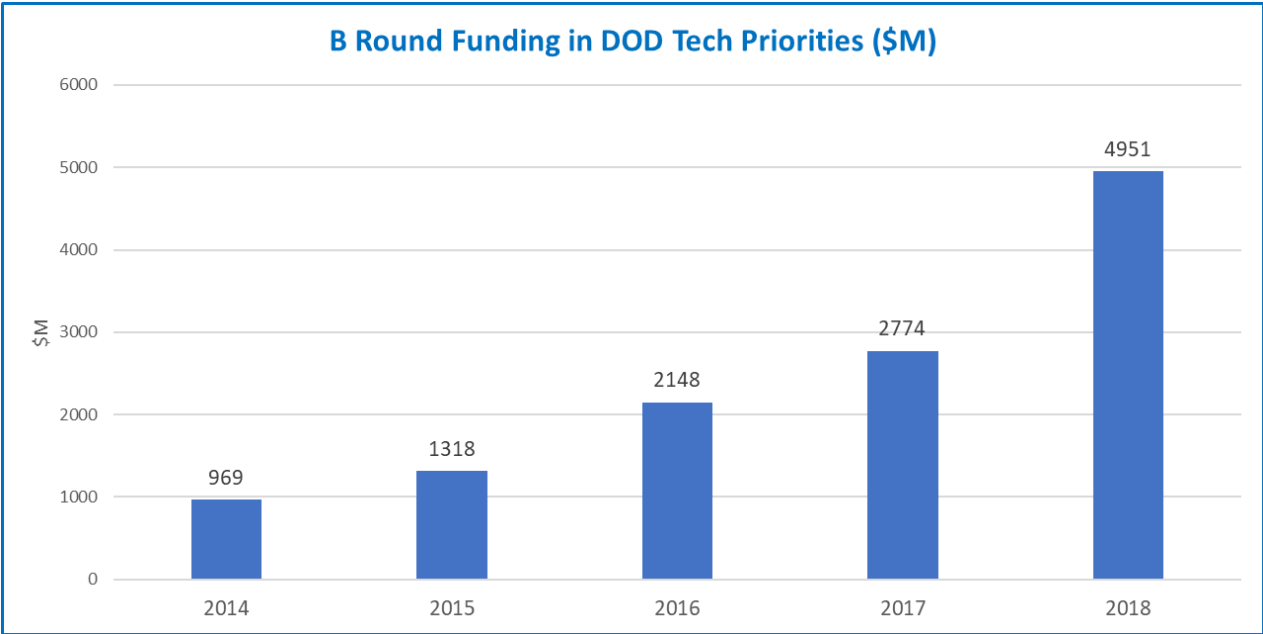
When looking at deal counts in the Mid Stage, the data is mixed. New A Round companies fell in 2018, as shown below. Momentum in the B Round deal counts showed sustained growth.

A Round DOD Deal Count

Year	Count
2014	222
2015	203
2016	253
2017	340
2018	329

B Round DOD Deal Count

Year	Count
2014	70
2015	93
2016	118
2017	148
2018	191
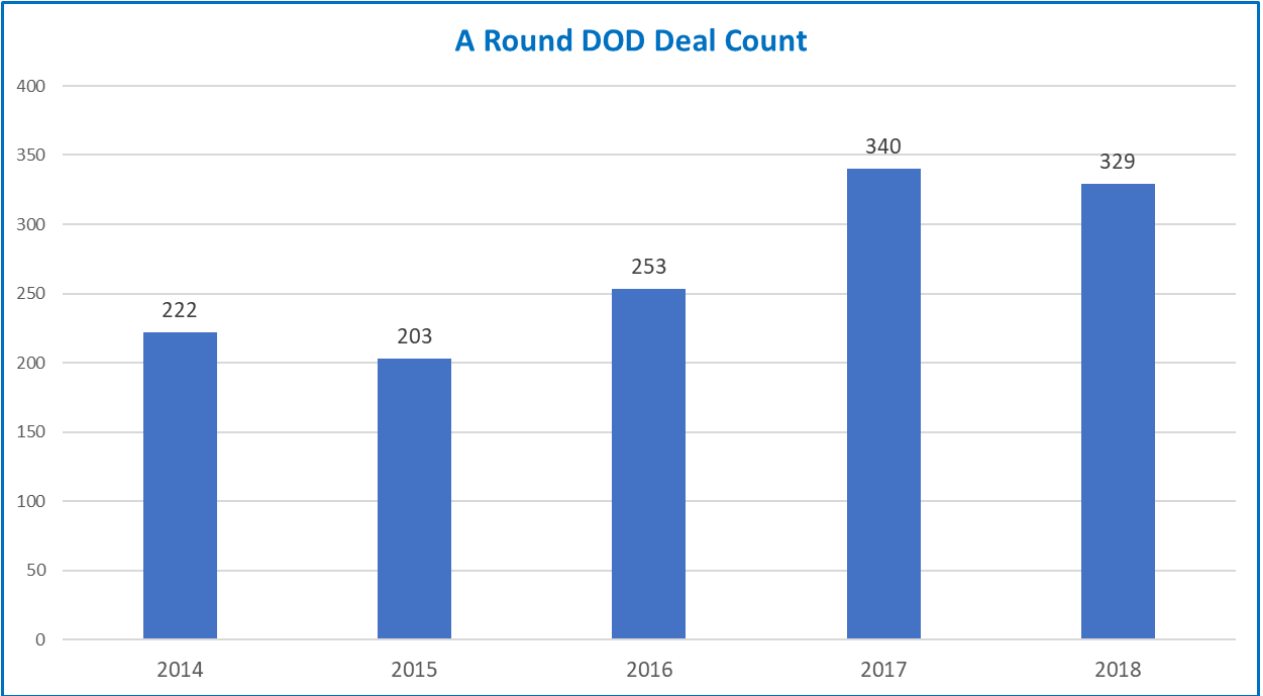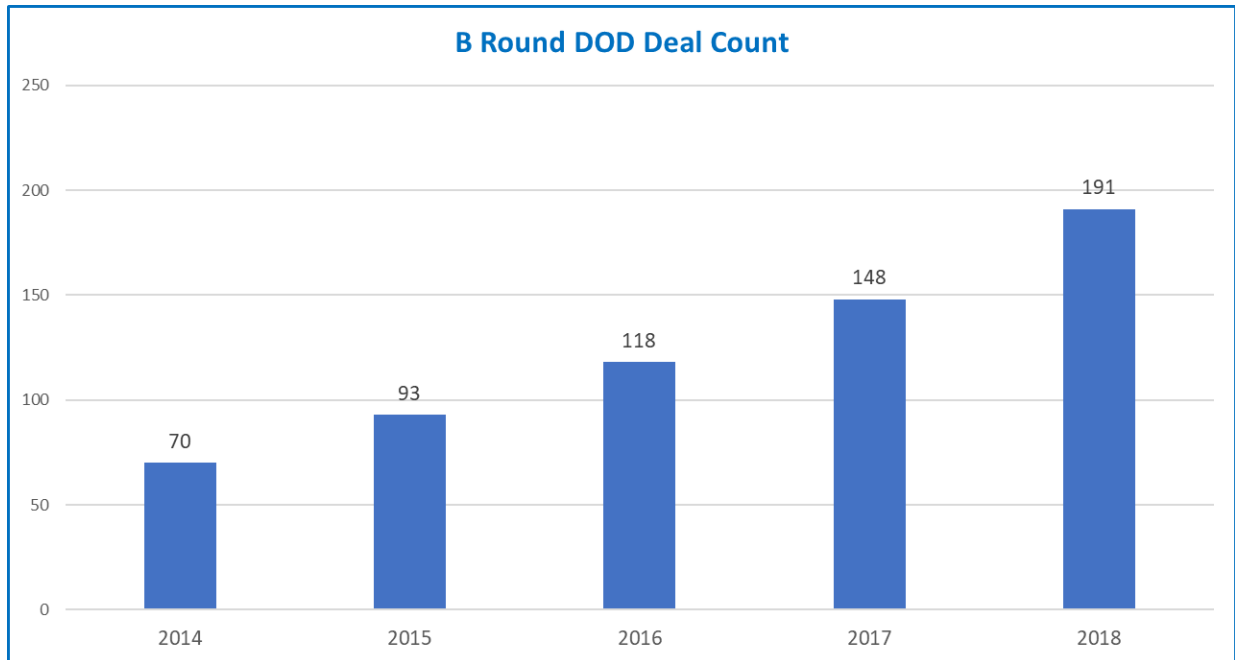
Mid Stage – Funding Stages and Sources

Start-ups crossing the line from the Seed to the A Funding Round also cross the "magical" line from Early Stage to Mid Stage. They are taken much more seriously by professional venture investors. What's important for DOD innovation policy makers is that the sources of funding for Mid Stage dual use begin to narrow and are concentrated more geographically.

A and B Round checks are much larger, averaging $7M and $15M in 2018 according to Pitchbook. Funding sources capable of writing checks to fit these round sizes are not as readily found in all fifty states. Potential funding partners move from being available locally to mostly being found regionally in the largest cities with the more robust innovation ecosystems. Silicon Valley and the West Coast become more important partners for the DOD and dual use starts ups in the Mid and Late Stages. According to Pitchbook's 4Q18 Venture Monitor, the West Coast region funded 61.7% of all VC funding in 2018.[21]

This is good news in one sense for the DOD, as it can start focusing its resources geographically towards these funding centers. As the founders will naturally begin building relationships into the networks that can support their next funding rounds.

Mid Stage – DOD Units

There aren't any.

That is a bit of an overstatement, as almost all the DOD innovation outreach units conduct activities that touch the Mid Stage. However, none of them are specifically aimed at this stage with the correct regional focus. The non-defense equivalent here would be an organization like Galvanize with a

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[21] "4Q 2018 PitchBook-NCVA Venture Monitor," January 9, 2019, https://pitchbook.com/news/reports/4q-2018-pitchbook-nvca-venture-monitor.

network of co-location Accelerators deployed in key innovation regional hubs like Denver and San Francisco.

A later section in this paper will survey the majority of the well-known DOD innovation units, where this gap will be more readily addressed. Also, the role of DIU comes up here. They are based primarily in Silicon Valley with tiny satellite offices in Austin and Boston. So, it would seem natural that they target the A/B Rounds; which they do. However, as this paper will argue later, DIU is uniquely positioned to support the DOD in the Late Stage where the checks, stakes, and potential warfighter impact, are much greater.

Mid Stage – DOD Goals

The role of DOD innovation units changes as they move into the Mid Stage. Happy hours, free tee shirts, and Sherpa services are no longer as useful to dual use start-ups here. Their Key Funding Milestones require more substantial help if they are going to continue with a defense focus. Beyond customer introductions, they need revenue from early customers. Not so much to fund their business models, but rather to validate their Minimum Viable Product.

DOD innovation interactions at the Mid Stage, then, should focus on finding DOD customers with priority problems and an agile contracting capability (Other Transaction Authorities being top of that list), and matching them with the most promising dual use start-ups. This is easier said than done. The Federal Acquisition Regulations make this sort of "customer interfacing" activity extremely difficult for the outreach unit attempting to act as the intermediary. However, the laws of venture funding are as firm as gravity, and they don't care about the need to first issue a Broad Area Announcement and then wait 90 days before undertaking vendor meetings. Those 90 days put the start-up one quarter closer to death (otherwise known as "cash out").
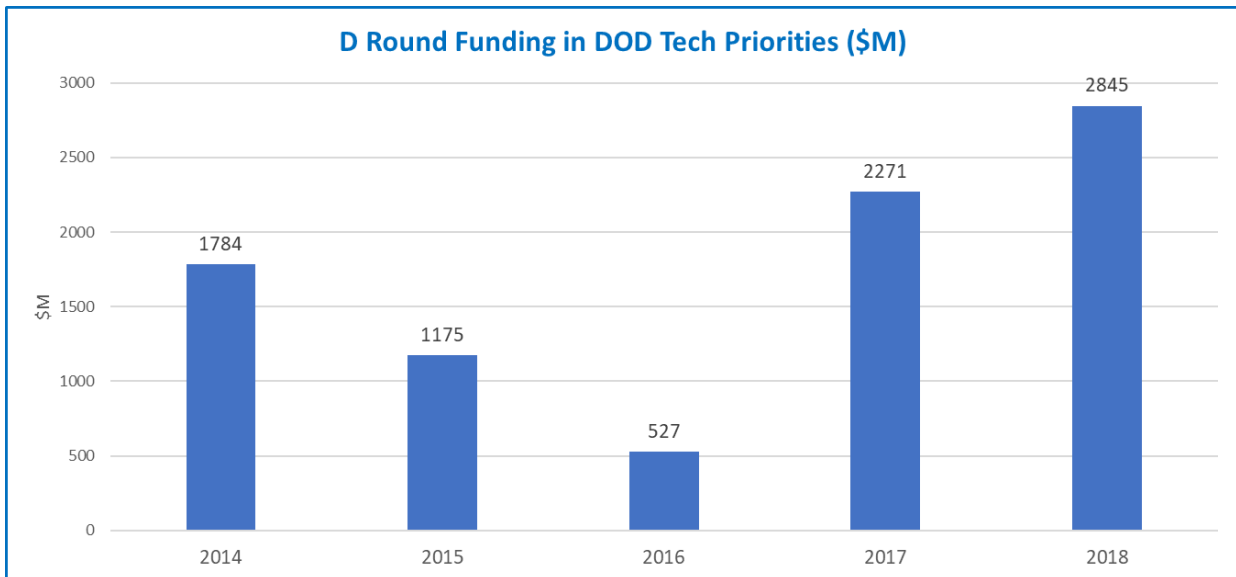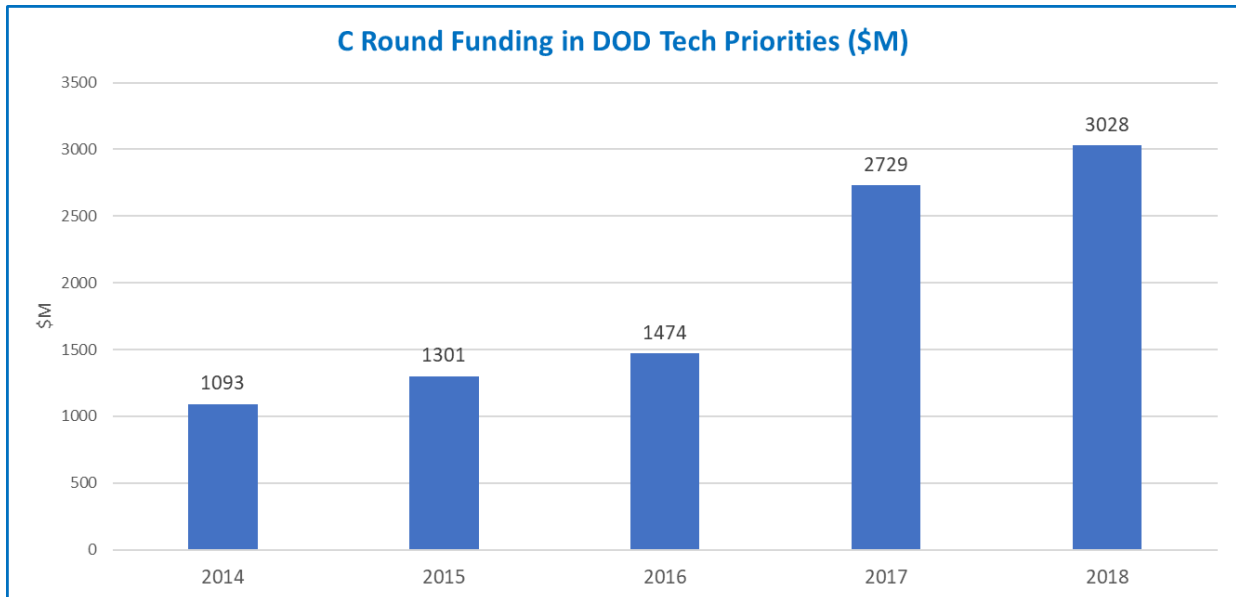
To address the issue raised in the preceding paragraph, the DOD has deployed all sorts of innovation funding experiments, dedicated funds, and related activities. However, no central directory thereof exists. The DOD innovation outreach units need to help solve this discovery problem in their regions. Just as they mapped out the Angel Networks in the Early Stages to better make funding introductions for their incubating dual use start-ups, they must also map out the DOD agile funding ecosystem.

They similarly need to map out the A and B Round funding sources. This should include determining which VC's have accepted Chinese LP's and discouraging dual use founders from taking their money.
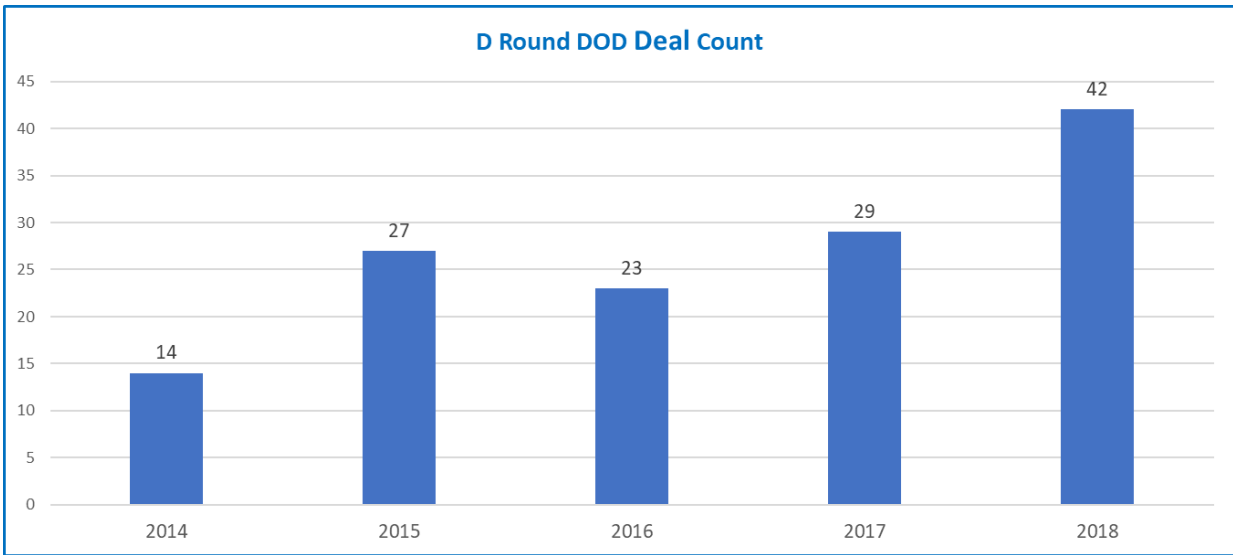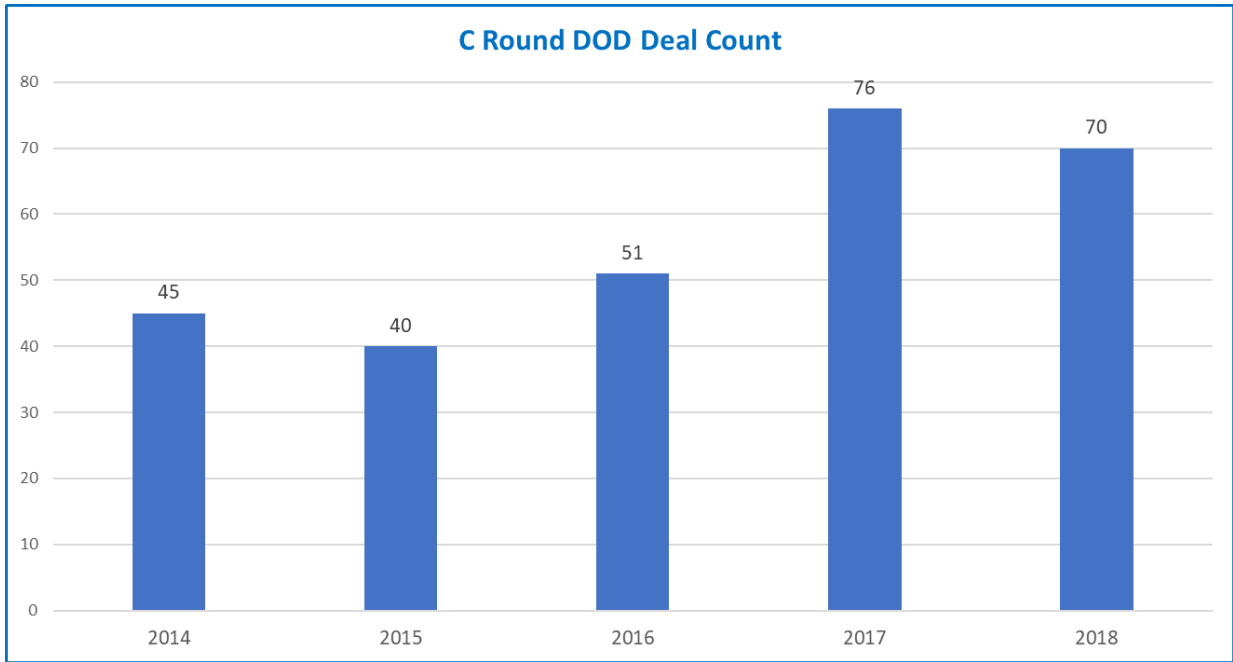
Finally, Mid Stage companies are mature enough to take the "on ramp" to a five-year journey from OTA prototyping contracts with minimal paperwork towards PEO full rate/full paperwork prime contracts. The DOD should work to more officially define this "on ramp" approach so that the paperwork requirements match the life stage of the start-up. For instance, an A Round company may be able to support some very modest form of cost reporting but not a full-blown Defense Contracting Acquisition Agency audit. To that point, professional venture investors rarely ask for fully audited financial statements until the company is nearing its exit, usually with $100M+ in revenue. They would rather the management team focus on growth rather than perfect accounting. The primary financial focus until the exit is on revenue growth, cash burn rate, and cash balance.

Late Stage - Funding Trends

Funding for C Round companies shows nice growth progress though the level in 2018 is down roughly $1B from the $4B+ in the A and B Rounds. D Round funding shows a more volatile pattern with strength in the last two years.

C Round Funding in DOD Tech Priorities ($M)

Year	$M
2014	1093
2015	1301
2016	1474
2017	2729
2018	3028

D Round Funding in DOD Tech Priorities ($M)

Year	$M
2014	1784
2015	1175
2016	527
2017	2271
2018	2845

On deal count, C Round declined in 2018 slightly while D Round deals surged. Also of note, is the sharp drop in deal numbers from the Mid Stage. Only 20-40 companies are making it to the D Round annually as compared to the hundreds in the A Round every year. The DOD should be prepared for significant mortality rates in its venture backed partners.

C Round DOD Deal Count

Year	Count
2014	45
2015	40
2016	51
2017	76
2018	70

D Round DOD Deal Count

Year	Count
2014	14
2015	27
2016	23
2017	29
2018	42

Late Stage – Funding Stages and Sources

Late Stage funding sources become very concentrated.   With a few rare exceptions (large family offices, corporates, and sovereign wealth funds), most of the late round equity financing either comes from Sand Hill Road or Wall Street, as shown in the next chart sourced from PItchbook.

2018 Most Active Late Stage Investors		
VC Firm	Deals	Location
New Enterprise Associates	53	SV
Kleiner Perkins	39	SV
Accel	37	SV
GV	36	SV
Bessemer Venture Partners	35	SV
Alumni Ventures Group	31	Manchester, NH
Khosla Ventures	28	SV
Andreessen Horowitz	28	SV
Lightspeed Venture Partners	27	SV
Sequoia Capital	26	SV
Keiretsu Forum	26	SV
Salesforce Ventures	25	SV
Battery Ventures	24	SV
IVP	23	SV
T. Rowe Price	22	Baltimore, MD
Insight Venture Partners	21	NYC
Revolution	21	DC
Spark Capital	20	SV
General Catalyst	20	SV
Bain Capital Ventures	19	SV
ICONIQ Capital	18	SV
Redpoint Ventures	18	SV
Norwest Venture Partners	18	SV
Y Combinator	17	SV
Tiger Gloal Management	16	NYC

The average check sizes (total) for C and D Rounds were $26M and $44M in 2018 according to Pitchbook. The days of the founder asking his or her parents for some funding are long behind. As pointed out earlier, the West Coast (mostly Silicon Valley) provided 61.7% of 2018 venture financing. However, the region only financed 39.5% of all total deals, which speaks to the much larger check sizes.

Funding also comes from Wall Street, where the leading technology investment banks, such as Morgan Stanley and JP Morgan work with large mutual funds to invest in "crossover" companies. Crossovers are late stage private venture backed companies focused on going public in the Initial Public Offering process within a few years. A small handful of mutual funds such as Wellington, Franklin Templeton, T Rowe Price, and Fidelity have poured billions of dollars into Late Stage financing for dual use start-up leaders such as Tanium and SpaceX.[22]

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[22] See funding rounds data at https://www.crunchbase.com/organization/tanium#section-funding-rounds and https://www.crunchbase.com/organization/space-exploration-technologies/funding_rounds/funding_rounds_list#section-funding-rounds.

Late Stage – DOD Units

There should only be one unit focused on the late stage. DIU is uniquely positioned by geography to manage the Late Stage VC relationships on behalf of the DOD. Venture investing is a relationship-based business. If the DOD wants to attract large checks for its dual use start-up partners, it needs to establish good relationships with those check writers. And those large check writers, like TCV, Andreesen Horowitz, New Enterprise Associates, etc. have more money than time. They and their peers are not interested in meeting every single DOD innovation outreach unit under the sun…AFWERX, CYBERWERX, SOFWERX, DIU, MD5, NavalX, AFC, SCO, REF, and especially those that use a traditional uniformed rotational assignment process.

Second, the PEO's need one authoritative emerging technology partner upon which they can base their long-term acquisition planning. As the PEO's can't integrate dual use start-ups until the Late Stage due to the overhead requirement, that authoritative partner probably should be the same one coordinating the Late Stage VC relationships.

Late Stage – DOD Goals

The Late Stage is where the DOD can finally achieve its ultimate goal of rapidly deploying new emerging technology in the hands of the warfighter at scale. That sounds an awful lot like an official Program of Record.

The early PEO partnerships discussed above are critical so that by the time the start-ups have scaled enough to afford DOD overhead, the PEO's had their requisite five years lead time to plan to incorporate the start-ups new technology in their acquisition plans.

Without the PEOs and their Programs of Record, the start-ups lack a big enough customer representing a sufficiently large Total Addressable Market to support an exit and justify their choice of the DOD as a target customer. Thus, the need for an exit drives start-up strategy at every stage. No exit; no VC funding.

Of course, the start-ups can always partner with Traditional Defense Contractors (Primes) and System Integrators (SI's), which they often do and should. However, these partnerships also take extensive time to materialize (and monetize), just as a DOD prime contract would.   And the enhanced overhead requirements are still material, even in a sub-contracting role.

CONCLUSION

Policy Adjustments

The key policy recommendation conclusions in the DOD efforts to effectively coordinate its partnership with Late Stage companies, and equally important, their financial backers on Sand Hill Road while addressing the need to integrate the services and the FAR into the whole process:

- Move DIU under the Vice Chair and connect it with the Joint Requirements Oversight Council.
- Assign senior uniformed personnel from each service to DIU on a rotating basis backed up by a permanent civil service.

- Develop a multi-year procurement policy "on ramp" for Early Stage companies on quick turn prototype contract that moves them to full FAR-based acquisitions gradually as they grow through their life stages.
- Embed senior uniformed personnel on a rotating basis from the major PEOs and ACAT1 programs at DIU backed up by a permanent civil services basis.
- Move MD5 under DIU.
- Strengthen MD5's mandate to cover all innovation ecosystems with permanent civilian representatives acting as the regional hub with nation-wide coverage.
- Use MD5's integration with DIU to manage the national Early Stage innovation ecosystem and provide early connections between the services and PEOs to networks of founders in working in areas of technological interest.
- DIU should work through MD5 to connect promising dual use start-ups with Mid and Late Stage funding sources outside of their local Early Stage networks (with no Chinese LPs).
- DIU and MD5 partner with all the services-based innovation outreach units (AFC, AFWERX, etc.) to coordinate efforts efficiently in each region to the benefit of each service's unique needs, in a harmonious effort that maximizes impact in each region without duplicating resources.
- Develop a metrics-based system to measure the effectiveness of the innovation outreach at each stage and geography.

Measure Everything

The challenge of measuring the effectiveness of DOD innovation outreach is much easier than policy makers think - if done from the perspective of a venture capitalist. There is a vast amount of publicly available data on VC funding rounds. The three leading industry sources are Pitchbook, Crunchbase, and CB Insights. The venture industry non-profit trade association, known as the National Venture Capital Association (NVCA) has partnered with Pitchbook thus making it arguably the most validated industry data source[23]. Therefore, the choice of Pitchbook data for this paper.

Early Stage Metrics – Deal Flow

Nearly every VC keeps a deal database. The local DOD innovation outreach reps could similarly track their own start-up interactions. The goal would be to track and grow the number of dual use start-ups hitting Day 1, Seed, and Angel Rounds in the local ecosystem across all areas of DOD tech interest.

MD5 again would be ideal for this role. A services-based component might only be motivated to look for deals in their specific interest areas. It's doubtful that AFC would spend much time on unmanned undersea drones, such that NavalX's interests would be left untracked in that region if the Army has the lead. Second, by nature of MD5's national mandate, an amalgamation of the local databases would compose the National Security Innovation Base's nation-wide Early Stage database.

Ideally, an inventive system would be put into place to reward the local MD5 units based on growth in these metrics over time.

Mid Stage Metrics – Capital Attracted

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[23] National Venture Capital Association, "PitchBook-NVCA Partnership," https://nvca.org/research/pitchbook-nvca-partnership/.

Measuring capital at this Early Stage could be somewhat problematic. Many of the innovation outreach units have access to small funds that can provide capital infusions or the equivalent thereof into Early Stage companies. Thus, the funding data metrics might suffer from the moral hazard risk of a unit using their own funds to "make their numbers" for the year on capital attraction measurements. As companies move towards their A Round with bigger checks from professional investors, the measurement of "attracted capital" becomes more relevant with higher data integrity.

From the A Round on, the funding data in the public databases becomes much "cleaner" and comprehensive because the participants are highly motivated to report their funding. This includes both the founders and investors.   The founders are self-motivated to advertise their funding round to help with recruiting, PR, marketing, customer attraction etc. The investors are highly motivated to announce funding rounds, to help burnish their brands in the Valley to help attract future deal flow. Additionally, the public databases are incentivized by their business models to aggressively track deal announcements as they sell advanced metrics and other subscription offerings off the data. So, the DOD does have access to exhaustive quantitative metrics to measure their progress.

Late Stage Metrics – Dollars Deployed

The ultimate goal here is to get new emerging tech more rapidly deployed to the warfighter. In other words, Army/Navy/USAF dollars on full rate production contracts (as opposed to OTA and/or similar prototype contracts). Each innovation outreach unit should be responsible for measuring the funding deployed through their efforts in connecting their services partners with dual use start-ups.

DIU attempted to just this in their 2017 annual report:

> "With the support of the Army Contracting Command – New Jersey (ACC-NJ), 48 prototype agreements were awarded for $104M in 2017 alone, averaging roughly 1 per week. With a limited budget of just $10M in RDT&E and $15.7M in O&M for FY17, DIUx worked diligently to find ways to collaborate with our DOD partners in order to fund these prototype projects. Of the $104M on contract, approximately $84M comes from DOD partners…in 2017, DIUx successfully transitioned two prototype projects into production contracts, marking the first DOD has ever done this under the OT authority. Building on an initial $13M prototype contract awarded in 2016, the first production contract was signed in September 2017 for endpoint security services provided by Tanium – supported by World Wide Technology. US Army Network Enterprise Technology Command (NETCOM) made the first order for $35M."

Ideally, this contract data would be tracked by DIU in its proposed national coordinating role and reported back to the Joint Chiefs, OSD, and Congress.

In summary, tools and data sources exist to track the effectiveness of DOD innovation outreach across all three stages: start-up founded in the Early Stage, capital attracted in the Mid Stage, and production contracts let in the Late Stage.   If the whole system works effectively, it becomes self-funding through exits and re-investment back into the ecosystem at the Early Stage.

Further Study

Venture Round Categorization: The funding data shown above should be broken down into its ten categories according to Dr. Griffin's priorities. This would show areas where DOD is getting ample

private funding versus areas of emerging tech where they may need to bolster the funding with a dedicated capital fund. As the Pitchbook company category labels do not neatly match those of Dr. Griffin, and the number of deals captured in this paper's five-year study exceeds 2300, this project was left for a later date.

Exits: A historical baseline of dual use funding exits should be established from which to measure the ongoing effectiveness of DOD efforts in the Late Stage.

Dual Use Funds: A database could be constructed of private venture funds who either have a dedicated dual use, industrial tech, or related strategy and generalist funds (with no Chinese LP's) that either have a focus or openness on dual use. This would be used by the DOD outreach units to help make VC introductions for their target dual use companies, as well as track "upstream" LP funding into the dual use category.

Geographic Analysis: DOD innovation unit staffing and budget levels should be analyzed by region, then matched against tech specialties in that region, levels of start-up activity, and funding levels. The output of this analysis would then enable a more efficient and focused allocation of resources by region.

Final Word

The early returns as measured in the dual use funding data described in this paper merit the strong support of National Security Leadership. With all due respect, the opposition to modest funding levels for organizations such as DIU must stop. The primes and system integrators should instruct their government relations teams to stop opposing these seedling efforts and instead partner them. Large defense contractors would be better served to fear Amazon's move into their market rather than DIU. The latter wants to help them; the former wants to dominate them in the digital arms race.

Again, to make the point, China raised more money in one financing round from western investors for its leading AI company than Congress is willing to commit the entirety of the DOD innovation units aimed at VC backed companies. Therefore, the early successes described in this paper should not cloud the fact that there is much work still to be done in winning the Digital Arms Race.

To complete the work of supporting the NSIB:

- Congress should fully fund from the appropriations side all the innovation efforts supported from the authorizer side.
- The DOD should deconflict and better coordinate all its innovation units at the OSD level.
- The Services should compel their PEO's to collaborate with the innovation units.
- The Primes should all launch their own venture funds, partner with dual use funds, and make strategically meaningful minority investments into Late Stage dual use companies. They should also increase commercial technology leadership on their boards of directors (see appendix).
- The System Integrators should facilitate the introduction of emerging technology companies to their customers in partnership rather than continuing to propose building their own (often antiquated upon delivery) custom technology solutions, particularly in software.

True success, finally, will be achieved when venture backed dual use start up IPOs are commonplace. Only then will the dual-use ecosystem become self-sustaining and the full power of US free markets be brought to bear on this new age of Great Power Competition.

APPENDIX

FURTHER BACKGROUND ON VENTURE FUNDING DATA

A key issue in parsing dual use venture funding, is that Dr. Griffin has yet to release much detail around what is exactly entailed in each category. For certain categories like Hypersonics, they are specific enough that further details are not necessary to conduct an accurate A Round start-up search within Pitchbook. Others, however, are much more problematic. For instance, Microelectronics is a rather broad category that would benefit from more detailed descriptions for areas of interest.

1. Hypersonics
2. Directed Energy
3. Command, Control, and Communications
4. Space Offense and Defense
5. Cybersecurity
6. AI/ML
7. Missile Defense
8. Quantum Science and Computing
9. Microelectronics
10. Autonomy

AI/ML is the exception where the recent Presidential Executive Order on "Maintaining American Leadership in Artificial Intelligence[24]" and the corresponding "2018 Department of Defense Artificial Intelligence Strategy[25]" provided tremendous detailed descriptions of specific areas of interest. Hopefully, Dr. Griffin's office follows suit in the other categories to enable better tracking of private capital flows into those areas. Until that time, the approach modeled above should be interpreted as a representative framework for further development, rather than as a source of exact, accurate measurements.

To add increased fidelity to the Pitchbook search, a broader set of technology category descriptors was used to compile the totals in the two A Round charts above:

"cyber security; cyber security service; cyber security software; cybersecurity; cybersecurity services; cybersecurity system; cyber defense; cyber threat; cyber attack security; cyber threat detection; threat analysis; threat detection; network security; cyber attack prevention; cyber attack; cyber threat defense; cyber protection; cyber threat management; threat intelligence; cyber; cyber security system; cybersecurity software; ai/ml; machine learning military; military software; defense systems; ai engine; artificial intelligence; machine learning; military communications; radio equipment; wireless antenna; wireless communication; military command; defense communication; satellite communication product; military; directed energy; laser defense; laser technology; laser beam; defense electronics; aerospace and defense; defense & space; missile systems; missile defense; missile; hypersonics; hypersonic speed;

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[24] President Donald Trump, "Executive Order on Maintaining American Leadership in Artificial Intelligence, February 11, 2019, https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/.

[25] Department of Defense, "Summary of the 2018 Department of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity," https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF.

hypersonic; aerospace weapons; aeronautics; aerospace & defense; defense aerospace; aeronautics and defense; hypersonic weapon; microelectronics; circuit board; microcircuit; microchip; microchip technology; wire bonding; digital integrated circuit; transistors; analog circuit design; electronic design automation; nanoelectronics; electronic design automation software; semiconductor; semiconductors; quantum science; quantum computing; quantum computing software; physics; quantum computing technology; quantum computer technology; quantum computing platform; quantum technology; quantum algorithm; high performance computing; quantum computer; quantum information sciences; quantum information; space offense; aerospace; military aerospace; rocket; space technology; rocket propulsion systems; nuclear weapon; nuclear power; nuclear; nuclear energy; space defense; Verticals: Artificial Intelligence & Machine Learning; Cybersecurity"

This search list was compiled after reviewing key DOD documents, press articles, and Congressional testimony where Dr. Griffin and other DOD leaders gave further details on areas of interest within emerging technology. These sources include, but were not limited to:

- Remarks by Secretary Mattis at the Reagan Defense Forum, December 1, 2018[26]
- The 2018 U.S. national defense strategy[27]
- "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States," a report in response to Executive Order 13806[28]
- Statements by Dr. Mike Griffin before the House Armed Services Committee (April 17, 2018) and the Senate Armed Services Committee (April 18, 2018)[29]
- The Congressional Research Service's report "Artificial Intelligence and National Security"[30]
- Dr. Mike Griffin's speech at DARPA's 60th anniversary symposium[31]
- Dr. Mike Griffin's speech at the Hudson Institute on "Regaining the Strategic Advantage in an Age of Great Power Competition," April 13, 2018[32]

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[26] "Remarks by Secretary Mattis on National Defense Strategy."

[27] "Summary of the 2018 National Defense Strategy of the United States of America."

[28] "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States," September 2018, https://media.defense.gov/2018/Oct/05/2002048904/-1/-1/1/ASSESSING-AND-STRENGTHENING-THE-MANUFACTURING-AND%20DEFENSE-INDUSTRIAL-BASE-AND-SUPPLY-CHAIN-RESILIENCY.PDF.

[29] "Statement by Dr. Mike Griffin, Under Secretary of Defense for Research and Engineering, before the House Armed Services Committee on Promoting DoD's Culture of Innovation, Second Session, 116th Congress, April 17, 2018," https://docs.house.gov/meetings/AS/AS00/20180417/108132/HHRG-115-AS00-Wstate-GriffinM-20180417.pdf; "Statement by Dr. Mike Griffin, Under Secretary of Defense for Research and Engineering, before the Emerging Threats and Capabilities Subcommittee of the Senate Armed Services Committee on Technology Transfer and the Valley of Death, Second Session, 116th Congress, April 18, 2018," https://www.armed-services.senate.gov/imo/media/doc/Griffin_04-18-18.pdf.

[30] Kelley Sayler and Daniel S. Hoadley, "Artificial Intelligence and National Security," Congressional Research Service Report for Congress, R45178, updated January 30, 2019, https://www.hsdl.org/?abstract&did=821457.

[31] "Remarks by the Honorable Mike Griffin, USD(R&E)" at DARPA's 60th anniversary symposium (D60), September 5–7, 2018, Gaylord National Harbor, Oxon Hill, Maryland, https://www.youtube.com/watch?v=UWUztOsO1Gg.

[32] Rebeccah L. Heinrichs, "FULL TRANSCRIPT: Regaining the Strategic Advantage in an Age of Great Power Competition: Conversation with Michael Griffin, Hudson Institute, April 25, 2018, https://www.hudson.org/research/14284-full-transcript-regaining-the-strategic-advantage-in-an-age-of-great-power-competition-a-conversation-with-michael-griffin.

- "Nuclear Command, Control, and Communications" in the U.S. Air Force Doctrine Annex 3-72 Nuclear Operations[33]
- The Defense Science Board's report on military satellite communication and tactical networking, March 2017[34]
- An assessment of how the U.S. military intends to revamp communications networks[35]
- The 2018 Department of Defense Cyber Strategy[36]
- The "2018 Directed Energy Summit: Summary Report" by Booz Allen Hamilton[37]
- The Center for Strategic & International Studies report "Distributed Defense: New Operational Concepts for Integrated Air and Missile Defense"[38]
- A backgrounder on U.S. nuclear weapons modernization from the Council on Foreign Relations[39]
- The "National Strategic Overview for Quantum Information Science," September 2018[40]

The exercise here is to show a possible framework for measuring the success of DOD innovation outreach. Ideally, the measurements would be expanded to include all funding stages, calibrated more carefully as the DOD unveils new details of its interest in venture backed emerging technology, and then analyzed by geography to enable a better deployment of innovation "boots on the ground." Given how many deals and investment dollars flow from Silicon Valley into dual use, it is the natural conclusion that all innovation outreach units should either be based there, have heavy presence there, or establish a deep partnership with DIU. Of course, other factors influence the geographic assignment of innovation troops such as Congressional support, proximity to test ranges, etc. However, if the DOD wants to attract private capital, it should deploy assets within driving range of those sources of capital rather than being thousands of miles away.

COMPARING DOD INNOVATION UNIT BUDGET RESOURCES

The DOD's money certainly is not where its mouth is when it comes to funding its innovation units. The Strategic Capabilities Office is the highest at $1.3B, then the new Joint Artificial Intelligence Center at

[33] U.S. Air Force, "Nuclear Command, Control, and Communications, in *Annex 3-72 Nuclear Operations*, last updated May 19, 2015, https://www.doctrine.af.mil/Portals/61/documents/Annex_3-72/3-72-D30-NUKE-OPS-NC3.pdf.

[34] Department of Defense, Defense Science Board, "Task Force on Military Satellite Communication and Tactical Networking: Executive Summary," March 2017, https://www.acq.osd.mil/dsb/reports/2010s/DSB-MilSatCom-FINALExecutiveSummary_UNCLASSIFIED.pdf.

[35] Jon Harper, "U.S. Military Intends to Revamp Communications Networks," *National Defense*, December 7, 2018, http://www.nationaldefensemagazine.org/articles/2018/12/7/u-s-military-intends-to-revamp-communications-networks.

[36] Department of Defense, "Summary: Department of Defense Cyber Strategy 2018," https://media.defense.gov/2018/Sep/18/2002041658/-1/-1/1/CYBER_STRATEGY_SUMMARY_FINAL.PDF

[37] Available at https://www.boozallen.com/s/insight/publication/2018-directed-energy-summit-summary-report.html.

[38] Thomas Karako and Wes Rumbaugh, "Distributed Defense: New Operational Concepts for Integrated Air and Missile Defense," January 2018, https://csis-prod.s3.amazonaws.com/s3fs-public/publication/171206_Karako_DistributedDefense_Web_0.pdf?GqH4Iie2m_7aMFqFKMRWu.3vdT18tMdO.

[39] Ankit Panda, "U.S. Nuclear Weapons Modernization," Council on Foreign Relations website, last updated February 7, 2018, https://www.cfr.org/backgrounder/us-nuclear-weapons-modernization.

[40] National Science and Technology Council, "National Strategic Overview for Quantum Information Science," September 2018, https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Strategic-Overview-for-Quantum-Information-Science.pdf.

$340M. However, neither of those units have a singular mandate to conduct outreach to venture-backed emerging tech innovation hubs. The Army Futures Command comes closest to that mandate but has a measly $100M this year, with which they are expected to begin the Herculean task of overhauling the Army's $30B modernization budget and correcting all the mistakes of past efforts such as Future Combat Systems. All the other dedicated innovation units such as DIU and AFWERX have tiny budgets that equate to what DC insiders often call "budget dust."

Policy recommendations here are obvious: double the innovation units budgets every year for the next five years and maybe then the DOD will start making progress on its aspirations to be a player in the Silicon Valley ecosystem. Ideally the Small Business Innovation Research program would evolve to also support high growth Early Stage companies. To do so would require a much higher risk tolerance within the program with minimal accounting and compliance expectations.
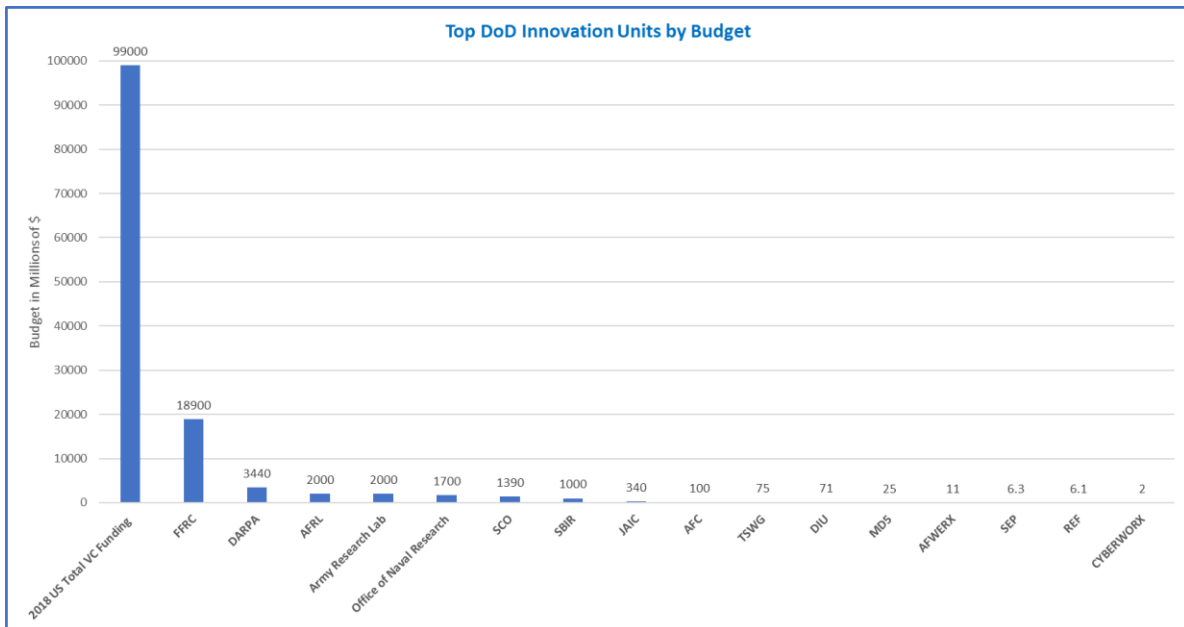
Top DOD Innovation Units by FY19 Budget	
2018 US Total VC Funding	99000
FFRC	18900
DARPA	3440
AFRL	2000
Army Research Lab	2000
Office of Naval Research	1700
SCO	1390
SBIR	1000
JAIC	340
AFC	100
TSWG	75
DIU	71
MD5	25
AFWERX	11
SEP	6.3
REF	6.1
CYBERWORX	2

Innovation Unit	Description	Budget	Team	Location
Defense Innovation Unit (DIU)	Provides non-dilutive capital in the form of pilot contracts for commercial innovation in the effort to solve DoD issues. Claims to solve	$71 million	75 military & civilian personnel. Michael Brown (Managing Director); Mike Madsen (Director);	Silicon Valley HQ: 230 R.T. Jones Rd., Mountain View, CA 94043 Boston: 1 Charles Park #1000,
MD5 - The National Security Technology Accelerator	Mission: "create new communities of innovators that solve national security problems".	$25 million (FY2017)	Morgan Plummer (Managing Director)	Fort McNair, Washington, Distri
Army Futures Command (AFC)	The Army's modernization strategy. Mission: "The modernization process will leverage commercial	$100 million	General John M. Murray (Commanding General, Army Futures Command); Lieutenant General James M. Richardson (Deputy Commanding General, Army Futures Command);	Texas HQ: 210 W 7th St., Austin, TX 78701
AFWERX	Founded by Secretary of the Air Force (Heather Wilson) and reports to the Vice Chief of Staff of the Air Force.	$11 million		DC HQ: 2011 Crystal Dr., Suite 325, Arlinton, VA 22202 Vegas: 3773 Howard Hughes
Special Operations Forces Works (SOFWERX)	"Public facing intermediary to assist with collaboration, innovation, prototyping and exploration with inudstry, labs and academic			1925 E. 2nd Ave., Suite 102, Tar
CyberWORX	"AF CyberWorx is a new venture for the Air Force, a public-private design center focused on cyber capability that melds AF, academic	$2 million	1400 employees	
Office of Naval Research	"The Office of Naval Research (ONR) is an organization within the United States Department of the Navy that coordinates, executes, and	$1.7 billion		
Air Force Research Labs (AFRL)	"The Air Force Research Laboratory (AFRL) is a scientific research organization operated by the United States Air Force Materiel	>$2Billion	4200 civilian, 1200 military	
Defense Advanced Research Projects Agency (DARPA)	"make pivotal investments in breakthrough technologies for national security"	$3.44 billion - FY2019 $3.17 billion - FY18	220 Gov. employees Dr. Steven H. Walker (Director)	675 N. Randolph St., Arlington,
Marine Corps Warfighting Lab	"The warfighting lab is part of the Marine Corps Combat Development Command (MCCDC) and its stated purpose is to improve			
Strategic Capabilities Office (SCO)	Reports to Undersecretary of Defense for Research and Engineering (Mike Griffin)	$1.39 billion	Chris Shank (Director)	
Joint Artificial Intelligence Center (JAIC)	"overarching goal of accelerating the delivery of AI-enabled capabilities, scaling the Department-wide impact of AI, and synchronizing DoD AI	$1.7 billion over next 5 years		
TSWG	"The Technical Support Working Group (TSWG) is a United States Interagency program for research and	$50-100 million	70 employees	
Rapid Fielding Initiative (RFI)	"The Rapid Fielding Initiative (RFI) leverages current programs, lessons learned from operations in Iraq and Afghanistan, and commercial-off-			
Rapid Equipping Force (REF)	"The Rapid Equipping Force (REF) is a U.S. Army organization charged with quickly providing Army units deployed globally with innovative	$6.1 Million (FY2018)	140 personnel including 30 military & 21 Department of the Army Civilians	
Soldier Enhancement Program (SEP)	"The Soldier Enhancement Program (SEP) is an enduring process designed to help the Army move at "the Speed of Industry" to evaluate	$6.3 million (FY2019)		
Small Business Innovation Research (SBIR)	"The Small Business Innovation Research (SBIR) program is a United States Government program, coordinated by the Small Business	>$1 billion		
Army Research Lab	"The ARL mission is to "Provide innovative science, technology, and analyses to enable full spectrum operations." We provide the	$2B	140 personnel including 30 military & 21 Department of the Army Civilians	

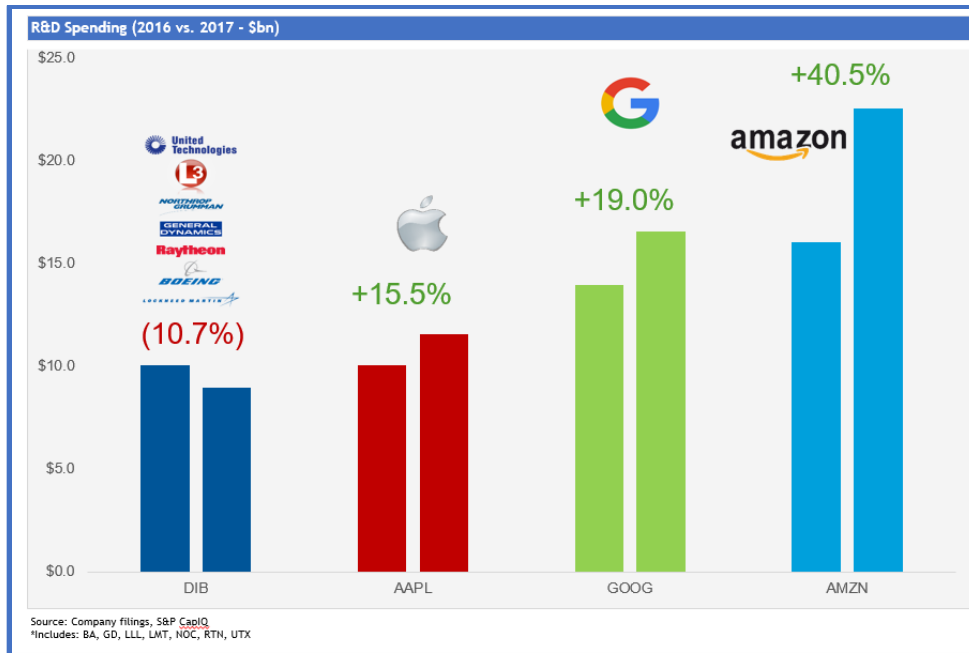## AEROSPACE/DEFENSE COMPANY CORPORATE VENTURE ACTIVITY

The traditional defense contractors, otherwise known as the "Primes" have somewhat gotten the message on the DOD's desire to partner with Silicon Valley. Boeing and Lockheed have opened dedicated Corporate Venture Capital (CVC) arms with around $200M allocated to each[41]. Airbus has been in and out of the CVC game over the years, as well.   Adding in a few larger industrial firms who sell to the DOD gets to a total of about $1.5-$2B of additional capital aimed at the dual use category, as shown below.   That's an encouraging amount in the context of the $4B+ invested in dual use A-Rounds as shown earlier.

The policy recommendation here is for senior DOD leadership to hold another "Last Supper[42]". In 1993, SecDef Les Aspin and DepSecDef Bill Perry hosted a dozen CEOs from the primes for dinner. They delivered the message that there were twice as many military contractors at the top of the market than the DOD wanted. After having to bail out Lockheed earlier in the decade, the DOD was prepared to watch some of its supply base go out of business as the defense budgets declined after the Cold War. For a detailed analysis: http://www.its.caltech.edu/~kpickar/e103/lectures/Tetra_Last_Supper.ppt.

The new Last Supper could be a similar moment focused on emerging technology. The primes don't spend much on R&D and the DOD is being forced to turn elsewhere for innovation as the Fourth Industrial Revolution takes hold in the battlespace. The message could be that the DOD wants the primes to spend some of their massive excess cash on emerging tech venture investing instead of mostly on M&A, stock repurchases, and dividends. They could encourage other players besides Boeing and Lockheed to set up venture shops in Silicon Valley and other innovation hubs, as well as take minority stakes in the large Late Stage dual use companies.

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[41] "Lockheed Martin Announces $100 Million Venture Fund Increase," press release, June 7, 2018, https://news.lockheedmartin.com/2018-06-07-Lockheed-Martin-Announces-100-Million-Venture-Fund-Increase.

[42] Leslie Wayne, "The Shrinking Military Complex; After the Cold War, the Pentagon Is Just Another Customer," New York Times, February 27, 1998, https://www.nytimes.com/1998/02/27/business/shrinking-military-complex-after-cold-war-pentagon-just-another-customer.html.

R&D Spending (2016 vs. 2017 - $bn)

Source: Company filings, S&P CapIQ
*Includes: BA, GD, LLL, LMT, NOC, RTN, UTX

Eventually, the DOD must change its incentive structure on prime R&D to encourage them to spend a higher percentage of revenue on R&D than the meager 1-1.5% levels currently seen. Lastly, the primes could be encouraged to upgrade their Boards of Directors with stronger emerging tech representation. As the chart below shows, according to their public filings, the current board slates do not represent the new Digital Arms Races.

Tech/Silicon Valley Representation Among Public A&D

A&D Company	Office in Silicon Valley?	# of Board Directors	# of Directors with Tech Industry Experience	# of Directors that are Active VCs	Total	% of Board with Either
AIR	Y	12	1	0	1	8%
AJRD	N	9	0	0	0	0%
ARNC	N	13	0	0	0	0%
BA	Y	13	1	0	1	8%
BAH	N	13	1	0	1	8%
CUB	Y	9	1	0	1	11%
GD	Y	10	0	1	1	10%
HII	N	10	0	0	0	0%
HRS	Y	11	1	0	1	9%
KTOS	Y	8	1	2	3	38%
LLL	Y	10	1	0	1	10%
LMT	Y	12	1	0	1	8%
NOC	Y	12	0	0	0	0%
RTN	Y	13	1	0	1	8%
SAIC	Y	9	3	0	3	33%
SPR	N	9	0	0	0	0%
TDG	N	12	0	0	0	0%
TXT	N	11	0	0	0	0%
UTX	Y	12	2	0	2	17%
VSAT	Y	10	2	0	2	20%
WAIR	N	11	0	1	1	9%

# of Companies	21					
# with Office in SV	13				Average	9%
% with SV exposure	62%				Median	8%

Following is a compilation of Pitchbook data reviewing dual use CVC activity:

A&D Corporate Venture Fund Profiles

Firm	Date Launched	Fund Size	Dry Powder	Deals TTM	Deals TTY	Exits	Largest Deal Size	Smallest Deal Size	Avg. Deal Size
Boeing/HorizonX	2017	$250M	$195M	15	19	0	$56.5M	$500K	$36.1M
Lockheed Martin	2016	$200M	$125M	5	27	10	$40M	$9.9M	$27.4M
Airbus Ventures	2015	$150M	$80M	13	26	0	$40M	$2.5M	$17.7M
3M Ventures	2008	N/A	N/A	4	36	13	$20M	$20M	$20M
Honeywell Ventures	2017	$100M	$86M	3	4	0	$20.3M	$13.6M	$17.8M
GE Ventures	2013	$1B	$300M	23	243	56	$200M	$5M	$36.1M

Capital Deployed by Industrial/ A&D CVC Arms by Category (annualized)

Industrial Categories	2018E Capital Invested ($M)	yoy % change
3D Printing	904	88%
Advanced Manufacturing (excl. 3D Printing)	1,409	140%
AgTech	2,225	10%
Autonomous Cars (excl. Ridesharing)	6,497	92%
Construction IT	445	-19%
Robotics & Drones (excl. Autonomous Cars)	7,305	83%
Ridesharing	25,024	171%
Space Technology	1,475	-26%

Recent A&D Corporate Venture Investments

CVC	Funding Round	Company Description
Boeing/HorizonX		
Accion Systems	Series A1	provider of propulsion systems for satellites
BridgeSat	Series B	offers small form factor laser communication terminals at a reduced priced compared to equivalent RF data throughput solutions
Digital Alloys	Series B	developer of high-speed, multi-metal additive manufacturing systems that print production quality parts.
Lockheed Martin Ventures		
Terran Orbital	Series B	leading innovator and provider of picosatellites, cubesats, and nanosatellites
Mythics	Series B	uses artificial intelligence to push today's device constraints enabling individuals to use all personal devices for smart personal assistant capabilities.
Airbus Ventures		
Aeye, Inc.	Series B	develops advanced vision hardware, software and algorithms that act as the eyes and visual cortex of autonomous vehicles
Impossible Aerospace	Series A	manufacturer of battery-electric aircraft products
Cognata	Series B	provider of driving validation platforms for the autonomous vehicle industry
3M Ventures		
Dispelix	Series A	offers a proprietary smart glasses concept to meet and exceed consumer expectations.
Guardhat Technologies	Series A	developer of a multi-product, feature-packed intelligent safety system that integrates cutting edge wearable technology
Propeller Health	Series C	mobile platform that offers sensors, mobile aps, analytics, and services to support respiratory health management
Honeywell Ventures		
IoTium	Series B	simplifies establishing and managing secure network infrastructures for industrial companies.
Soft Robotics	Series A1	opens new markets to automation through the application and commercialization of its proprietary robotic technology and systems
Element Analytics	Series A	creator of industrial analytics software that empower organizations to achieve new levels of operational performance
GE Ventures		
Xage Security	Series A	information technology company that offers block-chain protected security platforms for industrial IoT
Freightos	Series C	streamlines global trade into a frictionless system through use of an online freight marketplace and powerful international freight routing/pricing technology

Lockheed Martin Ventures Portfolio (by deal date)

Company Name	Industry	Description	Deal Date	Deal Size ($M)	Raised to Date ($M)
Terran Orbital	Wireless Communications Equipment	Provider of picosatellites, CubeSats, and nanosatellites intended to offer cost-effective end-to-end new space aerospace services.	6-Aug-2018	36.0	44.5
Forever Oceans	Aquaculture	Operator of aquafarms.	28-Jun-2018	9.9	15.0
Mythic	Electronic Components	Developer of a local artificial intelligence platform designed to turn devices into secure and trusted intelligent assistants.	20-Mar-2018	40.0	55.3
Humatics	Application Software	Developer of microlocation products designed to revolutionize how people and machines locate, navigate and collaborate.	6-Feb-2018	23.7	23.7
Terran Orbital	Wireless Communications Equipment	Provider of picosatellites, CubeSats, and nanosatellites intended to offer cost-effective end-to-end new space aerospace services.	4-Dec-2017	7.0	44.5
Ocean Aero	Robotics and Drones	Developer and manufacturer of unmanned underwater system products.	15-Sep-2017	12.9	17.2
IQ-Analog	Application Specific Semiconductors	Developer of analog semiconductor components.	20-Dec-2016	5.6	6.0
Peloton Technology	Transportation	Developer of an automated vehicle technology designed to improve the U.S. and global freight transportation.	31-Aug-2015	17.0	83.8
Forever Oceans	Aquaculture	Operator of aquafarms.	21-May-2015	0.1	15.0
Cybereason	Network Management Software	Developer of SaaS endpoint detection and cyber-security technology designed to protect companies from highly advanced attacks.	10-Apr-2015	24.8	190.0
QRA	Business/Productivity Software	Provider of systems and requirements tools designed to help engineers to build complex systems with confidence.	1-Mar-2015	1.0	4.0
Rocket Lab	Aerospace and Defense	Manufacturer of commercial rocket launchers intended to provide frequent satellite launch opportunities to lower Earth orbit and remove barriers to commercial space.	27-Feb-2015	21.6	257.3

Boeing/HorizonX Venture Portfolio (by deal date)

Company Name	Industry	Description	Deal Date	Deal Size ($M)	Raised to Date ($M)
Accion Systems	Aerospace and Defense	Developer of advanced propulsion technologies designed to accelerate the exploration of space.	10-Oct-2018	3.0	12.9
BridgeSat	Connectivity Products	Developer of optical communications network designed to connect satellites from space to the ground and meet accelerating demand for big data collection from LEO (Low Earth Orbit).	6-Sep-2018	10.0	16.0
Digital Alloys	Computers, Parts and Peripherals	Manufacturer of high-speed, multi-metal additive 3D printing systems designed to print production quality parts, in almost any metal.	7-Aug-2018	12.9	22.7
Matternet	Electrical Equipment	Provider of an on-demand delivery platform created to make access to goods as frictionless and universal as access to information.	26-Jun-2018	16.0	25.5
Agylstor	Storage (IT)	Provider of a computational storage systems designed to secure data storage and transfer.	30-May-2018	8.5	8.5
Kittyhawk.io	Application Software	Developer of a fully-native, cross-platform experience designed to empower effective drone operations.	18-May-2018	5.0	6.5
Morf3D	Business/Productivity Software	Provider of additive manufacturing systems created to offer full customization in manufacturing.	23-Apr-2018	4.5	4.5
Reaction Engines	Aerospace and Defense	Developer of an aerospace engine technology designed to unlock the future of space access and hypersonic flight.	11-Apr-2018	37.3	95.4
Fortem Technologies	Electrical Equipment	Provider of an AI-enabled drone object-detection system for airspace security and safety.	29-Mar-2018	16.4	21.9
Myriota	Systems and Information Management	Provider of low cost satellite IoT connectivity products designed to revolutionize satellite communications.	26-Mar-2018	15.0	16.4
Upskill	Business/Productivity Software	Developer of an enterprise software for augmented reality devices designed to connect hands-on workers to the information they need to do their jobs.	6-Mar-2018	17.2	57.7
Singularity University	Education and Training Services (B2B)	The company's education center and accelerator focuses on exponential technologies such as robotics, nanotechnology and biotech.	15-Feb-2018	32.0	35.1
Cuberg	Alternative Energy Equipment	Developer of batteries intended to address the major challenges of lithium-ion battery technology.	29-Jan-2018	2.0	3.4
Zunum Aero	Air	Developer of commercial hybrid-to-electric aircraft designed to be used for regional transit.	12-Jan-2018	0.0	-
Gamma Alloys	Aerospace and Defense	Developer of lightweight alloys designed to give a boost to next-generation aluminum alloys.	1-Nov-2017		
Near Earth Autonomy	Aerospace and Defense	Developer of software and sensors intended for manufacturers and users of low-flying aircraft.	20-Oct-2017	8.0	8.0
C360	Electronics	Developer of a 360-degree video recording device intended to deliver 6K immersive broadcast and streaming video facility.	2-Aug-2017	3.5	4.7
SparkCognition	Database Software	Provider of artificial intelligence systems to advance the most important interests of society.	26-Jun-2017	56.5	72.3
Upskill	Business/Productivity Software	Developer of an enterprise software for augmented reality devices designed to connect hands-on workers to the information they need to do their jobs.	5-Apr-2017	12.0	57.7