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FEATURE

# The future is …

## A conversation with Dr. Fred Kennedy, director, DARPA Tactical Technology Office

Joe Mariani and Isaac Jenkins

THE DELOITTE CENTER FOR GOVERNMENT INSIGHTS

Many technologies we use today, from PDAs to GPS receivers, originated from the Defense Advanced Projects Agency. Dr. Fred Kennedy of DARPA discusses the advanced technologies it is currently exploring.

Take out your phone, open the voice assistant, and ask it to give you directions to the pizza place. That seemingly simple act relies on three different technologies: the voice assistant to understand and process your question, GPS to find your current location, and the internet to find the pizza place nearest to that location. Now, you may know that as the easiest way to get your next tasty slice of pepperoni and green pepper, but you may not know that all of those technologies—the internet (1969),[1] miniaturized GPS receivers (1983),[2] personalized assistants that learn (2007)[3]—came from the same place. Not some Silicon Valley powerhouse. Not even from a massive aerospace company. They all came from the Defense Advanced Projects Agency, or DARPA.

For 60 years, DARPA has been supporting the most advanced technologies. But DARPA was not created to make take-out easier—it was created in 1957, under a cloud of fear.[4] The Soviet Union had just launched Sputnik and much of the United States was caught off guard by the sudden technological advance. In the aftermath of Sputnik there was a frenzy of activity. NASA and the National Reconnaissance Office were created, and a small organization named ARPA (it would add the "D" in 1972) was tasked with preventing a similar technological surprise from ever happening again. To do so, DARPA has dedicated itself to developing the most advanced technologies first, before anyone else can do so.

If our pizza story is an indication, DARPA has been quite successful thus far. In some sense, we all live in the world that DARPA has helped to create. So, what is next? What are the emerging technologies and ideas that will shape the coming decades? To find out, we sat down with Dr. Fred Kennedy, the director of DARPA's Tactical Technology Office.

## The future is ... a change in technology

**JOE MARIANI:** You oversee a wide portfolio of projects, but you have said that one of the key themes of your portfolio is the transition from irreplaceable, expensive, exquisite assets to constellations of small, cheaper, connected assets. Can you start by just describing that transition a bit more and what it means for the military?

**FRED KENNEDY:** Most of our systems, especially in space and on the sea, are high-value assets that, although they have exquisite capabilities, are incredibly expensive and require vast amounts of time to build. For example, the F-35 took 23 years from the start of development to the first deployment to a combat squadron. The Space Based Infrared System (SBIRS) took 24 years from requirements to full deployment of all satellites. The USS Gerald R. Ford aircraft carrier will not complete its sea trials until more than 19 years have elapsed since its original design. And the list goes on.

This allows potential adversaries ample time to analyze our systems, tactics, techniques, and procedures and develop countermeasures to them. So even before we have fielded these systems, they are in a sense outdated.

So what do we need to do? Well, we need to disrupt ourselves. Change our way of doing business to put the cost burden back on our adversaries and make them think on the fly, not vice versa.

That is what we are trying to do with DARPA's Blackjack project. Blackjack is a space-based internet, but rather than relying on a few, expensive communications satellites like today, it will be enabled by an interconnected network of small, inexpensive satellites in low earth orbit. Using thousands of satellites makes it incredibly resilient to attack, and the inexpensive nature of those satellites makes it fast and cheap to upgrade. New capabilities can be added in months or years, not the decades of traditional systems.

**JM:** This seems like a huge transition. What makes it so necessary? Is the problem protecting these critical assets or is it something larger?

**FK:** No, it is not at all about protection. There is always going to be someone out there to attack your assets even with the best protective capabilities.

For example, take the aircraft carrier. The carrier's days are numbered. You absolutely have to disaggregate the carrier and its air wing if you hope to operate in a contested environment. When we are talking about a threat environment where a carrier and its escorts are traveling at *n* knots and a salvo of missiles is incoming at 100 times n knots, it's going to be very hard to commit an expensive and heavily manned asset like a carrier to the fight. And our adversaries know this.

The problem this highlights is that we are not agile or responsive enough *organizationally* to meet the threats of a near peer power. We need new capabilities, new thinking to address the threat of ballistic missiles to carriers. But those new capabilities simply cannot take 30 years to be fielded, as current business practices dictate. That will simply be too late to matter.

It's going to come down to: Can we do this fast enough before we get surprised? And I think the answer is yes. But it's not just about finding new technology. It's about the culture and the institutions. The future will not be defined by major assets, because anything we can't afford to lose in battle cannot be the future of battle. The future will be about expendable assets, networked together in real time to form a hyperconnected information environment.

So, the goal is to be agile enough to dominate the next war, or better yet, to deter the next war. We want to create a deterrent so scary that no one wants to attack us in the first place. We're not fighting the last war; we're solving for the next war—and how to prevent it.

**JM:** How far can this transition go? Is it just space and aircraft carriers? Does life change for a soldier on the ground?

**FK:** Yes. It's multidomain. It's air, sea, land, space, and cyberspace. It's everything. The acting Secretary of Defense describes it as a consolidated battle management system.

What does that mean? Well, the defining question of future conflict is not about if our planes or tanks can beat an adversary's planes or tanks. The question is if our information can beat an adversary's information. Can we collect, analyze, distribute, and act on information faster than they can? And that's what Blackjack—with its space-based internet—is intended to address. Then add on top of that what we call Pit Boss and you begin to get an answer to that question.

Blackjack is intended to take advantage of the infrastructure provided by a space-based internet. Pit Boss is a key element in that program—the information management layer that sits on top of Blackjack's satellites. Much like the pit boss in a casino has a view of all gaming tables, Pit Boss decides what needs to be collected, how it should be collected, and where that information should be sent. That information can be sent to users in every domain, from other space systems to individual soldiers, airmen, and sailors. It is fundamentally about shortening the decision cycle. Getting perishable information from sensor to shooter much faster.

DR. FRED KENNEDY

The goal is to get exactly the information that a person needs to them exactly when they need it. Imagine a soldier dropped into a war zone—can I make sure he's not waiting another 30 minutes or even 30 seconds for a satellite to pass overhead, but instead give him real-time awareness of who's around the corner? And how do I make sure I get him that information, while providing slightly different information relevant for his buddy three blocks over? No one wants to come around that corner and be surprised.

Now to do that, you need to solve some really hard problems. For example, you need to be context-sensitive both about your information and nodes on the network. You need to know that an infantry unit needs different information about the current situation than a tank, even if that tank is only a few blocks away. But that is how you know what is coming around the corner. That is how you mitigate surprise at every level. Whoever can solve that problem is going to win.

Total data transparency is coming whether we like it or not. And so we need to be prepared because it is expected to bring with it massive changes. In the future, everyone will likely see everything. When that happens, how do you gain the advantage?

**JM:** Some of those challenges sound like cutting-edge computer science problems. Does integrating that level of advanced research into assets require a new approach to how we design those assets?

**FK:** Yes, absolutely. We definitely need to change the architecture, and to do that we need to change the organizational culture, which is incredibly risk-averse. Today, the culture is focused on technical success, but it isn't postured to recognize that we're dealing with an adversary, not just putting assets into a vacuum. It's no longer sanctuary; it's a contested space. We can't continue to whistle past the graveyard, because our adversaries are not just following our lead. They are pursuing different strategies that threaten our technological superiority.

To change the architecture, we need to change the culture, but you can't kill the existing culture that fast. It will likely take a generation to change. But when we do finally make that change, we will see PC and iPhone levels of innovation. We can finally achieve a Moore's Law pace of change in space, and get rapid, mass production of these assets. At that point, when the cost and time constraints come down, that is when innovation kicks in, because then everyone can play. When satellites cost hundreds of millions of dollars and take years of investment to finally fly, very few companies can manage that. But when you can launch a 750 Kg satellite for US$1 million, almost anyone can do it. That lowers the "energy barrier" to participating, so lots of folks can get involved—any smart engineer with a venture capital pitch.

And when everyone can do it, and can do it quickly and at low cost, risk goes down. More companies can build more assets, and then I don't care as much if I lose one of them. More companies also means more new ideas flooding into the industry. The result is that when you reduce that fear of risk, you can innovate more quickly. By innovating more quickly, you force our adversaries to respond to us, and not vice versa. So we are not the ones that have to respond in the heat of the moment to an unexpected threat with costly new technologies—like armored vehicles and jamming to respond to roadside bombs. Finally, our adversaries are the ones that have to assume that cost burden.

## The future is ... government and industry together

**JM:** Your description of that path to innovation involved a lot of commercial companies. Does that mean that the shift from "exquisite to expendable" also changes how we have to buy those assets? How the government needs to work with industry to build them?

**FK:** This shift is going to be hard. It is something we can do, but only if we can discard old, comfortable ways of doing business. Government could build these assets alone, but we will be slower and will spend far more money if we try to do it ourselves. In short, we would do it wrong. Our problem is that we are pathologically risk-averse. We would have a very hard time justifying the replacement of our legacy systems with a new, distributed architecture, without commercial industry paving the way. The private sector will do it, if there's a business case, and they'll do it faster.

But right now, there is an "energy barrier" preventing companies from getting involved. Lack of incentive for private companies to get involved in these areas is a classic problem. That is where Blackjack comes in again. Blackjack is not about DARPA building spacecraft better. It is about working with industry to create the tools and techniques that can allow the transition from exquisite to expendable. At the same time, it can provide commercial industry a jumping-off point for their own ventures.

A number of commercial companies are looking to build space-based internet services that would support something like Blackjack. We want to help. Just like railroads and seaports and airports, we want to ensure the infrastructure is in place that will enable further innovation. It will likely be some form of government–private partnership. As we've seen, there is inherent risk in supporting private ventures, and that type of risk is not something that the government space industry is used to assuming. But this transition from exquisite to expendable will be so transformational that even if only one of those new systems works we have to be a part of it.

**JM:** Does that risk come from the fact that these private business models may not pan out like the first generation of satellite communications?

**FK:** People say that we have seen this before and that it is destined to fail. But this is not 1994. The problems are not the same. The technology has changed, and what we can do has changed.

Will the business cases for these new companies ever be entirely self-funding? That, I don't know. Maybe not. It may be that there we'll have to provide the equivalent of a government subsidy. Like railroads, like aviation, it's about infrastructure.

So we will leverage the commercial efforts, and others can play on the same playground. We have to assume there will be international use of this commons. But that does raise the question of how will our data ride along with other people's data and if we can keep it secure.

**JM:** Is close cooperation with private industry difficult for those in national security, where secrecy and security are so highly prized?

**FK:** People are always telling me there is a security problem, but I don't see it as the major hurdle. There's a security problem inherent in all communications, in the internet, and companies are investing heavily in security already.

Government is not the only one worried about keeping its data safe while "sharing the rails" with other users. Another likely use of that space-based internet is in financial services. They'll take advantage of the low latency of the communications to do financial arbitrage. That community is certainly interested in locking down those communications, so security is not something I am particularly worried about. In some form, it will be there.

## The future is ... faster decisions

**JM:** Military strategy and business strategy both seem to rely on having information your competition doesn't have. So how do you win a fight or run a business in that world of "total transparency" when everyone can see everything?

**FK:** It's all about what you do with that information. Everything comes down to making faster decisions. So winning becomes about the apps and the analytics and getting them to provide timely results at scale.

Think about a battalion deploying to seize an airfield. You drop your assets, you drop your airborne units, you converge and set up base camp, and then you disperse to control the battlespace. But does it ever work that way? No, never. You land on the ground, and it's never easy. There's a team over here, a pallet landed five miles away, base camp is never optimal. How can you get beyond that? That's where the data comes in. One of our projects looks to transform everything in that mission into a sensor. So every pallet, every aircraft, every soldier is telling you where it is and what it is doing. All that data can then be made available to a "central data engine." With all of that information in one place, perhaps you can adjust and adapt on the fly. A unit can be retasked according to changing circumstances to accomplish the overall mission—not just left to focus on completing a subordinate task in a plan that may already be obsolete.

All of that technology will help, not replace, the commander. The commander needs to make the important decisions. The information just augments the human decision-maker to speed up the process.

It will be a real human–machine team. That is the future.

**JM:** In previous discussions, we heard that the introduction of technologies such as drones and blue force trackers in the 2000s initially increased a commander's desire and instinct to micromanage.[5] Will having all of this data available at the tactical edge similarly result in more micromanagement?

**FK:** No, because it will provide too much data. With so many microdecisions, all coming so quickly, a single individual just cannot keep up. They won't be able to micromanage even if they wanted to. You need an automated system just to help sort through all of the information and the decisions to be made.

At a strategic level, where there is time to make a decision, sure, you could get "analysis paralysis," where decision-makers are tempted to wait for more and more data. But those tactical scenarios will simply move too quickly to be micromanaged.

**JM:** Sort of like your high-frequency traders again? The leadership can monitor trends and set risk-thresholds, but could never possibly micromanage every trade?

**FK:** Exactly, you got it.

## The future is ... when?

### HOW TO ADOPT NEW TECHNOLOGIES

**JM:** The exquisite-to-expendable transition can change how technology is built, how it is bought, and even how we make decisions. These seem like huge changes. How long will it take for all of them to take root and when will we really see those benefits?

**FK:** To answer that question, we need to look at how innovation typically works today. Most military innovations begin as corner solutions. They solve for extremely complex, unusual problems. So the technology gets better and the assets get better by collecting all of these solutions to rare problems, and these are ultimately incremental innovations. That is to say that these innovations just make existing assets slightly better by covering rare use cases or incrementally improving performance. They do not address the underlying basis for that performance. The result is that there are vast areas of unexplored performance, areas where we can do really cool things.

For example, I often get asked, "Can you really perform as well with microsatellites as the exquisite, legacy platforms?" The answer was, not yet, not everywhere. But I can find where the performance gaps are, and I can close them. Can you do high-resolution imagery of the earth's surface from a constellation of microsats? Right now, we cannot do it as well as the exquisite system, but it is improving and it is a solvable problem. They'll say, sure, but you really need to get the timing perfect. Granted, but maybe we can solve that as well. You solve each one of these capability gaps in turn and very quickly the answer becomes, "Yes, microsats can do everything just as well as the exquisite, traditional satellites" plus do it faster and more cheaply.

Initially, we will be able to perform at or near the level of the legacy assets. But over time, our performance will improve. We will add new sensors, new capabilities, and we will do that faster than the legacy assets could possibly match. So, over time, we will supplant existing technologies with our better agility. We will win with innovation.

**JM:** That is fascinating. The trajectory you just described—filling performance niches that are currently overlooked and then increasing capability until you displace incumbents—is exactly the academic theory of disruptive innovation that Clayton Christenson and others have written about.[6] How does that displacement of legacy technologies finally play out? It seems like the big hurdle is not technology—which can be figured out in time—but rather organizational culture?

**FK:** Yes. Initially, those legacy systems will undoubtedly continue. They are part of the organizational culture, and culture takes time to change. So new and legacy technologies will likely continue in parallel for a while, until some crisis forces a change. Take the attack on Taranto in 1940 where British planes put half the Italian fleet out of action in one day. That attack was one of the watershed moments that crystalized in everyone's mind that aircraft carriers—not battleships—were the capital asset of the future. What we need today is a digital Taranto.

**JM:** Perhaps we could substitute many small crises for one big one. Earlier, you mentioned being surprised coming around a corner, and as someone who has been surprised like that, it is not pleasant. So maybe many small crises could motivate the shift to many small assets!

The transition from carriers to battleships also introduces another idea. While there were outspoken advocates for carriers such as Billy Mitchell, who paid with his career, there were also quieter advocates such as Admiral William Moffet. They used what later writers have described as "disguising" to cast the disruptive carrier initially in a supporting role to the battleship to help it win acceptance. Do you see the exquisite-to-expendable transition following similar tactics, perhaps arguing that it is a shift to protect legacy assets?

**FK:** No, I am not interested in disguising, because this transition is not about protecting legacy assets; it is about replacing them. If you start talking protecting assets, you will just continue to accrete more solutions to better and better protect those legacy assets, without ever getting real change. But no matter how well you think you are doing at protecting your assets, there is always going to be someone that comes at us with something new that you cannot protect against.

That is what this transition is all about: avoiding that surprise. For 60 years, that has been DARPA's mission, and this is the way to do that for the future: to design small, replaceable assets so that you can innovate faster and put the burden of responding to surprise back on the adversary.

That is what the future looks like.

# Endnotes

1. Defence Advanced Research Projects Agency (DARPA), "ARPANET," accessed February 8, 2019.
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5. Joe Mariani, "Leading to chaos: A conversation with General Stanley McChrystal," *Deloitte Review* 19, July 25, 2016.
6. Clayton M. Christensen et al., "What is disruptive innovation?," *Harvard Business Review*, December 2015.

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