Air Combat, the Mesh, and the Cloud

Employing fifth-generation technology

by LtCol Stanton S. Coerr, USMCR

The F–35 is a multirole, stealth-capable supersonic aircraft. The Marine version will be short takeoff and vertical landing capable. *(Photo by John E. Wilson, Lockheed Martin.)*

The F–35B Lightning II Joint Strike Fighter (JSF) will be the dominant actor on the networked battlefield. At last, what has until now been a roaring flood of information—video, raw data, coordinates, voice, satellite imagery—will be slowed, channeled, and presented in a useful way. This aircraft, which will be the first to truly employ fifth-generation technology, is currently imprisoned by a third-generation warfighting construct. Leveraging the JSF, and maximizing its capabilities to integrate and synthesize the battlefield into a coherent whole, requires a new framework for sharing information. The fifth generation of technology must be preceded intellectually by a fifth-generation paradigm.

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The Paradigm

That paradigm is the "cloud." The cloud, among computer scientists,

"No hay camino; solo la trayectoria nostros hace moveindose adelante."
(There is no road; there is only the path we make by moving forward.)
—Spanish poet, Antonio Machado

refers to both an idea and a place. Rather than storing information on a device—a hard drive, a disk, a medium you can hold in your hand—the user pushes information to the cloud. The cloud is a server, a network, or a combination of the two. It is both where information resides and a method of moving it from place to place. As we develop the cloud in its application for war, we are moving into a new world.

The concept is that rather than carrying information around with him, the user simply carries a port to the information, which is stored elsewhere. This port is a laptop, a netbook, an iPhone, or a similar device. The information storage itself requires massive bandwidth, storage, and piping; the portal, by contrast, is cheap, light, simple, and low tech. Using a port frees the user from the burdens, security risks, and prospects of loss of huge amounts of information. In the classified realm, such loss is even more profound. It frees up the user, allowing him to use a far less powerful portal to access what would otherwise be a tsunami of information. In this way he can sift and sort what he needs, using the cloud as a reservoir.

As an example of the storage problem, a new high-powered telescope, brought on line this summer, collected more raw data on the universe in 2 days than has been collected in the entire history of astronomy to this point. Researchers discovered within the first few hours that they would soon overrun their storage capacity, and the information they did manage to keep would be nearly useless. Finding a new star, quasar, or black hole in this flood of data would be like looking for one sentence in an unnamed book in the Library of Congress. It is there, somewhere, but may as well not be.

Such an overflow of data creates the same problem as a dearth of data. The user is paralyzed. The problem is no longer in collection. The difficulty now lies in synthesis of the flow and in presentation protocols translating the flow into useful form. Sifting supersedes storing.

The paradigm of the cloud creates a problem with two parts. Like with that new telescope, we must first address storing the massive amounts of data that will flow from next-generation machines and sensors. Second, we must create protocols to sort, synthesize, and serve that information to an end user. We need a server in the sky.

Process

The most frustrating decision process in the modern technology world is that of a binary decision tree. Automated telephone prompts, such as those of airline reservation lines, are built in this paradigm, sending users down one-way cul-de-sacs of information. Continual bumping into such

We can use the F–35 and maximize its capabilities to integrate the battlefield with a fifth-generation paradigm. *(Photo by Sgt Michael S. Cifuentes.)*

dead ends and forced backtracking over and across already covered information causes cognitive shutdown. This type of system imprisons the user, and information is trapped.

With such voice prompts at one end of the spectrum, at the other end is Google. Google is the cloud, a simple portal to untold terabytes of information. This is an example of the irony and paradox of modern systems of systems approaches: a brilliant scientist can be reduced to helpless fury by a simple series of phone prompts, while inversely a 3-year-old child can master the Internet through Google. That child knows that typing letters into a box on a computer screen will allow him to pull up a game he enjoys. He knows, further, that every single time he wants to play that game, it will be right where it was before. He doesn't need to know how to store it on the computer in front of him, and he doesn't need to know protocol levels to get at it. It lives somewhere else. No one really knows, or cares, where the information is stored. As long as the portal works, the interface works.

Push

Since the beginning of armed conflict men have tried to impose order on war, with such rigidity reaching apotheosis in the Prussian and German staff models. In the midst of existential chaos, the human mind begins to shut down options, trying to clarify a confusing situation into a pattern it has seen before and can therefore follow. Such a mental process limits human potential, which in turn limits battlefield decisionmaking. With such reality as background, officers and military theoreticians tried to impose order on an inherently entropic process. If the battlefield couldn't be controlled, at least the people could be.

This is called a "command push" heuristic, which dominated leadership and warfare up until the Soviets were embarrassed in Afghanistan and the Iraqis in Kuwait, and maneuver warfare and its tenets became ascendant. It meant that someone important decided that he wanted something done, ordered it so, and his underlings ran off and made it happen. Decisions were made in peace and executed in violent chaos—sending the boys over the World War I trenchlines into German machineguns, or ordering lumbering armored columns down single lane streets into Grozny. Command push, simply put, was a hierarchy in structure and in thinking.

Marines who came across Iraqi (Soviet bought) tanks during Operation Desert Storm climbed inside and were struck by the fact that these vehicles had communications to receive but could not transmit. This is the mental framework in which the Soviets and their proxy armies operated, and it is why they were defeated wholesale as fighting forces with the command hierarchy ideology left to rot.

The push model is deliberate, stepwise, and staid. This model sees information as a product to be pushed in "batches," chunks of data delivered staccato, punctuated by dead time. In the realm of intelligence gathering and fusion, the problem with a command push paradigm is that an order might have come down from days before, and the area of interest could well have (in fact, probably had) changed. If a ship moves, if tanks suddenly drive off perpendicular to their previous route of march, if a small insurgent cell appears and then melts away, the command push paradigm is helpless to adjust. Like the binary phone tree cul-de-sac, there is no going back, no way out, no one to whom you could appeal. You are stuck.

In an unmanned aircraft analogy, command push is represented by the first generation of the Global Hawk.

This was a more capable, higher flying, longer range, longer loiter aircraft that was superior in every way to any other unmanned system, with one exception. Global Hawk was programmed before it left the ground. Based on a command push profile, it flew a preprogrammed route (sometimes for 24 hours or more) and then returned. What if someone saw a new target during that time? Too bad. The aircraft was command pushed, programmed the day before, and unable to change its waypoints.

Pull

A decade ago the military went through a brief, faddish addiction to the term "recon pull." The idea of recon pull was that a small reconnaissance element—a team of men hiding in the mountains, an airplane high above the battlefield, an officer analyzing a satellite image—would demand further collection on a source. Intelligence was prioritized in realtime, with assets routed or rerouted to where they were needed.

The pull model is operationally focused, ad hoc, and flexible. In contrast to the batch construct for the push model, the pull is a realtime system. Information is delivered when it is needed and flows at the user's desire, but not otherwise. Though the term recon pull is itself now passé, the military maintains a strong cognitive bias for the idea. It is from whence military strategy grows and against which military thought is measured by modern officers.

Col John Boyd, USAF(Ret), and his merry band of maneuver warfare disciples used this heuristic for everything—fighter tactics, light infantry training, operational-level ship movements, even set-piece division-sized battle theory on the Mesopotamian plain. Whereas command push ideas meshed with heavy shock forces, a recon pull paradigm depends on light, agile forces led by officers who think and lead with imagination and verve.

Further to our unmanned aircraft example, the recon pull idea inheres. As Global Hawk was developing, so too was the smaller, slower, lower Predator. Predators were (and are) flown by pilots via realtime satellite link and can be sent where they are needed. This is the recon pull paradigm: if someone sees something of interest, he can divert this asset, in realtime, to go take a look. Information flows smoothly, and the flood is channeled and routed where it needs to go.

Portal

Adults know that any information they need can be pulled—and any they produce can be pushed—to the ether, and then pushed or pulled again and again as needed. Even our game-playing 3-year-old knows it. People around the world can edit a document simultaneously, and then save it (push it to the cloud). A tourist looking for a building can pull down grid coordinates, street names, a photo of the building—even a realtime photo of the traffic in front of the building—with a pocket-sized portal. The only hardware is a connection and an input device. Storage, session, interface, and protocols are clean and adjust to the user.

Aviators used to note, accurately and with admiration, that the F–4 Phantom was a "rocket with wings." Similarly, the JSF (which, take note, is already flying) is a server with wings. This aircraft will be fast, but not particularly so. It will be nimble, but no more so than many other line fighters. It will carry the same missiles and bombs that everyone else does. What will set the JSF apart will be its processing power and its ability to pull and push information around the battlespace.

Network-centric operations will inevitably be characterized by the cloud concept, with air, ground, sea, and satellite sensors pushing data to and through a mesh network and pulling data across a mesh. The mesh will be an interleaved nodal network, alive with information but designed to route only what the user needs and only when he needs it. The JSF will sit astride that mesh, pulling from sensors across the battlefield, fusing that information into a useful format and pack-

The pilot can easily be overwhelmed with a tsunami of data from the aircraft. *(Photo by David Drais.)*

ages, and pushing it as needed in real-time. The user—a Marine on the ground, a commander on a ship—will need only a portal.

With assured and consistent access, some applications and information will be locally available, but the bulk of data storage and synthesis will occur above this level. The mesh will be the paradigm for the self-healing multinodal pathways by which data flows, finding its way to its destination like water flowing around rocks.

In the user-cloud interaction, the mesh is the data pathway. The product for user data interface must leverage modularity described in the OSI (open system interconnection) reference model while producing a useful integrated whole. The problem will be in marrying next-generation technology to last-generation systems, and creating session presentation that allows the processing power of the JSF to run unfettered.

This is the prison in which data is currently held. We Americans are on the third generation of warfare, with state fighting state (or, as in our Afghanistan campaign, wishing we had a state to fight). We are still on the third generation of technology, with sophisticated fighter-bombers dropping explosives in front of people using maps spread across the hoods of HMMWVs and 20-pound radios to direct them. We are fighting our way out of the last generation of intellectual underpinning to the whole process, lurching back and forth between counterforce battles, such as those in Iraq, and counterguerrilla fights, such as those in Afghanistan, and trying to predict the military after next.

Path

Overarching all of this is our leap to the next-generation fighter. When the JSF comes on line, with a 10-airplane detachment ready to deploy in 2012, it will be simply another fighter and bomber if data pipes, protocols, process, portals and, most important, paradigms are not in place. Moving to the fifth-generation fighter does not mean buying another piece of hardware. It means changing from binary to mesh heuristics, from push to pull, and from batch to flow.

The JSF can be the category killer, the dominant species in the brutally competitive life and death world of military aviation. Information will move across the mesh, driven by the extraordinary computing power of a rugged airplane that can fly through the sound barrier and then land vertically on a road or on a pitching aircraft carrier at night.

We have never seen anything like this aircraft; it is not going too far to say that one of these planes will be able to run the battlefield. The recon pull paradigm is now the de facto and default baseline for the way we think about the future of war—realtime decisions, realtime changes, realtime effects.

USMC