

On Drones and the Paris Air Show

Mounting military experience points to armies of drones and industries of many.

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While I did not attend this week's Paris Air Show, the news flow and my ongoing research and analysis lead me to four main points about drones:

Mounting combat experience indicates that military spending on unmanned aircraft will increase sharply.

The diversity of drone builders showcased indicates an ongoing Hyundaization of the military aircraft industry.

Policy-makers should realize that wartime mobilization will necessarily favor unmanned over manned aircraft, because the latter cannot be built quickly.

Investors and industrialists should anticipate that even without a big war, the rise of drone makers may quicken.

Firms mentioned in this report include Atlas (Latvia), Baykar, Boeing, Elbit, Eurofighter GmbH, General Atomics, Leonardo, Lockheed Martin, MBDA, Northrop Grumman, Saab, Sierra Nevada, Tekever (Portugal), Turgis & Gaillard (France), and Ukroboronprom.

The preliminary judgement of Paris holds that mounting military experience points to armies of drones.

Drone technology and its industry have come a long way in the past few decades. In the 2008 symposium of the Association of Unmanned Vehicles Systems International (AUVSI), my colleague Ben Doeckel (later of Raytheon Missile Systems) remarked on the procession of straight-winged, pusher-propeller, surveillance aircraft lining the halls. Such an industry was bound to shake out, and it did. Fifteen years later, at this year's Sea-Air-Space show at National Harbor, Maryland, drones were everywhere: multi-copters, tail-sitters—all manner of solutions, and increasingly armed solutions. I noted halting progress as well. Bell Aircraft brought a model of a tilt-rotor drone with sonobuoys and torpedos, but the video was copyrighted 2021.

Then came this week's Paris Air Show. As Marina De Russé wrote for Agence France Presse earlier this week, drones "stole the spotlight." Suddenly, Romania is buying drones not just from Turkey's Baykar, but also from Israel's Elbit. Portugal's Tekever is sending drones to Ukraine with British financing. Italy's Leonardo is finally integrating a missile, MBDA's excellent Brimstone, aboard its Falco Xplorer drone. Baykar (with its already-legendary TB2) and Latvia's Atlas (with its "pocket drones") are each working to establish drone-building factories inside Ukraine, albeit with differing success. (See the serial reporting by Elisabeth Gosselin-Malo.)

It is understandable. As a senior Norwegian officer said at the Norwegian-American Defense Industrial Conference in Arlington, Virginia, this past March, "we were whispering in the hallways a few years ago about grenades on drones." Now the videos of tiny bombers taking out tanks and individual infantrymen are all over the Internet. In this context, noted Turkish analyst Can Kasapoglu finds that the experience of the Syrian Civil War, the 2020 Second Nagorno-Karabakh War, and the Russo-Ukrainian War point to several military-technical lessons. Drones do good work suppressing "low-to-mid-range" air defenses. When integrated with land-based precision weapons, drones do even more lethal work. Thus, without adequate sensors, electronic jamming, and counter-drone weaponry, "traditional ground units are in trouble."

To wit, as T.X. Hammes has noted, around Nagorno-Karabakh, 70 percent of the tanks destroyed were lost to drones. To achieve this level of destruction, access to international markets has mattered. Utilizing data from the Stockholm International Peace Research Institute, Greg Sanders' team at the Center for Strategic and International Studies (CSIS) estimated that Azerbaijan's arms imports from 2011 through 2020 were more than eight times Armenia's. Remarkably, Azerbaijan's imports from Russia were far greater than those from Turkey, but the Turkish drones the Azeris imported killed many more targets than the Russian armored vehicles did.

Perhaps drawing on those lessons, both sides in the Russo-Ukrainian War have resisted drone attacks better. At least until the recent offensive, US Army Intelligence was estimating that about a quarter of tanks destroyed have been lost to drones or loitering munitions. Then again, another 35 to 40 percent have been lost to cannon and missile artillery—whose targets are generally spotted by drones (analysis by Duane Stefaniak). The Ukrainians have also been using drones yet more creatively, and necessarily so, given the efficacy of air defenses on both sides. As Seth Jones and his team at the CSIS put it, Ukrainian innovation with drones spans battlefield awareness, target identification, strike, and "information operations" (damage assessment and publicity). The Ukrainians are boasting of "a drone in every trench," and of sending attacking infantry companies into battle with as many as 100 drones. Armed maneuver against this sort of pocket air force has become very difficult. Mark Clingan, a brigadier general of the US Marine Corps, recently noted that with those lessons in mind, the US Army and the USMC have already changed their initial infantry training to include spotting targets with drones.

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As news outlets continue to report, Russian attacks with Iranian loitering munitions (one-way attack drones) continue to vex Ukrainian air defenses. Ukrainian Minister of Defence Oleksii Reznikov noted on Twitter this week his “very productive call with [his] colleague, Minister of Defence of Israeli, Yoav Gallant,” seeking Israel’s assistance in dealing with their common enemy. That Ukraine would be calling Israel to deal with Iran’s supply of precision weapons to Russia would have seemed a strange thought not long ago, but such has been the rapid evolution of this worldwide industry. In April 2020, the now-regrettably-defunct Center for the Study of the Drone at Bard College reported that the number of countries with operational drone capabilities in their armed forces rose from 60 in 2010 to at least 102. The Center’s long-time director, Dan Gettinger, more recently estimated that “120 entities in over 30 countries are developing or producing these weapons or have done so previously.”

How did this happen? Drones have been a classic “disruptive” innovation, in Clay Christensen’s sense—even if, as Jill Lepore has observed, this type of disruption is hardly the only form of innovation. While drones currently underperform manned aircraft in almost every respect, they are also much less costly, and that matters for most powers with less money than the Americans. As I wrote in a paper with Mark Revor in 2014, drones bear the hallmarks of democratized information-based technologies, in that they offer a remarkable breadth of use, pace of development, operational potential for dispersion and concealment, and rapid diffusion across borders. In this last respect, they have been easy to sell. Loitering munitions, in particular, offer self-contained kill chains and a low degree of operational complexity (again, Greg Sanders *et alia*). They are easy to master organizationally in wartime, and by military forces with lesser resources than those of the greater powers. As Michael Horowitz (see below) would say, they pose low demands on military forces’ absorptive capacity for innovations. As Greg Myer recently reported for National Public Radio in the US, training for Ukrainian drone pilots lasts as little as a week—not a year, as with F-16s.

Today, the Ukrainians are building hundreds of armed drones daily. The Ukrainian Ministry of Defense and Ministry of Digitization are cooperating on the “Army of Drones” project, which is not at all an incredibly frightening concept. Building on this experience, as Riley Bailey and others at the Institute for the Study of War have noted, the Ukrainians have forged ahead with plans for much larger unmanned aircraft. In October 2022, Ukroboronprom announced development work on a drone with an operational range of 1,000 kilometers. Last week, that state-owned arms conglomerate announced that the Ukrainian Armed Forces had already used this drone operationally, perhaps in effecting some of those mysterious explosions deep inside Russia. Similarly, as noted analyst Dr. Can Kasapoglu recently wrote, “Turkish drone design and production capacity has reached a critical mass when it comes to tactical and medium-altitude/long-endurance systems, opening the door to increasingly higher-end sensors and larger combat payloads entering service.” In more than one realm, the learners have become the masters.

Wartime mobilization will necessarily favor unmanned over manned aircraft.

All this argues for a pending paradigmatic shift in our understanding of how wars should be fought. Loss rates from missiles in the air and precision attack on the ground will be very high. Thus, manned aircraft (at least those that are not quite stealthy) may be substantially restricted to operating within the support envelopes of their own surface-based air defense systems. Further, all military aviation will need to be field-independent and truck-portable, or based at great range from the front. Regardless of form, unmanned military aviation is gradually but assuredly supplanting manned military aviation in most roles.

The one mission seemingly out of reach remains air-to-air combat, but some modest developments suggest otherwise. As Patrick Tucker of *Defense One* wrote over three years ago, there was that series of dogfights in the simulator in which the algorithm kept beating the F-16 pilot, but that scripted game may not have been grounded in operational context. Then again, as Nicholas Slayton of *Task & Purpose* reported just last month, drone-on-drone dogfights have already occurred above the trenches in Ukraine, albeit only by ramming unarmed surveillance drones into one another. That is notably akin to how aerial combat began in the First World War—with reconnaissance pilots realizing that they could and should use their sidearms against one another. That quickly graduated to machine guns. More notably now, the Ukrainians have openly discussed building drones to shoot down Iranian Shahed kamikaze drones (missiles).

That has real implications for even American military procurement plans. The limited run of Boeing's F-15EX Eagle II is supposed to produce a linebacker, an aircraft with a large quiver of air-to-air missiles, ranging behind the lines to find and destroy ingressing cruise missiles, so that the stealth aircraft can tend to more penetrating problems. But could that role be undertaken more cost-effectively with drones? Rear areas should be relatively electronically secure, as air forces necessarily demand positive control of that mission. More generally, the lower cost of drones would certainly be important after any high initial losses of manned aircraft in a big war. After all, no country will have much potential to build quickly a lot more Eurofighters or Joint Strike Fighters or any other manned fighters. Across the worldwide industry, Lockheed Martin's F-16s and F-35s, Boeing F-15s and F-18s, Saab's JAS-39s, and Eurofighter's FGR4s all take about three years to build. Lockheed and its suppliers would struggle to build much more than 150 F-35s annually, but that many could be lost in just a few weeks of fighting China. If the war is not expected to last much more than three years, trying to expand production would be counterproductive.

To increase numbers in that context, the Air Force chiefs of staff from France, Germany, and Spain signed a "collaborative air combat" agreement at the show in Paris, on a common view of their Future Combat Air System (FCAS). This system of successors to the Rafael and the Eurofighter will be anchored on a *command fighter*—an airplane that can fight by itself in the air while controlling unmanned aircraft and commanding other manned aircraft (reporting by Vivienne Machi). However, whatever comes behind manned aircraft lost in combat will necessarily be unmanned, necessitating different tactics and operational significance. Tony Osborne reported earlier this month that the Royal Navy intends to test General Atomics' new Mojave short take-off and landing attack drone (analogous to its MQ-9 Reaper) from HMS

Prince of Wales. That is an excellent idea, but it will not quite backfill for any lost F-35s. As Lichen Pursley of General Atomics stressed at an Atlantic Council event recently, aircraft of this type are medium-altitude standoff surveillance systems—too valuable and too vulnerable to anti-aircraft missiles to hazard close to the front.

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However drones are employed, Air Force generals should stop calling drones “remotely piloted aircraft.” As Missy Cummings, director of the Director of Mason Autonomy and Robotics Center at George Mason University, has argued, Northrop Grumman’s RQ-4 Global Hawk and MQ-4C Triton are not at *piloted* in any sense of the term, and this will be increasingly true of long-range, autonomous aircraft. The flight crews remotely manage the drones with keystrokes, not joysticks. This portends organizational upheavals, with air forces run more like space forces—managed by engineers, not pilots. It is notable, then, as Greg Sanders’ team reports, that most American military spending on drones still resides with the US Army. Cultural resistance to change will continue to pose barriers to adoption, right up until it no longer does.

Along the way, there will be churn in requirements and suppliers. In August 2021, startup firm Volsani was making a big impression at Sea-Air-Space, with its combination fixed-and-rotary-wing drone for long-range logistics. What happened? Early the next year, I heard the comment that its CEO Will Roper, a former head of Air Force procurement, “couldn’t get a meeting in the Pentagon.” Without firmer customer interest, the firm failed to attract further funding, and was sold in October 2022 to Sierra Nevada (reporting by Stephen Losey). In contrast, in April 2023, Leidos won a contract from the US Marine Corps for its SeaOnyx resupply drone (see the article in *Seapower* magazine). Note that neither Sierra Nevada nor Leidos is a longstanding aircraft manufacturer, but also is neither a start up. The same could be said for General Atomics.

The US Air Force seems to be publicly pining for churn. At an event at George Mason University last month, Andrew Hunter, the new Air and Space Forces procurement chief, said that he anticipated that “20 to 30 competitors” would offer to build the forthcoming Collaborate Combat Aircraft (CCA), a stealth jet-powered drone designed to accompany F-35s and the future Next Generation Air Dominance aircraft into combat. The FCAS chiefs notably made no such prediction. Writing yesterday about the Paris Air Show, Byron Callan of Capital Alpha Partners noted that Europe “has seen very few defense/security firms emerge in years.” One exception, he and many others noted, is Turgis et Gaillard. Founded in 2011, the company was showing its Aarok drone, said to fly 30 hours at 250 knots. That timescale vouches for the idea that entry into military markets of even modest scope can take a decade or more.

Once established in arms markets, of course, stable customer relationships can last for decades. However, building drones is more like making missiles than assembling aircraft, with larger volumes, faster learning curves, more frequent technology injections. These differing factors affect how one organizes production, manages supplier relationships and alliances, and markets to existing and new customers. Notably, Lockheed Martin makes both fighters and missiles. Boeing is making at least a few more fighters. RTX’s Raytheon makes missiles,

but could make loitering munitions. General Atomics and many others focus on drones, though General Atomics has maintained a 40 percent market share of the acknowledged military spending on drones in the US over the past dozen years. It is just that the US military's spending on manned aircraft is still 20 times its spending on unmanned (once more, Greg Sanders *et alia*).

That ratio may decrease considerably. The CCA will be expensive, and two are planned for each F-35 and each NGAD. The US Air Force's planned successors to General Atomics MQ-9 Reaper and Northrop Grumman's RQ-4 Global Hawk are still "black" (unacknowledged, secret) projects, and black generally also means expensive. Because we keep seeing photographs of oddly-shaped aircraft flying at high altitudes around the world, and because we know that the Air Force rightfully fears Russian and Chinese air defenses, we should expect that its next long-range, high-altitude drone will be stealthy. Lieutenant General David Nahom, the deputy chief of staff for plans and programs, told the Senate in 2021 that what follows the Global Hawk will be ready between 2027 and 2029, and what follows the Reaper will come sometime in the 2030s (reporting by John Tirpak). No particular schedule for the CCA has been made explicit. That gives General Atomics and the rest of the "20 to 30" some time. The big question in selecting a firm to build a stealthy drone is which will be more important: experience with stealth, or experience with drones? The smaller and more numerous the aircraft, the more we should bet on a new industrial structure.

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