Drones: Over the Hill and Far Away

by Donald Wilkins

The recent Russian-Ukrainian "special military action" showcases relatively unsophisticated, unmanned aerial vehicles (UAVs), or drones, in a number of military missions. Drones, foreign- and Ukrainian-built, support the defenders by performing reconnaissance and attack missions. Images of Russian small vehicles, air vehicles and armored vehicles destroyed by the comparatively quiet drones proliferate on the Internet.

The amount of video coverage of the special military action is plentiful and, probably in many instances, misleading if not outright faked. Oddly the videos very rarely reflect any successful Russian operations. The Ukrainians are utterly dominating the information war. Equally strange, the Russians do not seem to employ drones or effective anti-drone defenses. Although the Russians have claimed destruction of a few UAVs, their defenses have not been enough to deter reconnaissance or strike missions by the Ukrainians.

In fairness, some attacks have been described as missile-based, while the same attack, in other reports, are described as drone-based. What is clear is that the Ukrainians have used a variety of drones, some commercial, others military, still others are home-brewed machines cobbled together by technically savvy civilians using spare parts.

UAV support crucial

The absence of UAV support fits with the apparent blundering of Russian combat operations. Perhaps when the special military action is over, Russian reporting will be unfettered and the bleak picture of Russian ineptitude will be balanced by other descriptions. Regardless of apparent Russian mistakes, the need to integrate drones into the U.S. armory was abundantly apparent even before the current collision between Russia and Ukraine.

U.S. military forces could integrate drones onto armored vehicles with the UAVs riding on the decks of tanks and armored personnel carriers; the drone control stations could be placed internal to the armor. Appropriately armed, provisioned with sensors and guided by autonomous navigation systems, the UAVs provide over-the-hill reconnaissance and attack capabilities, together with defense against hostile drones.

To prompt discussion on the employment of drones, the following scenario is provided. Five M1A1s are assigned to clear enemy forces that may be occupying a narrow pass through a series of low hills. Each tank carries an electrically driven quadcopter on its aft deck. The maximum speed of a quadcopter is 60 mph, enabling the drone to spring ahead of the carrier vehicle (tank). Its range is about 10 miles, although this limitation is more a function of communications line-of-sight rather than energy storage. After a sprint to its operational area, the drone can loiter over the target area for two hours before returning to its tank carrier to be recharged.

The quadcopter's composition minimizes metal and thus radar reflections, while the hull has limited ability to match the color of the sky. The vehicle's cooling system points skyward, making tracking by thermal sensors very difficult. Aerodynamic design, based on techniques derived from birds of prey, reduces the quadcopter's acoustic footprint. It's not stealthy in the sense of the F-35 Lightening II, but it's quiet and chameleon-like enough to evade tactical sensors.

Within five miles of the objective, the quadcopters lift from their tanks and speed ahead of the armored column. The first drone carries long range, high-resolution sensors; two carry a pair of anti-armor grenades fitted with tail fins; and the rest of the drones carry light automatic weapons. Airborne, the drones autonomously form a communications network while flying to the designated area. Signal compression reduces demands on bandwidth and vehicle power. Video and other sensor data are transmitted to the tanks, where the controller monitors the drone, supplying input as needed.

The controller in the tank does not "fly" the UAV in the sense of using a joystick to control drone trajectory. The controller simply selects a spot on a computer screen depicting the surrounding terrain; the UAV possesses enough processing power and sensors to autonomously fly to the desired location. In general, the drones will follow or "swarm" with the designated leader. However, various elements of the flight can be tasked to individual missions if the vehicle is released to its controller.

Feedback from the drone – which includes sensor video, mission and vehicle status – are displayed on the visor of the helmet the controller wears. Enhanced images, merged from at least two sensors operating at two different frequencies, provide enlarged pictures of suspected targets and enable increasing awareness of the battlefield for the tanks. Weapons release requires positive authorization by the controller.

The UAVs have enough mounting points so a number of mission loads, depending on operational needs, can be incorporated onto the vehicles. In this instance, the lead drone, carrying radar and high-resolution infrared sensors, detects two small, low-flying objects circling the pass. Immediately one of the drones, equipped with an automatic weapon, surges toward the objects. A controller in one of the tanks identifies the objects as enemy drones and authorizes an attack.

The first enemy drone is easily downed. Alerted by the loss, the enemy controller sends the survivor into violent maneuvers. The attacking drone autonomously locks onto the juking enemy, matches vectors and downs its opponent.

Jamming of the drone links immediately begins but the tank-drone links skip through the frequencies. The drones rise higher to peek over the hills. Six enemy tanks are behind the hills, accompanied by dismounted infantry, probably with anti-tank weapons. The enemy occupies the reverse side of the hills. Thermal plumes from the tanks and infantry moving into fighting positions show an aroused enemy willing to fight for the pass.

The drone controllers confirm targets and authorize the drones to attack. Two drones swoop close to the enemy armor, depositing anti-tank grenades on the lightly armored tops of the vehicles. Four of the hostile tanks erupt with explosions and fires.

The drone's laser paints the survivors. Two tanks elevate guns. Drone location, range to target are geometrically merged with the tanks' positions. Two shots are fired, and the remaining tanks are destroyed.

The fifth drone is released to autonomous attack. It drops lower, strafing the entrenched troops. Its firing does little damage, but the buzzing drone darting unscathed through hostile ground fire is a morale-breaker. Deciding discretion is the only part of valor, the enemy infantry flees.

Recall brings the UAVs back to the tank decks. The drones autonomously settle down onto the inductors that will refuel the craft. A report from one reveals an imminent motor failure. The status is included in the after-action report beamed to the rear. In response, two larger logistics UAVs arrive. One uncurls a long proboscis and begins refueling the tanks. The other drops bullets and grenades. It drops off a replacement drone while picking up the dubious drone for rear-area maintenance. When the area is secure, the tank crews will rearm the drones.

Protecting supply lines

The need for drone resupply is underlined by U.S. operations in Iraq and Afghanistan as well as Russian activities in Ukraine. Supply lines are traditional weaknesses subject to interdiction by enemy action and weather. Difficult to protect, often confined to roads, snaking through built-up areas, current logistics trains can be subject to well-prepared ambush and destruction of infrastructure such as bridges and culverts.

Aerial resupply alleviates many of those concerns. Flying supplies in UAVs can take varying routes, making ambush difficult to prepare. Manpower is conserved and can be reassigned to other missions. Small forces, such as the one described in this article, can be resupplied in the field, thereby extending operational time. Freed of traditional logistics transport, armor can operate with fewer constraints, becoming the force originally envisioned by the first theoreticians of armored warfare.

Basing drones on the decks of armored vehicles will extend the range of the drones and provide immediate air support for the vehicles, extending the column's defensive onion, which would otherwise shrink under the glare of enemy drones. Therefore, higher command could allocate more capable, and scarce, resources to more critical and better-defended objectives.

Way ahead

Current technology implemented in diverse applications could be quickly and inexpensively brought together to serve the warfighter. Technical risks, however, must be addressed.

First, a control structure must be implemented that guarantees safe operation of crewed and autonomous air vehicles within the same air and ground spaces. Areas of congestion such as airfields are particularly worrisome. The Federal Aviation Administration and Federal Communications Commission have started development and definition of such a control structure, but considerable work must be done to refine and deploy the necessary communications and control infrastructure.

Part of the development must take into account voice communications between air-traffic controllers and drones. Speech recognition by machines is currently inadequate for the task.

The human-machine interface between tactical operator and drone requires careful development. Optimizing the interface, increasing efficiency coordination and minimizing human workload are critical needs for the system. Cost vs. utility will determine device selection.

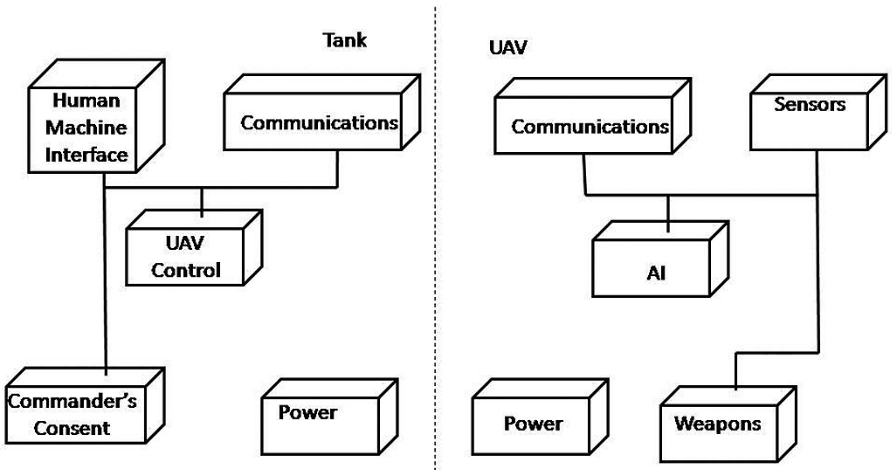

Figure 1. Way ahead for drones. *(Graphic by author)*

For example, a true three-dimensional display could be fed information from the drones. However, current designs of three-dimensional displays are expensive, and the processing capability needed to generate the images requires considerable resources. Does utility of display outweigh its cost and complexity?

Autonomous operations

Autonomous operations of the drone must be maximized without compromising safety. This will be critical to reducing operator workload because troopers have other tasks to perform in the tank beside the drones, including the demands on communications. The release of weapons from the drones must always require positive consent from the tactical operator.

The squadron commander's responsibilities will increase with the addition of the drones. The commander must include the UAVs in mission planning and in command-and-control during operations. New techniques must evolve to ensure the commander can effectively direct the varied resources under his/her responsibility.

During experiments with mobile ground stations controlling unmanned ground vehicles, a significant issue was motion sickness induced in the operator as the vehicle he was riding in moved in a different direction than the machine he/she was trying to control. Artificial intelligence aboard the drone offers relief from this problem. Removing the need for the operator to monitor, second by second, the trajectory of a different vehicle could eliminate or at least reduce to "manageable levels" the operator's distress.

Extending range, increasing payload and optimizing the loiter time over the target area will require weight reduction and an increase in power storage for the drones. Methods to accelerate refueling must also be developed, as current approaches take too much time.

Other considerations

Basing the drone on the deck of the tank will expose the drone to high temperatures. Therefore the design of the docking station must not block the flow of waste heat from the tank engines.

Doctrine must also be revised to take full advantage of the incorporation of tactical drones into the force structure. Present dreams of drone usage border on the fantastic, ignoring issues of range, payload, cost and a host of other factors that must be compared and contrasted to produce the needed design.

Once developed for practical operation, drones will substantially enhance the armored force's capabilities. Drones riding into battle with armored forces would put the surprised expressions of the Russians mired in the current "special military operation" onto the faces of enemy forces facing U.S. armor.

Donald Wilkins, a retired electronics engineer who holds 12 patents, has extensive experience with system design, requirements decomposition and assignment, autonomous systems, human-machine interfaces and *electronics design and manufacturing. During Wilkins' assignments with McDonnell Aerospace, he developed requirements for, designed, developed, manufactured and integrated the first color display for a U.S. fighter; developed requirements for, designed, developed, manufactured and integrated the first liquid crystal display for a U.S. fighter; developed requirements for, designed, developed and manufactured the avionics suite for advanced aircraft; developed requirements for, designed, developed, manufactured and integrated the first helmet-mounted display for a U.S. fighter; integrated the avionics suite for the MQ-25 program (U.S. Navy unmanned air system prototype); designed and integrated the avionics suite for a commercial cargo drone; and managed development of the neural architecture for mission planning. During his career, Wilkins' work entailed gathering requirements from U.S. Air Force, U.S. Navy and U.S. Army personnel to understand operational needs and translate those requirements into hardware and software instantiations. These designs were translated into physical implementations and, if the program was fully funded, into environmental and flight testing before going into production. Early in his career, Wilkins served as a U.S. Army Signal Corps first lieutenant with Headquarters and Headquarters Battery, 1st Battalion, 13th Field Artillery Regiment, 24th Infantry Division, Fort Stewart, GA; and as Signal Corps second lieutenant with 169th Signal Company, 36th Signal Battalion, Camp Humphreys, Republic of Korea. Wilkins has a bachelor's of science degree in electrical engineering from the University of Oklahoma and a master's of science degree in electrical engineering from the University of Missouri-Rolla.*

Acronym Quick-Scan

JTARV – Joint Tactical Aerial Resupply Vehicle
NTC – National Training Center
UAV – unmanned aerial vehicle

Figure 2. 11th Armored Cavalry Regiment and the Threat Systems Management Office operate a swarm of 40 drones to test the rotational unit's capabilities during the "Battle of Razish" on the National Training Center (NTC) May 8, 2019. This exercise was the first of many held at NTC located at Fort Irwin, CA. *(U.S. Army Photo by PV2 James Newsome)*

Figure 3. Soldiers of 3rd U.S. Infantry Regiment (The Old Guard), along with the Army Research Laboratory, participate in a Joint Tactical Aerial Resupply Vehicle (JTARV) exercise on Fort A.P. Hill, VA, Sept. 22, 2017. During the exercise, the JTARV showed its potential for one day making it possible for Soldiers on the battlefield to order resupply and then receive those supplies from an autonomous unmanned aerial vehicle. *(U.S. Army photo by PFC Gabriel Silva)*

Figure 4. Soldiers of 3rd U.S. Infantry Regiment (The Old Guard) receive supplies from a Joint Tactical Aerial Resupply Vehicle (JTARV) on Fort A.P. Hill, VA, Sept. 22, 2017. The JTARV, a quadcopter also known as the hover-bike, could someday make it possible for Soldiers on the battlefield to order resupply and then receive supplies from an unmanned aerial vehicle. *(U.S. Army photo by PFC Gabriel Silva)*

Figure 5. Soldiers of 3rd U.S. Infantry Regiment (The Old Guard), along with the Army Research Laboratory, participate in a JTARV exercise on Fort A.P. Hill, VA, Sept. 22, 2017. During the exercise, the JTARV showed its potential for one day making it possible for Soldiers on the battlefield to order resupply and then receive those supplies from an autonomous unmanned aerial vehicle. *(U.S. Army photo by PFC Gabriel Silva)*