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CRUSER · NEWS

Consortium for Robotics and Unmanned Systems Education and Research

From Technical to Ethical...From Concept Generation to Experimentation

Contents

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Special Edition

ROBOT ETHICS AND FUTURE WAR

by CAPT (ret) Wayne P. Hughes, Jr., USN, Professor of Practice, NPS, whughes@nps.edu

> "We may be on the leading edge of a new age of tactics. Call it the "age of robotics." Unpeopled air, surface, and subsurface vehicles have a brilliant, if disconcerting, future in warfare."
> Hughes, *Fleet Tactics and Coastal Combat, 1999*

On 14 December I listened to a lecture by Professor George Lucas entitled "Military Technologies and the Resort to War." This was for three reasons. First, I respect him as a distinguished expert on military ethics. Second, at NPS we have extensive research in air, surface, and subsurface unmanned vehicles. At the behest of the Secretary of the Navy the many components were recently consolidated in a center acronymed CRUSER[1] in which the ethics of robotic warfare is included explicitly. Third, a decade ago I addressed the Commonwealth Club of San Francisco on Just War.[2] For reasons that will become apparent, Just War Doctrine is inadequate to guide U. S. military actions, so I will conclude by speculating on suitable policies—or doctrine—to illustrate what might serve the nation and armed forces today.

Lucas described a common concern in ethical debates about the use of unmanned aerial vehicles (UAVs, or when armed, UCAVs). He put due stress on the future of autonomous lethal platforms, in other words robots, and on the development of cyber weapons. These and other emerging technologies such as autonomous or unmanned underwater vehicles (AUVs or UUVs) carrying mines or torpedoes might render war itself less destructive and costly, raising concern that it would be easier to rationalize their employment in inter-state conflict. This would lower the threshold for going to war, which then might expand in unanticipated, unintended, and deadly ways.

Three days later I attended out-briefings of short, sweet student work, the purpose of which was to develop analytical tools to examine Marine amphibious operations when the enemy could not defend all possible landing points. Small, unmanned reconnaissance vehicles figured prominently in the teams' tactics.

Soon thereafter came reports of a powerful, lethal, UCAV attack by the CIA into Pakistan that did considerable damage and resulted in sharp reactions in Pakistan. The attack illustrated quite well the points Lucas had made.

There are two issues, one being whether the U. S. ought to pursue robots energetically, the other being Lucas' emphasis on the "threshold problem." Both led him to discuss classical just war doctrine and one of its guiding principles, which is that war should only be contemplated as a last resort. International law, just war doctrine as interpreted today, and (I will add) the Weinberger-Powell doctrine of the Reagan administration, all assert that war is only justified when every option for conflict resolution short of war has been attempted first. Both international law and just war doctrine limit just causes to defense against territorial aggression, i.e., invasion. The Weinberger doctrine carried no such limitation but it had its own quite sensible strictures.[3]

Lucas then discussed what sort of "principle" is a principle of last resort, and whether it carries an unconditional duty to wait or is contingent and subject to revision under different expected outcomes. In other words, as anyone knows who has studied international law and classical just war writings, the subject will unavoidably become arcane and legalistic. In conclusion, Lucas swept away some of the underbrush, saying war, like lying or law-breaking or killing, is a species of action always prohibited (I would have said "always undesirable"), hence it will require an overriding justification after first exhausting all non-violent alternatives.

JUST WAR INJUSTICE

In the question and answer period Professor Dorothy Denning, a nationally known expert on computer security, pointed out the sabotage of computer controls of Iranian centrifuges. An intrusion, called a Stuxnet worm, was doubtless a cyber attack on Iran's nuclear weapons program and by all reports a very effective one, setting back Iran's hope of developing nuclear weapons for months or even years. Denning observed that whoever the perpetrator might be, it was not a last resort attack. In the arcane logic of just war doctrine, however, it was a preventive attack, an action which sometimes is considered just.[4]

The pertinent issue is that Cyber attacks are not contemplated in international law, just war doctrine, or the Weinberger-Powell doctrine, yet attacks and intrusions are going on right now in many forms. This new manifestation of conflict—attacks on computers and attempts to protect their content for safe operation—is a constant, complicated, and destructive non-lethal activity. Against terrorists, unwritten American policy is domestic defense complemented with overseas offense against an elusive but often-identifiable enemy with deadly intent. Cyberwar is a good bit more intricate to frame. Cyber attacks world-wide have involved actions by states, surrogate attackers acting for some purpose that may or may not be state-sponsored, individuals who are interested in financial or other criminal gain, or just clever hackers who intrude or plant worms for the personal satisfaction of being a pest. Their domain extends from combat effectiveness on a battlefield, to attacks on national infrastructure such as the financial system or electrical grid, to exploitation of the enemy information system for espionage.[5] The Naval Postgraduate School is bombarded with attackers all the time and our internal defenses, aided by the Computer Science and Information Science Department faculties, are in some instances capable of locating the source. As in all forms of warfare, defense alone is difficult. If counterattacks were authorized for appropriate government organizations and agencies an "active defense," might give pause to some attackers. Cyber attacks beg for a "combat" doctrine of defense coupled with counterattacks.[6]

The second question from the audience came from an Air Force officer student. He asked if it was ethical not to pursue robots and robotic warfare when they save the lives of pilots—or soldiers, or sailors.

A third observation came from Professor Mark Dankel. He said in a crisis at the edge of war, robots might be the first on scene and the safest way to reconnoiter the situation, exhibit an American presence, and indicate our intention to respond with minimum escalatory actions. I thought Dankel also implied that a last resort criterion presumes robot involvement to be the source of the crisis. There is no whisper in it of an enemy who may be striving to attack, whether by cyber attack, by polluting water reservoirs with germs, or with a big bomb in a shipping terminal. A doctrine of last resort does not address threats of action by China against an Asian ally that we are committed to defend. Nor does last resort contemplate that by assuming responsibility to keep the seas free for the trade and prosperity of all the nations, we might have to threaten an attack on a country which claims ownership of a trade route and the right to deny free passage.

JUST WARS AND "DEMOCIDES"

I don't know that classical just war doctrine described by Augustine, Thomas Aquinas, or Hugo Grotius specifically forbids interference in the internal affairs of a state, but Michael Walzer, who is one of its principal contemporary interpreters, says no state has a just basis for interfering with the internal affairs of another. The Weinberger-Powell doctrine has no such provision. Certainly Colin Powell as Secretary of State for President Bush endorsed the anti-terrorist campaign in Afghanistan and the liberation of Iraq from the despot, Saddam Hussein. In recent experience every instance of outside interference has come after many and patient warnings by the United Nations and sovereign states because a tyrant must never back down, his personal survival being at stake. The issue is important because a government's murder of its own people is frequent in modern times. Thus, a doctrine that contemplates interference to stop a despot from killing his own state's population is as important today as a doctrine to prevent wars between states when killing is the foremost ethical issue.

Democide is a word coined by Professor Rudolph J. Rummel in his "Death by Government," published in 1994. It is defined to be killing by government when no interstate war exists. We are all aware of the purges of Jews by Nazis before and during World War II. Many are aware as well of the democide in the Soviet Union inflicted by Joseph Stalin. More recently, many Americans have demanded interference with African nations' democides.

The most pernicious example of murder or starvation of its own people is China. The democide within China is estimated by Rummel to be 77 million of its own people in the 20th Century.[7] By contrast, 0.6 million soldiers died in battle and from disease in our major internal war, from 1861 to 1865.[8] China is a state we want to influence but not intrude upon, much less go to war with. A decision about going to war ought to include one practical maxim as fundamental as any in doctrine: "Never pick on somebody your own size." The corollary is, "Avoid an attack by a strong power by indicating that the cost of its attack will exceed any reward it might expect."

Director's Corner

Ray Buettner, CRUSER Director

We continue this month with our effort to more seriously explore topics of interest to the CRUSER community. The ethics of employing autonomous vehicles, and even unmanned vehicles, has been much in the news for several years. This discussion is quite appropriate and demands the attention of the CRUSER membership and indeed everyone who is engaged in the development, deployment, and employment of robots in war and crisis situations that entail killing. Attached without change is a the first of part of a paper written by my NPS colleague, Captain Wayne Hughes, USN retired. Wayne is Dean Emeritus and is much published, including his classic Fleet Tactics and Coastal Combat. The second of Captain Hughes' paper will appear in the next CRUSER Newsletter. Enjoy!

THE CENTRAL ISSUE OF ROBOT DEVELOPMENT

Touched on by Lucas and brought to the forefront by Denning and the Air Force officer is the central question, Who gets to choose? The fundamental error of a debate over robot development is to assume we have a choice. A shift to a new era of robotic warfare is underway. Among our many visiting lecturers on new technologies, an expert on robotics and autonomous vehicles said pointedly ". . . it's not a question of whether robots will have the ability to select their targets and fire their weapons. It's a question of when."[9]

We should ponder the ethics of robot war—and every other form of lethal conflict—when we control the situation, but a doctrine of last resort fits neither the circumstances of small wars nor those intended to influence and constrain a peer competitor. The assumption that the availability of robots will lead to our use of them is the more insidious because many American military leaders don't look favorably on autonomous vehicles or robotic warfare. Yet the Chinese already have in considerable numbers cheap, autonomous little weapons called Harpies. Upon launching a swarm of them, they will fly to a predetermined point and circle while searching for a designated radar signal from a warship. Once the frequency is detected, a Harpy will home on the transmitter and destroy the radar. Swarms of them are the forerunners of what navies will see in future wars that include robots.

Recall the result of The Washington Naval Disarmament Treaty of 1922. By constraining the development of battleships the treaty hastened the development of aircraft carriers, especially in the American and Japanese navies. An unexpected consequence of international law which forbad unrestricted submarine attacks was to breed a generation of American submarine commanding officers who were trained in peacetime to attack warships from long range and had difficulty adapting to merchant ship attacks at point blank range.

A simple policy of last resort for cyberwar or robotic attacks is untenable. A better point of view is to frame a suitably ethical policy for conducting cyber operations and employing autonomous vehicles—in the air, on the ground, and in the water—while staying technologically current and tactically ready. Combat doctrine, called "tactics, techniques, and procedures," already exists for missiles, mines, and torpedoes. What is involved is constant revision, first, to link new tactics with new technologies, and second, to integrate the geopolitical environment with American economic realities.

[1] Consortium for Robotics and Unmanned Systems Education and Research
[2] Preceded by vigorous discussions at The Hoover Institution as the guest of one of the Navy's great philosophers, VADM Jim Stockdale.
[3] The Weinberger Doctrine is widely thought to have been drafted by his military assistant, BG Colin Powell. It had six tests, abbreviated here: (1) a purpose vital to our national interest or that of an ally, (2) a commitment to fight "wholeheartedly and with the clear intention of winning," (3) with "clearly defined political and military objectives," (4) subject to continual reassessment and adjustment, (5) entailing "reasonable assurance that we will have the support of the American people and . . . Congress" and (6) "The commitment of U. S. forces to combat should be the last resort."
[4] A defensive preemptive attack when an enemy attack is imminent and certain, by contrast, is doctrinally just.
[5] Cyberwar is a term coined many years ago by Professor John Arquilla of the NPS faculty. His writings are a treasure chest of sound thinking on information warfare in its many manifestations. To grasp his several contributions that relate cyber operations to just war doctrine, start with "Can Information Warfare Ever Be Just?," in The Journal of Ethics and Information, Volume 1, Issue 3, 1999.
[6] I have been told an active defense from NPS or other DoD organizations would require a change of the law. NPS is a good laboratory for study because our defenses are superb, but our faculty expertise is in teaching and research. Teachers don't think of themselves as "combatants." We exemplify the need for a comprehensive policy. The maxim is that when there is a war going on, learn how to fight it before a serious defeat is suffered.
[7] Taken from R. J. Rummel, China's Bloody Century (2007). Here are his numbers: 1928-1937: 850,000; 1937-1945: 250,000; 1945-1949: 2,323,000; 1954-1958: 8,427,000; 1959-1963: 10,729,000 plus in the same period 38,000,000 more deaths from famine; 1964-1975: 7,731,000; and 1976-1987: 874,000. Rummel claims that deaths imposed within states were six times greater than the deaths from all wars between states in the 20th Century.
[8] A proper comparison would include civilian deaths. That number is hard to find. In his classic, Battle Cry of Freedom, James McPherson estimates it to be 50,000. This seems remarkably low, but if the number were several times bigger, American deaths that seem staggering to us are small compared to China's.
[9] The speaker was George Bekey, Emeritus Professor of Computer Science at the University of Southern California and visiting Professor of Engineering at Cal Poly in San Luis Obispo.

From the General Chair of 23rd AIAA Aerodynamic Decelerator Systems Technology Conference

by Prof. Oleg Yakimenko, ADSC Director, NPS Systems Engineering Faculty, oayakime@nps.edu

The AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar took place 30 Mar - 2 Apr 2015 in Daytona Beach, FL and was held in conjunction with the Parachute Industry Association Meeting and Symposium. This event provided the world's leading scientists, engineers, researchers, and managers from NASA, Draper Laboratory, Boeing, and Natick SRDEC, as well as promising students from a half a dozen universities working in the field of parachute and aerodynamic decelerator systems, an opportunity to present recent advances in modeling and simulation, system applications and operations, design and development, materials and manufacturing, testing, and more. Some of conference highlights included a discussion of recent Google executive space jump, plans to land a heavy unmanned rover on Mars in 2020 using inflatable decelerator and the largest round parachute, parachute cluster system for NASA's Orion crew module re-entry from deep space missions, Boeing's Crew Space Transportation system to provide NASA with transportation to and from the International Space Station, recent advances in precision autonomous aerial payload delivery.

The Aerodynamic Decelerator Systems Center at NPS (ADSC) is involved in some of these projects and provides a wide variety of thesis opportunities in different areas, such as conceptual design, mission planning, CSD/CFD/FSI analysis, computer modeling, image processing, photogrammetry, system identification, control engineering, sensor integration, test and evaluation. Among conference attendees there were two NPS MS graduates who helped establishing ADSC in the early 00's and now became Draper Laboratory Associate Director for Defense Systems and Boeing Test Director, and two recent NPS PhD graduates who worked on a precision guided airdrop for vertical replenishment of Naval vessels and ram-air parafoil based delivery system modeling. Supported by CRUSER, ADSC conducts regular testing of different concepts and systems at Camp Roberts using Arcturus Jump 20 VTOL UAV as an autonomous high-performance deployment platform.

The Ladder Side of Drones

Eric Hanscom, Managing Attorney, InterContinental IP, Eric@icipLAW.com

My wife is from Thailand and every summer my family spends part of the summer in Thailand. My father-in-law owns a farm with a cement shingle roof that is too fragile to walk across, so he asked me to use my drone to shoot video of the roof and show him where a leak was originating. It was an easy flight and took all of 5 minutes to see where a workman had failed to completely cover a hole in the roof made when installing a TV antenna.

My brother-in-law was a Buddhist monk at a nearby temple and he saw me fly doing the roof inspection at the farm, then asked me if I would mind using my drone to inspect the roofs of his temple. I immediately understood why. Thai temples are usually 40' or more high, and the roofs are steeply pitched, making roof inspection difficult. Adding to the difficulty are the ladders they use: bamboo frames with bamboo steps held together with some combination of screws, nails, and pieces of inner tubes tied together. So, roof inspections at the temples are among the least popular jobs around a temple, and usually fall on the newest (and lightest) monks.

I showed up with my drone and flew over all of their temples, then downloaded the video and stills onto a laptop which they looked at and decided what parts needed fixing. The older monks were happy to get a bird's eye view of their temple roofs, and the younger monks were delighted not to have to climb the rickety ladders. After using the drone to inspect the roofs, they were able to hire a cherry-picker to come in and safely do the repairs. The monks spread the word and we now have a number of other temples which have requested drone roof inspections for our visit next summer.

http://ireport.cnn.com/docs/DOC-1164686 and **https://www.youtube.com/watch?v=UzaLhICUT9c**

Librarian Corner

Mind the Gap: The Lack of Accountability for Killer Robots
http://www.hrw.org/sites/default/files/reports/arms0415_ForUpload_0.pdf

NPS Student Graduate Theses & Projects
http://my.nps.edu/web/cruser/resources

CRUSER Calendar of Events

CRUSER Robo-Ethics: 14-16 Apr
Monthly Meeting - Mon 18 May, 1200 (PDT)
Monthly Meeting - Mon 1 Jun 1200-1250 (PDT)
details/remote connect at: http://CRUSER.nps.edu

Drones Ideal for Spectral Imagery Sensors – Here's Why

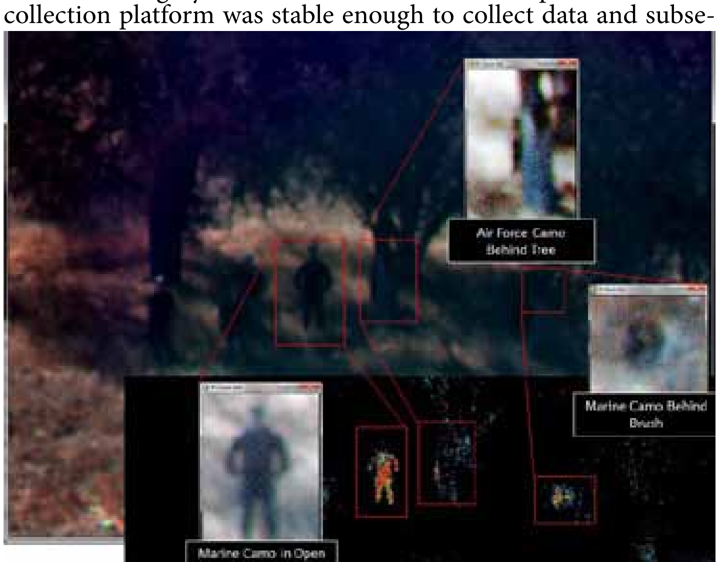
by Tim Haynie, Spectrobotics, Business Development Mgr, thaynie@spectrabotics.com

Spectral imagery collection and exploitation from a small Unmanned Aerial System (sUAS) was recently demonstrated at the Naval Post Graduate School's Joint Interagency Field Experiment (JIFX) and the Secretary of Defense's Rapid Reaction Technology Office (RRTO) Thunderstorm 15-3 for both multi and hyperspectral sensor systems. While spectral imagery collection and exploitation from high-altitude and satellite platforms have been around for many years and are well-documented, recent advancements in sUAS systems make them an ideal platform for spectral data collection for their increased resolutions, dynamic flight profiles and introduce a new dimension in data collection thinking.

At the JIFX, the sUAS platform used for the Pixelteq SpectroCam ™ multispectral camera was an eight-engine multicopter controlled with a 3DR open-source Pixhawk flight control computer as found in many commercial systems. The system consumed roughly 18,000 watts of power to manage both the flight control, sensor operations and demonstrated a 25-minute flight time. At the Thunderstorm 15-3 demonstration, the smaller, lighter Headwall Photonics Nano-Hyperspec ™ required only a six-engine multicopter flown with the same flight control computer (3DR Pixhawk) and attained a 15 minute flight time.

These Spectral sensors record reflected light energy across the electromagnetic spectrum in the Visible and Near Infrared (VNIR) region (400-1100 nanometers). The Pixelteq SpectroCam ™ uses eight filters to record the light-energy in multispectral bands while the Headwall Photonics Nano-Hyperspec™ records 270-bands of hyperspectral data using a diffraction grating to split the incoming light energy into measurable bands. Post-flight analysis of the spectral data was able to identify physical and chemical features within the scene for material identifications using a reference spectra (library signature of a target material.)

For the JIFX, the team demonstrated the versatility of the multispectral sensor/platform to not only record overhead imagery of target materials, but also lowered the platform below the tree line to collect imagery off-nadir and below the canopies. The sUAS collection platform was stable enough to collect data and subsequent analysis successfully detected the presence of the target material (military uniforms) despite being in shadows and masked by foliage.



The dynamic flight characteristics of the multirotor sUASs were essential to the hyperspectral data collection at Thunderstorm 15-3 because of the need for a high-precision flight path. Scanning an urban area for the presence of a chemical hazard (Methyl salicylate simulant), the Nano-Hyperspec™ required overhead collection at very specific speed and altitude in order to maintain the correct exposure and frame-rate needed for proper sensor operation. This can only be accomplished using autonomous flight under the control of the sUAS's 3DR Pixhawk flight management system. The hyperspectral imager was able to detect the chemical simulant hidden within an urban environment after flying an autonomous "lawnmower pattern" over the target area.

The use of the sUAS platform for these sensors directly improved the temporal and spatial resolutions for the spectral imagery sensors above those attained through satellite and high-flying manned/unmanned systems, even those hosting larger, more capable sensors. Temporal resolution was significantly enhanced as data collection was completed within an hour of notification of the target area encompassing mission planning, flight/data collection and system recovery. The low-level flight of the sUAS was able to capture data at a 3-inch spatial resolution which helped analyst by collecting data with up to 100% pixel-saturation of the target material. It is also important to note that despite the cloud cover (that would have prevented high-altitude collections) and filtered sunlight the sensors were able to collect sufficient data for analysis that detected the target simulant material.

The combination of these resolution-enhancements, coupled with the increased flexibility of a sUAS to alter its flight performance based on the individual sensor collection requirements make the sUAS a viable platform to not only incorporate other sensor systems, but also explore flight parameters that expand the data-potential of these systems. Data collection from aerial systems has always been performed from a two-dimensional plane (fixed orbit, operating altitude); the sUAS, multicopters in particular, enables data collection from a three-dimensional space and the ease of deployment and operation increase their frequency of use giving more on-demand data.

Our next level of effort is infuse this "sUASA data-layer" into the overall intelligence data cloud architecture and begin to open the data for advanced analytics by other users. sUAS systems will eventually host other types of sensors beyond cameras recoding imagery (vapor sensors, signals detectors, laser rangefinding for 3D modeling to name a few) and the true benefits of the sUAS technology are the potential to increase the number of sensors deployed and broaden access to places unattainable by conventional platforms.

Participating in these two events and comprising "Team Peregrine" were Spectrabotics, Autonomous Avionics, PixelTec, and Exogenesis Solution from Colorado and Headwall Photonics from Massachusetts.

STUDENT CORNER

Student: LT Brenton Campbell, USN

Title: Human robotic swarm interaction using an artificial physics approach

Curriculum: Applied Physics

Link to Completed Thesis: http://calhoun.nps.edu/handle/10945/44531

Abstract:

This thesis explores the use of an artificial physics framework to provide centralized control of a collection of agents in close proximity to a human operator. Based on the spatial separation between agents, agents to way-point, and agents to operator, the artificial physics framework calculates virtual forces that are summed and translated into velocity commands. The virtual forces are modeled after real physical forces such as gravitational and Coulomb, forces but are not restricted to them, for example, the force magnitude may not be proportional to one divided by separation distance squared. These virtual forces allow the collection of agents, or the swarm, to autonomously find the operator, create a formation, and navigate way-points. The operator has high-level control of the agents via a hand held-controller. This framework is applicable to a scenario where an operator in the field needs to work with several autonomous vehicles but is unable to devote a high-level of focus to controlling agent behavior.We implemented an artificial physics framework in two simulation environments and in physical indoor experiments with a team of three unmanned aerial vehicles. The results from the physical experiments show that an artificial physics-based framework is an effective way to allow multiple agents to follow a human operator inside a small arena with only minimal operator input.

NMSU Physical Science Lab tests new Unmanned Aircraft System with Vanilla Aircraft

by Dennis Zaklan, Deputy Director, UAS FTC, New Mexico State University, dzaklan@psl.nmsu.edu

Under the New Mexico State University Physical Science Laboratory Unmanned Aircraft Flight Test Center's Certificate of Authorization (COA) Vanilla Aircraft LLC successfully completed the first flight of the VA001 Unmanned Aircraft System (UAS), a 36-ft wingspan Ultra-Long Endurance (ULE) aircraft designed to fly missions of up to 10 days, on Feb. 25.

The aircraft (N240HR) launched carrying an 18-lb simulated payload and sufficient fuel for a 24-hour flight. Powered by an efficient heavy-fuel engine, the UAS flew autonomously in Las Cruces national airspace at altitudes up to 6,000 feet MSL, meeting all test objectives prior to landing.

"The team's hard work really paid off – the airplane flew beautifully and showed all the performance we expected. This maiden flight test provided validation of the VA001 design and its remarkable capabilities," said Neil Boertlein, co-founder and chief engineer for the VA001.

The VA001 went through the NMSU UAS FTC's airworthiness assessment program under the oversight of the Federal Aviation Administration's UAS Integration Office. The inaugural flight was the culmination of the extensive efforts of the Vanilla design and flight team working hand-in-hand with the NMSU UAS FTC crew to responsibly address the many details and challenges of integrating the flight of a new unmanned aircraft into public airspace.

"Working with NMSU was truly a pleasure," said Jeremy Novara, co-founder and flight director of Vanilla Aircraft. "All of us at Vanilla concur that the NMSU team's enthusiasm and efforts contributed to the successful outcome of our program."

Initial flight of the VA001 UAS validated the airworthiness assessment of the aircraft's control system, airframe, power plant and other subsystems of the aircraft and ground control segments.

"The maiden flight of this UAS was something truly to behold," said Dennis Zaklan, deputy director of the NMSU UAS FTC. "It was the culmination of a dedicated group of professionals from both Vanilla Aircraft and the NMSU FTC that ensured success. Working with the Vanilla team was pleasure and they will always be welcomed back."

Additional flight tests are being planned with Vanilla's customer to reach the aircraft's full payload, endurance and altitude capabilities.

"In operation, the VA001's unmatched range and endurance will greatly reduce the operating cost and man-power burden to provide persistent aerial coverage, and enable new missions previously beyond the capabilities of mid-sized UAS." said Peter Bale, head of business development and strategy. "We are really looking forward to the next phases of this game-changing program."

Vanilla Aircraft is a small business located in Falls Church, Virginia, specializing in the design, fabrication and test of unmanned aircraft. The VA001 program began development under Vanilla IR&D funding and Phase I and Phase II SBIR funding from the NASA Earth Sciences Division.

Short articles (up to 500 words) for CRUSER News are always welcome
submit to: cruser@nps.edu