POSITION STATEMENT

UNMANNED AIRCRAFT SYSTEMS & RELATED TECHNOLOGIES

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Unmanned Aircraft Systems (UAS) – sometimes called Unmanned Airborne Vehicles (UAVs), Remotely Piloted Aircraft Systems (RPAS), Remotely Piloted Airborne Vehicles (RPAVs), or simply, drones, -- are an area of emerging technology that is gaining increasing worldwide notoriety, in both military and civilian contexts. While UAS can be an effective and efficient means of conducting particular operations for national security and social good, and are considered to have significant potential for a wide range of commercial applications, there are also many risks and issues that need to be acknowledged and addressed.

For these reasons, IEEE-USA recommends that the U.S. government adopt UAS policies, and provide adequate funding for programs that:

- Preserve vital radio frequency spectrum segments for safety critical air operation, navigation, air traffic management, remote sensing, and other vital uses and applications

- Promote closer collaboration between public and private entities that provide products and services using UAS and related technologies in order to de-conflict and optimize operations

- Support standardized regulation and enforcement frameworks at public agencies and private organizations for UAS operations and capabilities

- Incentivize the national security and social good use of UAS and related technologies, such as for military applications, national border protection, or civil law and order purposes, emergency services and disaster management, and environmental monitoring

- Encourage U.S. private investment in areas considered to have significant potential for practical and viable commercial applications of UAS and related technologies

- Utilize UAS and related technologies to provide products and services for public education and scientific purposes, as well as improve training for graduate engineers and research scientists

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This statement was developed by the IEEE-USA Committee on Transportation and Aerospace Policy, and represents the considered judgment of a group of U.S. IEEE members with expertise in the subject field. IEEE-USA advances the public good and promotes the careers and public policy interests of the more than 200,000 engineering, computing and allied professionals, who are U.S. members of the IEEE. The positions taken by IEEE-USA do not necessarily reflect the views of IEEE, or its organizational units.

BACKGROUND

The strategic trends in UAS development and the implications, good and bad, of what the next decade will bring to their operation in (or against) the national interest, convey with them many issues, positive and negative. These issues can be effectively considered in the normal strategic context of the National Interest, by splitting that general concept into its three constituent elements – National Security, Economic Prosperity and Social Values.

1. **National Security:** The use of UAS for military surveillance purposes is well established, but the next decade will see the weaponising of even small, easily available, unmanned airborne systems, as well as the development of high precision, beyond line of sight control and navigation technologies. In the right hands, such capabilities can enhance the defense of a nation's people and assets by dramatically reducing collateral civilian death and damage; and in the wrong hands, however, another dimension is added to terrorist attacks – lightweight, loitering, self-navigated air vehicles – deadly, hard to detect, cheap, and potentially overcoming defensive efforts by swarming.

2. **Economic Prosperity:** There is currently an explosion of interest in the commercial use of UAS, in many sectors. Positive economic effect in the next decade will be limited only by industry imagination and the ability of regulations to be an enabler, rather than an inhibitor. Current air safety regulations at international and national levels are a poor fit for the safety issues associated with remotely piloted aircraft of the sophistication and capability now widely available, or being contemplated. UAS now in operation range in size from one ounce to about 50 tons, and several international companies are well advanced in their plans to deliver their services by remotely piloted aircraft; a Boeing 747 cargo drone is not just a possibility, it is close to inevitable. Such developments are forcing regulators to urgently address the safety and regulatory implications and requirements associated with commercial UAS operations. However, for every positive scenario, a mirror image can be postulated; UAS being used to threaten, or even destroy, key national economic assets would amount to blackmail on an industrial scale.

3. **Social Values:** This is already an area of opportunity and controversy. Smaller UAS, such as quadcopters and large-scale remote-controlled aircraft, have also become much more readily available and affordable for hobby and sports enthusiasts, which in turn have raised societal concerns on their use, and the intent and competency of their owner/operators. Surveillance, from UAS and more broadly, raises important questions about privacy and the right to be unobserved, to liability for damage or harm to physical and personal property in the evident of equipment malfunction or human (pilot) error. Future quieter, longer

> endurance, multiple sensor, small UAS will contribute to the effectiveness of first responders -- police, fire and ambulance -- but equally the irresponsible use of UAS by others can seriously inhibit first responder operations. Similarly, these UAS have the potential for negative covert surveillance, fuelling the privacy debate, and enabling organized crime. Likewise, drugs for good may well be dispatched to crisis points by UAS, and illegal drugs flown across borders in the same way.

In order to address the national security and societal challenges and implications of the rapidly expanding use and sophistication of UAS and related technologies, and to achieve an effective and efficient commercialization of UAS applications, the U.S. government must adopt policies that balance the rights and responsibilities of the individual with public sector capabilities and private sector growth. Those policies need to consider the properties of UAS, the different types of unmanned aircraft and aerial systems currently being deployed, or in development, the challenges and risks posed by the private and commercial use of UAS (including the potential for such uses to interfere with first responder operations), safety regulations as applied to the manufacture and civilian use of UAS, issues of privacy and the nature of surveillance, and other UAS missions, and how these impact on important national security and societal values in the United States.

To protect the flying public, UAS must be fully incorporated into the FAA's National Airspace Management so that they are visible to Air Traffic Controllers and general, commercial and business aviation/aircraft. However, unsecured UAS control channels and/or clear channel recordings of what they see are vulnerable to significant adverse exploitation. In addition, existing regulations covering collision avoidance in civil aircraft operations need to be reviewed by the FAA to ensure UAS operations meet safe aircraft separation standards. Specific collision avoidance requirements for UAS operations may also need to be established that recognize the capabilities of new and emerging technologies, (such as camera, infrared, acoustic sensor) being considered in the development of autonomous sense-and-avoid maneuvering systems. New technologies can also be applied to perform autonomous emergency maneuvers for safe navigation and landing in case of communication disruption. Importantly, the U.S. government must also adopt policies that assure the integrity of UAS control security is established and maintained in all conditions and operational scenarios, and that UAS control and flight safety is demonstrated before airspace integration is considered. IEEE-USA believes that the FAA has credible manpower and policy processes to handle the current UAS operations. However, this may require revisiting, if/when UAS operations increase significantly.

Special emphasis must also be placed on spectrum management on intra and inter-system interactions (platform integration), mission specific data security and bandwidth requirements, and robust performance in the presence of high intensity radiated fields (HIRF). UAS applications will use significant radio bandwidth for telemetry from the UAS, particularly for real time imagery. Since many recreational and light-commercial UAS will operate at an altitude under 500 feet, the effect of altitude will result in impacts on other users of the same frequency within a foot print that increases in size with

UAS altitude. Poorly planned choices of spectrum for UAS could impact adversely other aeronautical spectrum users, as well as unlicensed users and cellular radiotelephone systems that were planned assuming users were purely terrestrial. Thus, an integral part of authorizing UAS must include explicit selection of frequencies that are selected based on acceptable impact on other operations. Policy directives should therefore fully exploit existing FAA, FCC, and DOJ standards and regulations where appropriate by extending those in place, or require the development of new standards and regulations, where current ones are inadequate.

RECOMMENDATIONS

Specific recommended policy considerations that will contribute to maintaining the safety of the national air space include:

1. Policy directives must be worded using terminology that best encapsulates the key elements of unmanned airborne systems: if it flies, it is an aircraft; there must always be a pilot responsible for the control of an aircraft (irrespective of the level of autonomy); and an aircraft is a system of systems, including those associated with its command and control. For example, the International Civil Aviation Organisation (ICAO), of which the United States is a member state, has chosen the descriptor, Remotely Piloted Aircraft Systems (RPAS), over other terms in common use (e.g. UAS, UAV, RPAV and drone).

2. Policy directives must address the primary issue of public risk and safety, by emphasizing the importance of a robust legal and regulatory framework across the range of RPAS operators, platform/vehicle types, payloads, and communications between operator and platform/payloads. The FAA should be delegated as the central registry and authority on all RPAS types and applications, including small toy-type remote controlled aircraft that could be easily deployed as lethal weapons or surveillance platforms, and hobby and enthusiast aircraft, which could be similarly deployed or used for commercial or civil applications. The FAA can then use its database to provide guidance to local communities and authorities on how to regulate RPAS applications and operations in their jurisdictions, in the interest of public safety and privacy.

3. The IEEE-USA does not support the use of RPAS in areas where personal privacy can be infringed upon, unless companion education and transparency are provided to the public. Policy directives must promote the responsible use of the technology, recognizing that existing laws designed to protect the privacy and civil liberties of individuals may need to be reviewed and if necessary, amended to address use and remote control of technology (including RPAS), by a person or persons, to invade another person or persons' privacy or deny a person or persons' civil liberties.

4. Policy directives should reinforce the application of new technologies to provide safety functions of RPAS in case disruption of communication with a remote pilot. These technologies will be based on intelligent behaviors, involving autonomous environment perception and reaction/planning. For safety reasons, the directives will also promote the application of technologies to compensate for the unexpected loss of satellite positioning, including autonomous localization based on on-board sensors.

5. Policy directives must place more emphasis on the air vehicle as a platform, the mission capabilities of platforms and their payloads (current and potential), and the integrity of related technologies that enable them to operate remotely. What the aircraft is carrying and for what purpose are far more important policy drivers than vehicle mass and flight envelope. Therefore, specific size/speed/weight/duration/ distance metrics for RPAS operations need to be developed.

6. Policy directives must consider electromagnetic compatibility (EMC) of the airborne system, and its ground control system, to ensure flight safety. In particular, operation in High Intensity Radiated Field (HIRF) environments should be addressed. EMC aspects emphasize the potential non-cooperative, system-level requirements for safe operation, whereas solely focusing on spectrum management presumes a cooperative environment for Command and Control and onboard systems. RPAS downlinks in bands planned for terrestrial applications (e.g., cellular and Wi-Fi bands), could have a disproportionate impact on other users of such spectrum; therefore, RPAS downlinks should be limited to bands specifically selected for them. Thus, it is vital that FCC act in parallel with FAA to identify which bands can and cannot be used by RPAS, rather than permit RPAS to use cellular and Wi-Fi bands without adequate consideration of terrestrial users. In particular, the FAA and FCC must prohibit any jamming of RPAS communications, until legislation exists to protect RPAS communications supporting military and first responder operations, noting that federal users use bands controlled by NTIA, and in most cases, they have sole or prime access to such bands.

7. The IEEE-USA does not support the use of RPAS in populated or other high-asset areas, unless hardware and software systems control is guaranteed. Policy directives must require that RPAS control security is assured at all times, and RPAS control safety is demonstrated before airspace integration is considered. This will require cooperation and coordination across agencies and between different levels of the U.S. government. There is significant potential for future developments in these technologies and their adverse capabilities, such as the ability for hostile agents to take control of and semi-autonomously direct airborne systems against the better interests of mankind. RPAS rely on significantly more command and control data being relayed between the ground operator and the aircraft than in manned aircraft operations, hence RPAS are highly susceptible to cybersecurity infringements. Therefore, safe-guarding the command and control integrity of large commercial RPAS operations is particularly important, where the size and mass of

the RPAS and its cargo could cause death and destruction on a large scale, similar to 911, if that integrity is compromised by hostile agents.

8. The IEEE-USA position is that RPAS must be fully incorporated into the FAA's National Airspace Management, so that they are visible to Air Traffic Controllers and other operating aircraft. To mitigate the potential for mid-air collisions between RPAS, and RPAS and manned aircraft, policy directives must require that RPAS operations meet safe aircraft separation standards. The FAA must ensure that regulations for collision avoidance in civil aircraft operations are reviewed and extended to RPAS operations. This may cause the FAA to regulate and assert specific collision avoidance requirements for RPAS operations. FAA rules need to be established now to address the capabilities of proposed and future autonomous 'sense-and-avoid'/maneuvering systems. Importantly, the U.S. government must also adopt policies that assure RPAS flight safety in a shared environment is demonstrated before full airspace integration is considered.

9. Policy directives must continually remind their intended audience that a competent pilot, even one physically remote from the aircraft, remains essential for the safe operation of the aircraft and its mission. It is recommended that for anyone to operate a RPAS, they must be licensed to an equivalent level of competency as other aviation pilots conducting similar private or commercial flight operations. The Academy of Model Aeronautics (AMA) has a long and successful history in advocating for the flying privileges of the aero-modelling community; it is one of the top reasons why aero-modellers join the AMA. The AMA's pilot training and accreditation scheme provides a good model that can be adapted for regulating the training and certification of private RPAS operators, such as hobbyists and enthusiasts, and small RPAS commercial operators. A government background check must be conducted on the applicant RPAS pilot, and the person's record kept. Those operating without a license or in contravention of their license will be violating air space law and be liable for prosecution under applicable local, state, or federal laws.

10. Policy directives must address the issue of operator/pilot integrity, including the potential for incompetent, negligent, reckless, mischievous, malicious and criminal use of RPAS, whether in private or commercial applications. This issue requires a two-part solution: firstly, that which enables an air vehicle to be identified and traced back to its owner/operator/pilot, so that accountability for the vehicle's operation (where government, for profit, non-profit, public safety, etc.) can be enforced within a robust legal and regulatory framework; and secondly, that which addresses operator/pilot competence, through effective training and certification. Such measures must be designed and implemented so as to also alleviate the potential for intentional or unintentional flight interference of private and/or commercial RPAS with first responder operations.

11. Pilot situational awareness plays an important role in RPAS safety. Policy directives should also promote the adoption of technologies to increase RPAS pilot situational awareness and facilitate pilot intervention in case of complex manoeuvres.

12. Policy directives must be reasonable so that model aircraft enthusiasts can still enjoy their hobby, while air space safety is maintained and without risking national security and FAA violation. Since AMA has demonstrated consistent and professional quality control over their membership, it is recommended that they be formally designated as one of the responsible authorities to represent the model aircraft community in these matters.

This statement is intended to place focus on “what” needs to be done to best introduce RPAS standards and regulations (i.e. "what" outcomes need to be achieved for the responsible use of this technology and its safe integration into the National Airspace). While it is not a function of IEEE, or its organizational units to design and develop the solutions required, IEEE-USA stands ready to work with government, regulatory and industry stakeholders to determine "how" to get the "what" in place, being the details of using technology to help regulate and create transparency for RPAS users and stakeholders.