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Disruptive Change in Unmanned Aerial Systems, Nuclear Facilities, and Radiological Protection: A Review of US and French Developments

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Disruptive Change in Unmanned Aerial Systems, Nuclear Facilities, and Radiological Protection: A Review of US and French Developments

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Abstract: Unmanned aerial vehicles (drones) have the potential to be highly disruptive for nuclear technology, radiation protection, and emergency response. With rapid growth expected to sustain amidst concerns about destructive applications, it is critical to understand how drones are changing the nuclear and radiological playing fields. Such knowledge applies not only to delivery mechanisms for radiological dispersal devices, but also for alarm systems at nuclear power plants, radiation monitoring for emergency response, and perimeter monitoring and protection. Given the range of opportunities and challenges with drones, it is important to establish appropriate regulations for their use. The paper addresses the risks and benefits of drone technology amidst rule changes. Drawing upon case analysis, and historical record review, this work examines the extent to which such changes are occurring in two, established nuclear states, the United States and France, to identify where convergence and divergence in rule-making is occurring.

Keywords: Unmanned aerial systems, drone, nuclear, regulation

1. Introduction

The rapid emergence of unmanned aerial systems – more commonly termed drones -- is spurring a range of disruptive developments. Drone technology operates at various levels of autonomy and is providing novel platforms for industries and knowledge to evolve, such as with precision harvesting in agriculture. Yet, increased use of drone technology is also testing the bounds of traditional regulatory oversight. One area which highlights unusual opportunities and challenges with drone technology involves nuclear facilities and radiological protection.

In the past few years, drone overflights at nuclear facilities have triggered security concerns. In June of 2016, for example, unmanned aerial vehicle flights were observed over the Savannah River Site (SRS) in South Carolina, US [37] -- a site which spans 310 square miles, processes nuclear materials, and is a no fly zone for aircraft. Similar breaches of restricted airspace occurred in what appeared to be a coordinated effort over 13 of France's 19 nuclear power plants (NPPs) by unidentified drones between October and November of 2014 [9, 34]. Intrusions, such as these, highlight obvious needs for new thinking about how nuclear facilities and radiological sources are protected.

Looking beyond basic overflights, the use of drone technology by terrorists has become a pressing reality. Evidence indicates that the Islamic State terrorist group, for instance, is using unmanned aerial technology for surveillance and destruction of targets [41, 31]. Global leaders discussed terrorist use of such devices as vectors for radiological dispersal at the Nuclear Security Summit in March-April 2016 [20, 36]. Partnering on knowledge sharing will remain critical to readiness for the evolving threat.

In tandem with the above concerns, drone technology is also constructively deployed by experts for disaster recovery efforts. At the Fukushima Daiichi accident site in Japan, for instance, aerial and land-based drones have been used to evaluate reactor core damage and radiation levels in areas which are unreachable or that have uncertain safety conditions [7].

As prices for unmanned aerial systems decline and capabilities continue to rise [5], the adoption of UAS is expected to grow substantially.[1] Looking at an early adopter country, like France, estimates show that 300,000 drones were sold in 2015 alone [27]. France now has at least 1,250 registered drone businesses, which, by one estimate, outnumbers all French wine appellations (i.e. wine geographic indication) [39]. With 2.5 million drones expected to be sold this year and annual sales anticipated to climb to seven million by 2020, the market potential is seen to be in the billions [20, 39]. Such growth will intensify pressures and bring heightened need for regulatory priorities, as security, safety and privacy dimensions will be tested.

In light of these developments, France and the United States provide interesting examples with which review the rapidly shifting interface of emergent drone systems with more traditional nuclear and radiation protection technology. Both countries lead in civilian nuclear energy use. France is one of the first countries to establish rules on commercial drone use [39]. The United States, by contrast, just recently developed its first regulations in this domain [15]. Opportunities and risks are discussed, followed by developments in drone rules for the two countries. The paper concludes with specific areas to watch, including rule gaps, and potential for harmonization.

2. Opportunities and Risks

Unmanned systems hold pivotal potential for management of nuclear facilities and radiation protection. Drones can be used to assess damage from accidents, leaks or weather; to support facility maintenance; or to assist with surveillance of plant perimeters by operators.

Following the Fukushima Daiichi incident, research in this area advanced to fill information gaps by mapping of large land expanses, while minimizing overall doses of radiation to responders. Despite anomalies with naturally occurring material in granite, drone use proved to be feasible and useful [29], with continuing potential in accident response planning and possible dose evaluations [44].

Unmanned aerial systems can also be employed by individuals wanting to breach secure facilities to survey the design and layout of a plant. While tools like Google Earth can already be used to examine such geospatial layouts, real time locations of responders and the status of potential entryways can be provided by a drone. There is also potential for a drone to be used to observe security schedules from a safe distance to evaluate potential attack timing. Smaller drones might also allow operators to avoid conventional radar detection [5].

Drones that carry electronic-warfare devices have the potential to jam radio frequencies or to disable wireless communications in restricted areas [46]. In conjunction with this, nuclear facility managers can fortify against jamming devices with reflective exteriors and wireless repeaters which amplify ranges [46]. Managers may also utilize mesh networks for wireless device communications, instead of hub and spoke systems. Such mesh networks allow devices within close range of each other to communicate peer-to-peer. They also allow for faster recovery times during systemic disruption [46].

[1] Between 2012 and 2015, 1,300 commercial drone licenses were approved in France [34]. This is likely to be a share of larger drone ownership, as the technology is easily acquired without a license on-line and on the street [34].

Drone technology is also capable of delivering equipment to a saboteur or explosives that can damage spent fuel pools, communications and power systems, or unhardened reactors [5, 32, 46]. It is well documented that non-state actors have used drones as delivery devices for explosives to varying degrees of success. Such technology might also be used to distract, or to generate public panic over the drone's presence. An attack with multiple assailants and the addition of multiple drones could be catastrophic to a facility that is not prepared to defend against the intentional use of drones as distraction devices or delivery platforms.

To date, responses to drone intrusions at nuclear-radiological facilities have been limited. French soldiers have been granted authorization to shoot drones; however, this does not extend to areas close to nuclear power plants [34]. The French air force has also been training eagles to intercede [40]. In the US, there appears to be no planned form of response in place. Beyond the options already in use in France, possibilities include drone-on-drone attacks, use of water cannons, and lasers to disable or deter.

3. Rules

Drone technology cuts across a range of jurisdictions, such as aviation, security, safety, energy, and commerce. In line with this multi-faceted playing field, countries and regions are adopting different regulatory approaches. The European Union, for example, currently regulates civilian drones over 150 kg and monitors with the European Aviation Service Agency [25]. It also is considering more extensive harmonization of national rules. The International Civil Aviation Organization has also evaluated the potential for international standards [23, 25]. It is unclear what timelines are planned for unifying standards. To date, differences exist in how unmanned aerial systems are defined as well as the extent to which they are regulated.

Specific to nuclear facilities and radiological protection, a number of key regulatory areas are worth closer inspection.

3.1 No fly zones

No fly zones are in place above and near nuclear power plants within France and the US. French law prohibits flights by all aircraft within 3 miles (5 km) of a nuclear plant [31]. In the US by contrast, a general notice to airmen by the FAA strongly advises pilots (and now UAS operators) to avoid airspace above or in proximity to sites like power plants, indicating that "they should not circle as to loiter in the vicinity (FDC 6/8818)."[2]

Geofencing and use of Unmanned Aerial System (UAS) Clouds may prevent drones from entering restricted areas. Geofencing utilizes global positioning systems or radio frequency identification to delineate geographic boundaries [25]. A UAS Cloud functions by activating an alarm when a drone crosses into restricted airspace [25].

3.2 Design basis threat (DBT)

The design basis threat is another way in which drone use may be regulated for nuclear and radiological technology. The DBT contains a set of adversary characteristics for which nuclear facility operators and State actors must collectively bear responsibility by providing

[2] Altitude and distance were not specified; violations could include fines up to $10,000 [3, 12].

protection [21]. In the US, the DBT does not cover drones. In France, it is unclear whether drones are formally covered.

Questions have been raised with the U.S. Nuclear Regulatory Commission in relation to the DBT and licensee plans for drones.[3] Citing Title 49 of the United States Code, Transportation, § 40103, the NRC has indicated that the FAA, rather than the NRC, regulates manned and unmanned aircraft [18]. Specific to the DBT, [4] the Commission continued by saying that "…active protection against the airborne threat rests with other Federal government organizations. The Commission explicitly addresse[s] security plan provisions noting that protection of NRC-licensed facilities against aircraft attacks is beyond the scope of a licensee's obligation [18]."

3.3 Drone-specific rules on usage

France

In France, requirements for civilian drone use came into force on January 1, 2016, replacing earlier rules from 2012. The newer rules differentiate requirements on the basis of drone technology purpose, namely recreational, experimental, and 'other' activities [25]. These explicitly address training requirements, restrictions on performance, size/weight, line of sight, night flight and use.[5] Additional legislation was passed in October 2016 without mention of nuclear facilities.[6] The timing for implementation of these newest rules, and their interaction with the former regulations is yet to be clarified.

United States

In the US, the FAA Modernization and Reform Act of 2012 mandated that the FAA develop a plan to "integrate commercial unmanned aerial systems into the national airspace system" (Public Law 112-95). In June 2016, the first operational rules for commercial use of UAS were passed, and in August they came into effect.[7] In brief, these rules indicate that "commercial enterprises will be allowed to fly small, remote-controlled unmanned aerial systems to conduct routine flights in accordance with public safety and national airspace rules, and without special permission from the federal government [37]." They include operational limits, command certification and responsibilities, as well as aircraft requirements, but are silent on restrictions pertaining to nuclear facilities. The rules also include model aircraft stipulations that are incorporated into FAA Part 101 noting that "aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nation-wide community-based organization" [1]. Here, specifics pertaining to community-based guidelines were left open. The applicability of Rule 101 versus 107 for model aircraft operators also carries some uncertainty [15].

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[3] [18]; See also ADAMS Accession Nos. ML15218A475 and ML15299A089.

[4] DBT – 10 CFR 73, Physical Protection of Plants and Materials (72 Federal Register (FR) 12705; March 19, 2007), and 10 CFR Parts 50, 52, 72, and 73 (74 FR 13926; March 27, 2009).

[5] Order of December 17, 2015, Regarding the Use of Airspace by Unmanned Aircraft;
Order of December 17, 2015, Regarding the Creation of Unmanned Civil Aircraft, the Conditions of their Use, and the Required Aptitudes of the Persons that Use them. TEXT000031679906&dateTexte=20160330

[6] Law n° 2016-1428 of October 24 2016, Regarding the Enforcement of Security with the Usage of Civilian Drones.

[7] 81 FR 42063, https://www.federalregister.gov/documents/2016/06/28/2016-15079/operation-and-certification-of-small-unmanned-aircraft-systems.

Mirroring the current French approach, the American-based Nuclear Energy Institute recommended that the FAA go further with its oversight by prohibiting unauthorized drone flights above and surrounding any nuclear power plant licensed by the NRC within approximately a 3 mile radius [24, 43]. The NEI also noted that drone technology "may have beneficial uses for [nuclear plant] members," proposing that commercial nuclear power plant operators have power to authorize use of small UAS [43].

Together with the new FAA rules, provisions within the 2017 National Defense Authorization Act (NDAA) also outlined an extension of authority to the Department of Defense and Department of Energy to "use reasonable force to disable or destroy" drones considered to be a risk to their facilities (H.R.4909, S.2943) [19]. Such provisions align with existing authorizations granted in France.

4. Conclusion

Nuclear technology and radiation protection systems are emergent technologies of earlier eras which now must co-exist or contend with yet newer entrants, like drone technology. In conjunction with this, policy-makers must decide how to provide clarity and order amidst this highly dynamic environment, as learning continues across multiple jurisdictions.

In looking ahead, a number of critical areas will be key to watch. Do the United States and France explicitly incorporate drones into their DBT requirements? Given the common drone-related risks associated with nuclear facilities and radiological systems, will rules for recreational as well as commercial drone models be established and applied uniformly to all types of UAS? In terms of standards and harmonization, should the ICAO, EU, and other international bodies develop one set of rules? Moreover, will the International Atomic Energy Agency and International Commission on Radiation Protection contribute? Given the pressures of the coexisting technologies outlined, here, policies will require clarity and adaptive flexibility to balance security with progress.

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