FLIGHT SAFETY IN THE DRONE AGE

Managing Risks in the Presence of Unmanned Aircraft*

v1.0

This technical paper serves as an internal working draft of the Permanent Editorial Board. Its primary purpose is to address the need for drone safety guidance for manned aircraft pilots. Its primary audience is manned aviation flight safety educators and policy professionals. The audience for Appendices 1 (poster) and 2 (brochure) is manned aircraft pilots.

PREFACE

Unmanned Aircraft Systems, commonly referred to as "drones" create substantive—if not profound—new capabilities, opportunities, and benefits. They offer startling new applications throughout the aviation sector. When drones offer an equivalent level of safety to that of manned aircraft, they deserve an expanded role and opportunity to operate as equal stakeholders in the National Airspace System (NAS).

While the vast majority of drone operators are neither trained nor certificated as manned aircraft pilots, the FAA has granted exemptions to commercial, civil, and public drone operators, [*temp*: review/confirm upon release of Part 107] who utilize certificated pilots to operate their drones. Their training includes proper use of airspace, safe operation of applicable equipment, traffic avoidance, response to emergencies, knowledge and understanding of safety management (or risk management) principles, processes, and practices, and a commitment to adhere to standard operating procedures and applicable rules. As professional operators, they may represent segments of the aviation community with the best of safety records.

Nonetheless, as drones become more common, and as recreational, commercial, and public drone applications proliferate, manned aircraft operators face new challenges.[1] In terms of sheer numbers, there are now more registered drone operators than manned aircraft pilots, creating an increased likelihood of midair collisions.[2] Safety standards, rules, and guidelines for drone operators are available and continue to be refined,[3] but guidance for pilots flying aircraft in the vicinity of drones is sorely needed.[4]

Training and safety regimes for manned aircraft are well-defined, data-driven, and rigorously implemented and validated through structured training and testing. They are the product of a century of scrutiny and development.[5] Such regimes include general operating rules, traffic avoidance and separation (from other manned aircraft), flow control, compliance with airspace restrictions and prohibitions, wildlife strike avoidance, communications, and rigorous normal and emergency procedures—*but they include nothing material with regard to drones*.

The FAA asserts that drones "are inherently different from manned aircraft" and "create situations not common to manned flight."[6] A few noteworthy differences include that:

- most drones are at least an order of magnitude smaller than manned aircraft, thereby impeding effective *see-and-avoid* by manned aircraft pilots;
- the lack of a human pilot in a drone limits effective operator see-and-avoid;
- many (predominantly small) drones have neither airworthiness certification nor redundant systems;
- most drones do not necessarily fail predictably;
- even if drones were equipped with transponders, low airspeeds (and unique vector profiles) may fall below thresholds that trigger TCAS or ADS-B alerts;
- few drone operators maintain radio communication with manned aircraft pilots and ATC; and
- most drone operators lack pilot certification, recurrent training, or flight reviews.

In light of these differences and other considerations, how might this compromise flight safety? And, what information and pilot training do pilots need to maintain safety when drones are present?

Global, regional, and state aviation authorities have developed "roadmaps" to integrate drones progressively into controlled airspace.[7] So far, they maintain flight safety largely by requiring visual line-of-sight (VLOS) operation and separation of manned aircraft operations from small drone operations, and with notable exceptions, by keeping drones outside controlled airspace.[8] Current safety initiatives advancing aircraft integration focus almost exclusively on drone operators, addressing education,[9] regulation, and (more recently) enforcement.[10] The FAA's policy arm has addressed Air Traffic Control (ATC) challenges concerning drone guidance,[11] and initiatives are in development to assist airports with drone safety.[12] Additionally, promising technologies may, in the near future, provide effective manned/unmanned aircraft interoperability, but these efforts do not yet fully address the risks to manned aircraft created by drones.[13]

This brings us to the purpose of this paper: responding to the need for drone avoidance safety guidance *for manned aircraft pilots*.[14] Effective guidance is crucial because the essential visual flight rules (VFR) safety mechanism—"see-and-avoid"—is largely inadequate with regard to the small drones[15] that create the greatest risk of collision with manned aircraft.[16]

The current emphasis on drone and drone operator-related issues, with its consequent distraction from manned-flight safety, can be attributed to a number of factors:

- Congressional, administrative,[17] and industry[18] pressure to prioritize, accelerate, and complete drone rules;
- limited applicable safety research[19] and risk analyses;[20]
- lack of, or inappropriate prioritization within manned aviation non-governmental organizations (NGOs);[21]
- varying perspectives of manned aviation NGOs and the drone community regarding safety regulation, particularly with respect to airspace;[22] and
- a belief that little can be done by pilots to improve safety against drones.[23]

We offer the following guidance to fill the void.[24]

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SAFETY GUIDANCE FOR MANNED AIRCRAFT PILOTS OPERATING IN THE PRESENCE OF DRONES

INTRODUCTION

The following safety guidance is designed for pilots who may experience unexpected, increasingly frequent encounters with unmanned aircraft operations. It responds to safety issues resulting from diverse drone operations, including both small and large drones operated recreationally, commercially, and publicly. Not *all* these provisions apply to *all* flight operations. The guidance is general in nature.

The guidance assumes that pilot awareness and response are particularly important where drone safety technologies and rules have not yet been developed fully or implemented effectively. Pilots are encouraged to review and selectively integrate these recommendations into their operations.

The guidance is organized in five sections (presented by phase of flight, not in any order of importance): (1) General Education and Preparation, (2) Preflight Operations, (3) In-flight Operations, (4) Post-flight Operations, and (5) Aviation Community.

1. GENERAL EDUCATION AND PREPARATION

Pilots should:

a. recognize that most drone operators are not certificated pilots [revisit/confirm upon release of Part 107] and may not understand or adhere to aviation operations and safety requirements;

b. recognize that most small drones operate without systems that provide a level of safety equivalent to manned aircraft in terms of collision avoidance capability and reliability;

c. become familiar with drone regulations, and to distinguish the flight profiles, characteristics, and operations of manned aircraft from those of drones;[25]

d. recognize that drones may be operated in unexpected or unauthorized ways, including at night, in instrument meteorological conditions (IMC), in controlled or uncontrolled airspace, at unauthorized altitudes,[26] and beyond visual line-of-sight (BVLOS) of the operator, possibly impeding effective collision avoidance;

e. consider that many drone operators are preoccupied with maneuvering for photography or other applications, which may compromise situational awareness;

f. anticipate that some (larger, typically public) drones may require "chase aircraft" while in controlled airspace—possibly making departure and arrival procedures, traffic pattern altitudes, and handling non-standard;

g. review and understand the limitations of even the most effective visual scanning techniques;[27] and

h. train to respond to possible collisions and other emergencies arising from conflict between manned aircraft and drones.[28]

2. PREFLIGHT OPERATIONS

Pilots should:

a. review diverse information sources, including: Notices to Airmen (NOTAMs), Temporary Flight Restrictions (TFRs), Chart Supplements U.S., online flight planning resources,[29] airport and airport/pilot association resources, charted UAS procedures, and Flight Service;[30]

b. recognize that information supporting the separation of manned from unmanned flight operations is neither readily available nor standardized, and may change frequently; pilots should monitor those changes accordingly;

c. when indicated, query Flight Service, airport operators, and ATC regarding drone operations in the airport environment prior to taxi-out;

d. consider that airport personnel or ATC may acquiesce to drone activity in the airport environment without notice to pilots;[31]

e. where practicable, identify and monitor drone site activity, including *lost link loiter points* along their planned route;[32]

f. recognize that most commercial drones are permitted to operate as close as 2 NM from airports without a published instrument flight procedure or an operating control tower;[33]

g. know that some drone operations may occur within 5 SM of airports;[34]

h. give attention to aeronautical chart symbology for drones ("UA" for unmanned aircraft activity), identify charted drone operations affecting planned flights, and plan for ample separation;[35] and

i. contemplate delays at airports basing and facilitating drone operations—be patient.[36]

Unmanned Aircraft Activity Symbol

3. IN-FLIGHT OPERATIONS

Pilots should:

a. increase their awareness of drone hazards where incursions are most likely:

   i. during flight below 500' AGL;
   ii. during climb-outs and descents on terminal segments of flight;
   iii. while flying faster, lower—where see-and-avoid margins are reduced by the increased speed;
   iv. near areas of high public interest—such as fires, festivals, parades, attractions, parks, and popular photographic and vista points;

b. query ATC and/or Flight Service regarding possible drone operations in the airport environment;

c. recognize the risks of drone *fly-away* (loss of command and control, "C2"), and *lost link* (pre-programmed procedure upon loss of C2);[37]

d. use available aircraft lighting to increase your visibility to drone operators;[38]

e. when in a climb, consider a cruise climb which maximizes visibility;

f. listen attentively, including on 121.5 MHz, for radio reports of drone sightings/activities, make periodic transmissions, and answer inquiries concerning drone operations;[39]

g. recognize that many private airports and heliports are not accurately charted (on a current FAA Form 5010 - *Airport Master Record*), if at all;[40]

h. for rotorcraft operations, exercise heightened vigilance when landing at off-airport locations. Conduct a high recon around the intended landing site to provide visual and aural warning to drone operators nearby;

i. when flying rotorcraft at low altitudes, keep airspeeds at or near the best autorotation speeds; flying higher may improve safety margins;

j. recognize that risk of collision is exacerbated by distractions during high-workload phases of flight;

k. if aggressive maneuvers are necessary to avoid collision, consider the acute vulnerability that can result (to windshields, jet intakes, or rotor systems);

l. anticipate that fires, public gatherings, points-of-interest, and newsworthy events are likely to attract drone operations; avoid operating in their vicinity;

m. consider that nonstandard lighting may indicate that the aircraft is a drone;

n. maintain greater separation from drones than might otherwise appear necessary; be prepared for the unknown;

o. fly predictably so drone operators can better avoid you;[41]

p. recognize the potential for drone collision even beyond congested areas;

q. make in-flight reports (a PIREP) of all unsafe drone sightings or incidents. To report a near-miss in-flight, one must request that ATC file a Near Mid-Air Collision (NMAC)[42] report; and

r. identify and preserve material evidence of drone incidents and rogue drones.[43]

4. POST-FLIGHT OPERATIONS

Pilots should:

a. understand that reporting hazardous drone operations and near-miss incidents will not only assist in education and possible enforcement actions against errant drone operators, but will help build the database required to promote the safe integration of manned and unmanned aircraft operations; and

b. become familiar with and file (or request that ATC file) applicable reports, including:

    i. Near Mid-Air Collision (NMAC) reports;[44]
    ii. Law enforcement (e.g., incident) reports;
    iii. Mandatory Occurrence Reports (MOR - filed by ATC);[45]
    iv. The Aviation Safety Reporting System (ASRS) General Form;[46]
    v. Aviation Safety Action Program (ASAP) reports;
    vi. Air Traffic Safety Action Program (ATSAP) reports;

vii. National Transportation Safety Board (NTSB) notifications;[47] and
viii. Other.[48]

5. Aviation Community

Pilots should:

a. communicate to all stakeholders the critical impact of the risks and awareness of drone operations on aviation safety;

b. directly engage ATC and airport management regarding drone operations and safety;[49]

c. avoid the assumption that airport and tower personnel:

   i. are fully apprised of local drone activity and hazards;
   ii. understand and exercise the scope of their authority[50] regarding drone safety oversight;
   iii. have operational procedures in place to document and manage drone activity effectively;
   iv. respond to operator notifications of planned flight proximate to airports in a manner consistent with safety of flight;[51] and
   v. file and communicate NMACs and other appropriate drone safety reports and notifications to all relevant parties (including ATC and airport/pilot associations).[52]

d. engage and inform local governments near airports of relevant safety risks, and urge their active engagement in advancing flight safety;[53]

e. urge government and industry to accelerate technical solutions advancing manned aircraft/drone separation and interoperation to burdening manned aircraft operations;[54]

f. encourage aviation membership associations to track and report developments in the integration of drones into the NAS;

g. serve as a drone safety resource to local airports and airport/pilot associations;

h. serve as ambassadors to the local drone community, recognizing that many drone operators are unfamiliar with manned aircraft operations and safety;[55] invite drone operators to relevant safety meetings and seminars; and

i. in the absence of Federal preemption, consider engaging local government to address exigent safety hazards near airports and heliports by measured (exclusively ground-based, and *strictly not airspace*) zoning and land use action.[56]

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CONCLUSION

There is no widespread education for pilots regarding drones; most resources are instead focused on drone operators. Nonetheless, pilot education is one of a set of mutually supporting flight safety pillars, together with drone operator, airport management, and ATC education. Ultimately, safe separation and interoperation of manned and unmanned aircraft will require new technological solutions, but, to date, such technologies are neither widely implemented nor perfected. Effective strategies for manned aircraft pilots should be further developed and may include response to:

a. the potential for drone operations along their routes of flight;
b. the possibility of unsafe drone operations;
c. equipment failure modes and consequences;
d. the importance of developing relationships between local pilots, airport management and drone operators; and
e. development of beyond visual line-of-sight, and autonomous flight capabilities.[57]

The purpose of this document is to educate pilots regarding the potential for in-flight drone encounters, and to provide strategies designed to help prevent mid-air collisions. It is intended to be voluntary guidance—rather than a standard—that will complement formal rules, procedures, and checklists. Our intent is to advance flight safety.

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Appendix 1 – Poster

This poster summarizes key points of the safety guidance presented in this technical paper. The poster's target audience is manned aircraft pilots. It includes a reference to a URL which contains the pilot brochure, technical paper, and other supporting materials. These materials, as well as a version for business aviation, are available at secureav.com/drones.

Flying in the **Drone Zone**

As drones proliferate, manned aircraft pilots face new safety challenges. The number of drone operators exceeds that of manned aircraft pilots, increasing potential for midair collision. What can you do to fly more safely through the Drone Zone?

Where is the Drone Zone?

The Drone Zone is EVERYWHERE — in any airspace, altitude, and phase of flight.

- While most small drones operate below 400' AGL and beyond 5 SM from airports, there are many exceptions.
- Airports and ATC may know of drone operations in the airport environment without notifying pilots.

Before you fly

- Review NOTAMS, aeronautical charts, Chart Supplements, and other resources for drone avoidance planning. Contact Flight Service for drone updates.
- Be familiar with the Unmanned Aircraft Activity symbol.
- Consider that drone operations may take place near airports, public gatherings, and newsworthy events.

In the Drone Zone: Defensive Flying Tips

- Assume drone operators may not know or follow the rules.
- Expect erratic maneuvers and unpredictable flight paths by drones.
- Recognize the significant limitations of see-and-avoid regarding drones. Remain vigilant.
- Anticipate drone operations at fires, public gatherings and points-of-interest.
- Monitor ATC; ask for drone updates. Report drone incidents to ATC.
- Avoid complacency; be prepared for the unknown.
- Fly predictably & visibly (lights on), so drone operators can better avoid you.

For additional guidance: **www.secureav.com/drones**

FLIGHT SAFETY IN THE DRONE ZONE

Appendix 2 – Brochure

A safety guidance brochure is available at: secureav.com/drones. The brochure expands upon the poster presented in Appendix 1, above, and presents this technical paper's safety guidance in abbreviated form. Its target audience is pilots. The brochure's title, "Flight Safety in the Drone Zone" is intended to present a more popular flavor.

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Appendix 3 – Terminology and Abbreviations

The following abbreviations, definitions, and terms are used in this guidance.

AC – FAA Advisory Circular

ADS-B – Automatic Dependent Surveillance-Broadcast

A/FD – Airport / Facilities Directory, now included in Chart Supplements U.S.

AGL – Above Ground Level

AIM – Aeronautical Information Manual

AMA – Academy of Model Aeronautics

AMCC – Aviators Model Code of Conduct

ASAP – Aviation Safety Action Program

ASRS – NASA Aviation Safety Reporting System

ASTM F38 – ASTM International, Committee F38 on Unmanned Aircraft Systems

ATC – Air Traffic Control

ATIS – Automated Traffic Information Service

BVLOS – Beyond Visual Line-of-Sight

COA – Certificate of Waiver or Authorization

CTAF – Common Traffic Advisory Frequency

C2 – Command and Control

drone – Unmanned Aircraft (UA) to include: model aircraft, unmanned aircraft system (UAS), unmanned aerial vehicle (UAV), remotely piloted aircraft (RPA), or remotely piloted aircraft system (RPAS). See endnote 1.

fly-away – Drone flight suffering loss of command and control

FMRA – FAA Modernization and Reform Act of 2012

GA – General Aviation

ICAO – International Civil Aviation Organization

IMC – Instrument Meteorological Conditions

JARUS – Joint Authorities for Rulemaking of Unmanned Systems

LLLP – Lost Link Loiter Points

lost link – loss of command and control link contact precluding flight operator management of the drone

model aircraft – A "model aircraft" as defined in the Special Rules on Model Aircraft

MOR – Mandatory Occurrence Reports

NAS – National Airspace System

NMAC – Near Mid-Air Collision

NOTAM – Notice to Airmen

NTSB – National Transportation Safety Board

NM – nautical miles

pilot – a manned aircraft certificated pilot

PIREP – Pilot Report

RPA – Remotely Piloted Aircraft

RPAS – Remotely Piloted Aircraft System

should – denotes a recommended procedure

SM – statute miles

small UAS (sUAS) or small drone – A drone weighing less than 55 lbs.

SMS – Safety Management System

Special Rule on Model Aircraft – The FAA Modernization and Reform Act of 2012 § 336

SUA – Special Use Airspace

sUAS – small UAS

TFR – Temporary Flight Restriction

UA – Unmanned Aircraft

UAS – Unmanned Aircraft System(s)

UAV – Unmanned Aerial Vehicle(s)

VLOS – Visual Line-of-Sight

**

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About the AMCC Initiative

The AMCC initiative develops tools advancing aviation safety and offering a vision of excellence for aviators. The AMCC website is at secureav.com, and its drone content is available at secureav.com/drones. The AMCC Initiative's Permanent Editorial Board membership is listed below.

Endnotes

* **The Permanent Editorial Board:** Michael S. Baum, JD, MBA, ATP; Deonna Neal, Ph.D., CFI; Ric Peri, VP AEA; Michael Radomsky, CFII; Bill Rhodes, Ph.D.; Stan Rose; Rusty Sachs, JD, DhE, MCFI; and Capt. Don Steinman, ATP, CFII. *See* secureav.com/PEB.pdf.

[1] **Terminology:** Herein, "drone" means unmanned aircraft (UA) to include: model aircraft, unmanned aircraft system (UAS), unmanned aerial vehicle (UAV), remotely piloted aircraft (RPA), or remotely piloted aircraft system (RPAS). While arguably colloquial, the term "drone" encompasses diverse types of unmanned aircraft, and is increasingly accepted as a generic term for unmanned aircraft. Indeed, an FAA website search for the term "drone" returned more than 1,000 listings; and was used in the FAA *Administrator's* Keynote Address, FAA UAS Symposium, Daytona Beach (Apr. 19, 2016), at http://www.faa.gov/news/speeches/news_story.cfm?newsId=20254. Nonetheless, some people define drones as distinct from model aircraft and/or RC (radio controlled) aircraft; others assert that many drones are not "unmanned" (where operated by manned ground control stations, for instance); still others assert that RC aircraft are not drones unless supported by GPS or other navigation and stabilization systems.

An "aircraft" is "any contrivance invented, used, or designed to navigate, or fly in the air." 49 U.S.C. § 40102(a)(6), at https://www.gpo.gov/fdsys/pkg/USCODE-2011-title49/html/USCODE-2011-title49-subtitleVII-partA-subparti-chap401-sec40102.htm. Herein, this definition includes drones used for public, civil/commercial, as well as recreation or hobby purposes. "The term 'unmanned aircraft' means an aircraft that is operated without the possibility of direct human intervention from within or on the aircraft." FAA Modernization and Reform Act of 2012, Pub. L. 112-95, 126 STAT. 11 (2012) (FMRA), § 331(8), at https://www.gpo.gov/fdsys/pkg/PLAW-112publ95/html/PLAW-112publ95.htm, or "a device used or intended to be used for flight that has no onboard pilot." FAA, Pilot/Controller Glossary (May 26, 2016), at http://www.faa.gov/air_traffic/publications/media/pcg.pdf. "Unmanned aircraft system" (UAS) include UA, control station(s), and data link. "Manned aircraft" is used to distinguish manned aircraft from (unmanned) drones. "Pilot" or "pilot(s)" means certificated manned aircraft pilot(s). "Operators" means drone users. *Cf.* Mike Whitaker, FAA Dep. Admin., stated, "People flying unmanned aircraft are aviators." Keynote Presentation, Aero Club of N. CA, NASA AMES, Mt. View (Apr. 28, 2016). Other terminology and abbreviations are contained in Appendix 3, herein.

Drone Types: The FAA distinguishes drones (UAS) operators as follows.

(a) *Public* aircraft operations. *See* 49 U.S.C. §§ 40102(a)(41), 40125, at https://www.gpo.gov/fdsys/pkg/USCODE-2011-title49/pdf/USCODE-2011-title49-subtitleVII-partA-subparti-chap401-sec40102.pdf (defining "public aircraft"); and FAA, Advisory Circular, AC 00-1.1A, *Public Aircraft Operations* (Feb. 2, 2012), at http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_00-1_1A.pdf (explaining "public aircraft operations");

(b) *Civil* aircraft operations (those which do not meet statutory criteria for public operations yet comply with applicable FAA regulations) per special airworthiness certificate or FMRA § 333 exemption, and COA; and

(c) *Model aircraft* operations for hobby or recreational use per FMRA § 336, the Special Rule on Model Aircraft. Model aircraft safety guidance is presented in FAA, Advisory Circular, AC 91-57A, *Model Aircraft Operating Standards*, at http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-57A_Ch_1.pdf. Material restrictions on model aircraft include: weigh of 55 lbs. or less, flight ceiling 400 AGL, line-of-sight, remaining clear of manned aircraft operations and beyond 5 SM of airports (except with notification to tower and airport; drone activity within permanent locations within 5 SM are permitted by mutual agreement, and operation clear of people, stadiums, and special use airspace (SUA) without permission. *Cf.* Senate Bill S.2658 (2016) § 44808, Special rules for model aircraft: "(5) when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator, where applicable, and the airport air traffic control tower (when an air traffic facility is located at the airport) with prior notice *and receives approval*, to the extent practicable . . ." (emphasis added). At https://www.congress.gov/bill/114th-congress/senate-bill/2658/text#toc-idFBE78AB7D862474C8C55C0A649B82206.

And, consider the following perspective from the Academy of Model Aeronautics. "Pilots should: be aware and recognize that traditional model aircraft (MA) have operated safely and responsibly in the national airspace for decades and do so in compliance with federal law and under a standardized set of safety procedures developed and maintained by the Academy of Model Aeronautics (AMA). These guidelines include an extensive set of See & Avoid procedures that effectively prevent collision hazards between MA and manned aircraft. Although categorized as sUAS, model aircraft are distinctly different from "drones" in their purpose, use and operation. Most model aircraft are operated from established flying sites that meet and operate under the AMA rules. Other model aircraft are operated under the same set of safety guidelines on private property and on some public lands." Email from Rich Hansen, AMA to Michael Baum (May 10, 2016).

Precise operating requirements and limitations for public and civil aircraft are stated in the applicable Certificate of Waiver or Authorization (COA). COAs are issued as standard, blanket, or emergency (such as for certain law enforcement operations). Drone operation requirements vary according to the class of airspace. *See* FAA, Air Traffic Org. Policy, Notice N JO 7210.891, *Unmanned Aircraft Operations in the National Airspace System (NAS)* (Nov. 25, 2015), pp. 2-4, at http://www.faa.gov/documentLibrary/media/Notice/Notice_UAS_7210.891.pdf (hereinafter "FAA, UAS in the NAS").

Drone Types, Internationally: Types / categories of drones vary globally. For example, the Euro. Avi. Safety Agency (EASA) regulates unmanned aircraft with an operating mass greater than 150 kg. Reg. (EC) No. 216/2008 of the Euro. Parliament and of the Council (Feb. 20, 2008), Annex II(i), at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:079:0001:0049:EN:PDF; those of lesser mass are regulated by member states. The regulatory framework is moving toward an "operation centric, proportionate, risk- and performance-based" approach with three incrementally greater categories of risk: *Open, Specific, and Certified*. EASA, Opinion of a technical Nature, *Introduction of a regulatory framework for the operation of unmanned aircraft* (Dec. 18, 2016), at https://www.easa.europa.eu/document-library/opinions/opinion-technical-nature; and EASA, A-NPA 2015-10, *Introduction of a regulatory framework for the operation of drones* (Jul. 21, 2015), at https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2015-10. *See generally*, JARUS, *Regulations*, at http://jarus-rpas.org/regulationshttp://jarus-rpas.org/regulations. Presentation of the many country-specific regulatory schemes are beyond the scope of this paper.

Industry Growth: *See* FAA, *FAA Aerospace Forecast, Fiscal Years 2016-2036* (2016), pp. 30-34, at http://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf (presenting unit sales forecast for commercial drones for: 2016 0.6M, and 2020 7.0M – noting more than 4,000 FMRA § 333 exemptions as of Mar. 16, 2016; and for model aircraft: 2016 1.9M; and 2020 4.3M. *Id*. at 31); NPD Group, Press Release, *Year-Over-Year Revenue Soars, According to NPD*, May 25, 2016, at https://www.npd.com/wps/portal/npd/us/news/press-releases/2016/year-over-year-drone-revenue-soars-according-to-npd/ (reporting drone dollar sales for the past 12 months were three times higher than sales from prior year); FAA Admin. Michael P. Huerta, Keynote Address, AUVSI Xposition, New Orleans, May 3, 2016 (noting more than 5,100 commercial exemptions, and 443,000 hobbyist registrations). *See also* FAA, *Registration and Marking Requirements for Small Unmanned Aircraft. Interim Final Rule Regulatory Evaluation* (Dec. 2015), at http://www.faa.gov/news/updates/media/2015-12-13_2120-AK82_RIA.pdf (presenting a Model Aircraft Sales Forecast Summary – asserting total small drone sales of 1.6 million in 2015, projected to 7.1 million in 2020, at Table 1, p. 17); and *'Exponential' growth of Drones prompts Federal warnings in Canada*, TORONTO METRO, Dec. 21, 2015, at http://www.metronews.ca/news/canada/2015/12/22/exponential-growth-of-drones-prompts-federal-warnings.html.

Consumer Market: "[T]he global market for consumer drones will approach $130 million in revenue in 2015, increasing by 55 percent from 2014, with unit sales of consumer drones expected to reach 400,000 [and revenues] expected to easily exceed $1 billion in just five years." Consumer Electronics Show Press Release, *Unmanned Systems Take Flight at the 2015 International CES,* at http://www.cesweb.org/News/Press-Releases/CES-Press-Release.aspx?NodeID=a8cf1815-ad54-4bfd-9e70-62d7e4a1868a.

Military: *See* Business Wire, *Global Defense Drones Market to Exceed USD 8 Billion by 2020, According to Technavio* (Mar. 9, 2016), at http://www.businesswire.com/news/home/20160309005024/en/Global-Defense-Drones-Market-Exceed-USD-8; and Craig Whitlock, *More Air Force drones are crashing than ever as mysterious new problems emerge,* WASH. POST, Jan. 20, 2016, at https://www.washingtonpost.com/news/checkpoint/wp/2016/01/19/more-u-s-military-drones-are-crashing-than-ever-as-new-problems-emerge/?hpid=hp_hp-top-table-main_drones-10pm%3Ahomepage%2Fstory (noting "a virtually insatiable appetite" for surveillance, thus bolstering demand).

Applications: Lower equipment and operating costs, lower risks in hazardous environments, and fast deployment are some key features driving the transition from manned to unmanned systems. *See* Austin Choi-Fitzpatrick, et al., U. of San Diego, *Up in the Air: A Global Estimate of Non-violent Drone Use 2009-2015* (2016), at http://demo.sandiego.bepress.com/gdl2016report/1 (reporting 1,145 discrete cases of drone use drawn from 15,000 news reports); CES, *id.*; and FAA Aerospace Forecast, *id.* (Exhibit 2: Forecast Non-model Units by Application, at p. 57). *See generally*, AUVSI, *The First 1,000 Commercial UAS Exemptions (2016)*, at https://higherlogicdownload.s3.amazonaws.com/AUVSI/b657da80-1a58-4f8f-9971-7877b707e5c8/UploadedFiles/ZAvlBnqWSeSYXPsnKkoc_Section333Report_online022516.pdf, and http://www.auvsi.org/auvsiresources/exemptions (evaluating major applications by key industries, and identifying the top applications as aerial photography, aerial survey, real estate, construction, aerial inspection, infrastructure, agriculture and emergency management). Indeed, yet-to-be-imagined applications will likely be developed, in-line with other disruptive technologies, further increasing demand.

[2] *See, e.g.,* NASA Aviation Safety Reporting System (ASRS), Search Request No. 7223, *Unmanned Aerial Vehicle (UAV) Related Incidents* (Feb. 5, 2016), available at www.secureav.com/ASRS-UAS.pdf (reported drone incidents increased from 13 in 2012 to 81 in 2015); ASRS Database Report Set, *UAV Reports* (Aug. 31, 2015), at http://asrs.arc.nasa.gov/docs/rpsts/uav.pdf; Euro. Cockpit Ass'n, *ECA RPAS/UAVs incidents directory* (Aug. 2015), at https://www.eurocockpit.be/sites/default/files/summary_short_version_draft_rpas-uav_incidents_directory_15_0826_v5.pdf; and FAA, *Clarification of the Applicability of Aircraft Registration Requirements for Unmanned Aircraft Systems (UAS) and Request for Information Regarding Electronic Registration for UAS,* 80 F.R. 63912, 63913 (Oct. 22, 2015), at

https://www.federalregister.gov/articles/2015/10/22/2015-26874/clarification-of-the-applicability-of-aircraft-registration-requirements-for-unmanned-aircraft ("Pilot reports of UAS sightings in 2015 are double the rate of 2014." "Pilots have reported seeing drones at altitudes up to 10,000 feet, or as close as half-a-mile from the approach end of a runway.").

"A mid-air collision is generally considered as having catastrophic consequences for all aircraft types, *irrespective of size or weight*. Even impacts with small, low weight, RPA [remotely piloted aircraft] can result in damage that can compromise the safety of both aircraft." JARUS, *Scoping Paper to AMC RPAS.1309*, Issue 2 (Nov. 2015), p. 34, at http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_04_doc_2_scoping_papers_to_amc_rpas_1309_issue_2_0.pdf (emphasis added). "Upon ingestion of a small drone into the intake of an F-35, we'll probably lose the airplane." Steven Pennington, Exec. Dir., Policy Bd. for Fed. Avi., Presentation at the FAA UAS Symposium, Daytona Beach (Apr. 20, 2016). And, regarding drone-helicopter collision hazards, "[O]ur vehicles are extremely sensitive." Matt Zuccaro, Pres. And CEO, Helicopter Ass'n Int'l, Presentation at the FAA UAS Symposium, *id*.

See also, The Aviation Innovation, Reform, and Reauthorization (AIRR) Act, H.R. 4441, introduced by Rep. Shuster (Feb. 3, 2016), § 435, p.226, available at http://transportation.house.gov/airr-act/ ("It is the sense of Congress that— the unauthorized operation of unmanned aircraft near airports presents a serious hazard to aviation safety."). "It's not a matter of if it will happen, but when." Matt Zuccaro, Presentation at HeliExpo 2015, Louisville, KY (Mar. 1, 2016).

[3] **Standards:** *See, e.g.,* ASTM Int'l, Committee F38 on Unmanned Aircraft Systems, at http://www.astm.org/COMMITTEE/F38.htm, and RTCA Special Committee (SC)-228, *Minimum Operational Performance Standards for Unmanned Aircraft Systems*, at http://www.rtca.org/content.asp?contentid=178. The current standard addresses surface to base of Class A operations; the next set of standards will address C2 and detect-and-avoid. *See* below note 37 regarding drone security standards.

Rules and Guidelines: *See, e.g.,* FAA, *Operation and Certification of Small Unmanned Aircraft Systems*, Docket No. FAA-2015-0150; Notice No. 15-01, Notice of Proposed Rulemaking (2015), at http://www.faa.gov/regulations_policies/rulemaking/recently_published/media/2120-AJ60_NPRM_2-15-2015_joint_signature.pdf. For model aircraft, *see* FMRA § 336, above note 1; and the *Know Before You Fly* campaign, at http://knowbeforeyoufly.org (founded by the Ass'n for Unmanned Vehicle Systems Int'l (AUVSI), the Acad. of Model Aeronautics (AMA) in partnership with the FAA, and supported by diverse aviation organizations, at http://knowbeforeyoufly.org/supporters/). Separately, see the Canadian recreational drone safety site, at http://www.tc.gc.ca/eng/civilaviation/standards/standards-4179.html.

[4] *See, e.g.,* below note 14 (material lack of drone guidance in the Aeronautical Information Manual (AIM)), and below text accompanying note 36 (lack of UAS symbology on aeronautical charts).

[5] Aviation regulation predates the U.S. Air Commerce Act of May 20, 1926, 44 Stat. 568, and forms the foundation for the Federal government's control of civil aviation. Consider that aviation regulation evolved in step with over 100 years of aviation developments whereas drone regulation must overcome the challenges of entering into this pre-existing regulatory environment.

[6] FAA, Unmanned Aircraft Systems, at http://www.faa.gov/uas/; and FAA, Air Traffic Org. Policy, Notice N JO 7210.891, *Unmanned Aircraft Operations in the National Airspace System (NAS)* (Nov. 25, 2015) p. 1, at http://www.faa.gov/documentLibrary/media/Notice/Notice_UAS_7210.891.pdf.

[7] *See, e.g.,* FAA, *Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap* (1st ed. 2013), at http://www.faa.gov/uas/media/uas_roadmap_2013.pdf. *See also,* European Aviation Safety Agency (EASA), *Roadmap for the integration of civil Remotely-Piloted Aircraft Systems into the European Aviation System,* Final report from the Euro. RPAS Steering Group (June

2013), at http://ec.europa.eu/DocsRoom/documents/10484/attachments/1/translations/en/renditions/native ; http://unmanned-aerial.com/european-aviation-safety-agency-sets-guidance-on-risk-based-uav-operations/. "RPAS development and integration should be considered as an evolutionary step in aviation." Drones are also viewed "as the next major evolutionary step in aircraft design." And, "[e]ven on relatively simple RPAS, reliance on the remote crew to manage failures may no longer be realistic . . ." JARUS, *Scoping Paper to AMC RPAS.1309*, Issue 2, Safety Assessment of Remote Piloted Aircraft Systems (Nov. 2015), pp. 10-11, 14, at http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_04_doc_2_scoping_papers_to_amc_rpas_1309_issue_2_0.pdf. Future phases of such roadmaps include *integration* and *evolution*, the safety of which will demand certification (or standards conformance) and (presumably ubiquitous) deployment of certain new technologies.

[8] There are material exceptions, however. For example, public aircraft may operate in controlled airspace via COA. *See* http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/aaim/organizations/uas/coa/. And, private and commercial operators may operate via FMRA § 333 exemption where it is determined the safety of the NAS will not be compromised. *See* http://www.faa.gov/uas/legislative_programs/section_333/. Model aircraft may operate in controlled airspace and within 5 SM of an airport with prior notice and for a permanent location within 5 SM, upon establishing "mutually-agreed upon operating procedures with the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport)." FMRA § 336(a)(5), available at https://www.govtrack.us/congress/bills/112/hr658/text; and FAA, *FAQ about the Use of Model Aircraft Near an Airport*, at http://www.faa.gov/airports/special_programs/uas_airports/model_airplane_faqs/.

[9] The FAA response includes: the *Know Before You Fly* campaign (above note 3), FAA Advisory Circular, AC 91-57A, Chg. 1, *Model Aircraft Operating Standards* (Jan. 11, 2016), at http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-57A_Ch_1.pdf, as well as the collateral educational benefits precipitating from the FAA's drone registration regime. Indeed, much more is needed.

A small UAS commercial rule will invariably contain knowledge requirements. Additionally, the commercial training community has responded with diverse knowledge and practical training courses. And, the model aircraft community has published extensive safety guidance for its members, including the *Academy of Model Aeronautics National Model Aircraft Safety Code* (Jan. 1, 2014), at http://www.modelaircraft.org/files/105.pdf.

Cf., FAA Order 8900.1 (FSIMS) 16-4-1-3, at fsims.faa.gov/PICDetail.aspx?docId=8900.1, Vol.16, Ch4, Sec1 ("UAS pilots are responsible for controlling their aircraft to the same standards as the pilot of a manned aircraft." And, presenting FAA pilot certificate requirements.).

Separately, for example, further education benefiting uncertificated operators might include specialized weather products to the extent that traditional aviation weather products are not necessarily actionable by non-pilots.

[10] "The FAA has had a hard time enforcing manned aviation. . . . It is virtually impossible for us to enforce unmanned aviation." Reggie Govan, FAA Chief Counsel, Presentation at the FAA UAS Symposium, Daytona Beach (Apr. 20, 2016). *See, e.g.,* FAA, *Law Enforcement Guidance for Suspected Unauthorized UAS Operations*, at http://www.faa.gov/uas/regulations_policies/media/FAA_UAS-PO_LEA_Guidance.pdf; FAA, Notice, *Education, Compliance, and Enforcement of Unauthorized Unmanned Aircraft Systems Operators* (Jul. 15, 2014), at http://www.faa.gov/documentLibrary/media/Notice/N_8900.268.pdf; and Jon Loffi, et al., *Analysis of the Federal Aviation Administration's Small UAS Regulations for Hobbyist and Recreational Users,* ERAU

INT'L JOUR. OF AVI. AERONAUTICS, AND AEROSPACE, Vol. 3, Iss. 1, Art. 3 (Feb. 19, 2016) at 18 ("It is likely that more aggressive enforcement action will follow swiftly on the heels of final implementation of sUAS rules [and] sUAS violations will probably be designated by the agency for special emphasis enforcement, and be considered an aggravating factor . . ."). *See generally,* FAA Law Enforcement Resources, at http://www.faa.gov/uas/law_enforcement/.

[11] FAA, Notice N JO 7210.891, above note 6. "It's not practical to think ATC is going to separate the low altitude airspace." Presentation by Elizabeth L. Ray, VP, FAA, Air Traffic Org. Mission Support Serv., FAA UAS Symposium, Daytona Beach (Apr. 19, 2016).

[12] *See, e.g.,* Airport Cooperative Research Program, Report 144, *Unmanned Aircraft Systems (UAS) at Airports: A Primer* (2015), at http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_144.pdf; and Transp. Res. Bd., CRP 01-32 [Pending], at http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4012 (Updating ACRP Report 16: *Guidebook for Managing Small Airports*). *See also,* Airmap & the Am. Ass'n of Arpt. Execs (AAAE) Launch UAS Notice System (Mar. 29, 2016), at http://www.prnewswire.com/news-releases/airmap--the-american-association-of-airport-executives-aaae-launch-uas-notice-system-300242406.html# (describing a Digital Notice and Awareness System (D-NAS) to provide airports information about drone location proximate to airports). "D-NAS is very similar to the UAV maps provided on Flight Service's 1-800-wxbrief website since January 2016." Email from Mike Glasgow, LMFS (Apr. 17, 2016 [yet not integrated into the aircraft].

Additionally, despite Federal assertions of exclusive control of the NAS, local governments increasingly seek to exert control over low-altitude airspace—most frequently without a full grasp of flight safety considerations. Guidance is needed to help local governments appreciate the issues and constraints, and to make effective safety risk-based decisions. *See* below note 56, and accompanying text.

[13] It is widely believed that a technological solution is essential and inevitable. With commitment and resolve, an effective technology solution will likely be deployed widely within five years. This forecast is based on the belief that drone technology will evolve rapidly and result in a rapid turnover cycle for existing drones, arguably akin to rapid advancement in mobile telephone technology. However, to the extent that the anticipated "technology solution" relies on ADS-B, it has not been practical for most small drones including because of price, weight, power requirements, size and legacy issues. Operationally, hills may impede low altitude performance, and the large number of small drones may saturate the system. "2.5 million drones would create some potential bandwidth problems." Mike Whitaker, FAA Dep. Admin., Presentation at the Aero Club of N. Cal., NASA AMES (Apr. 28, 2016). "We can't say we totally understand the [sense-and-avoid] problem set." Dr. Ed Waggoner, Dir., NASA Integrated Avi. Sys. Prog., Aeronautics Research Mission Directorate, Presentation at the FAA UAS Symposium, Daytona Beach (Apr. 19, 2016).

See generally, Robert C. Strain, et al., *A Lightweight, Low-Cost ASD-B System for UAS Applications* (2007), at https://www.mitre.org/sites/default/files/pdf/07_0634.pdf (ADS-B general background). *But see, e.g.*, http://www.uavionix.com/ (describing "PING", a micro-miniaturized ASD-B transceiver). Some experts urge that ground-based surveillance systems will precede airborne systems due to certification issues. *See, e.g.*, *Dugway tests system for easier UAS transit*, SUAS NEWS (May 16, 2016), at http://www.suasnews.com/2016/05/dugway-tests-system-easier-uas-transit/?utm_source=sUAS+News+Daily&utm_campaign=4f28da8c9f-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_b3c0776dde-4f28da8c9f-303675929&mc_cid=4f28da8c9f&mc_eid=a9df228121 (radar-based system). And, e.g., new low-weight, low-power radar, low profile detect-and-avoid radars are nearing production. *See, e.g.,* FORTEM Technologies, at www.fortemtech.com (announcing the DAA-1500 DAA radar – weighing 490 gm).

"Collision avoidance" was first productized in a consumer drone on Jan. 6, 2015 as "ultrasonic proximity detection to avoid large obstacles." At http://tinyurl.com/j2fjm3l (utilizing Intel's "RealSense" technology).

See http://www.intel.com/content/www/us/en/architectue-and-technology/realsense-overview.html. Such technology "must come to maturity on a commercially available scale." Mark Skidmore AM, Dir. of Avi. Safety, Aus. Gov't, Civil Avi. Safety Auth. (Mar. 7, 2016), at https://www.casa.gov.au/about-us/standard-page/regulating-rpas-safer-operations. Competing approaches to separation and traffic management include, for example, PrecisionHawk's Low Altitude Tracking and Avoidance System (LATAS – exploiting cellular networks). *See* http://flylatas.com/; and, among others, a DARPA-sponsored integrated sense-and-avoid system, at http://www.darpa.mil/news-events/2016-04-05a.

Geo-fencing technology supporting separation of small drones has been advanced primarily by leading drone manufacturers, such as DJI, to mitigate drone incursions into unauthorized airspace. Yet even those systems may permit operators to override ("unlock") its constraints [except perhaps in certain highly sensitive locations]. *See* Press Release, *DJI Launches Public Beta of New Geofencing System* (Dec. 31, 2015), at http://www.dji.com/newsroom/news/dji-launches-public-beta-of-new-geofencing-system. Moreover, geo-fencing is neither implemented industry-wide, nor assures compliance (e.g., some drone operators have intentionally avoided updating software that invokes geo-fencing).

[14] Other than mention of exercising increased vigilance and checking NOTAMs, the only material advice offered by the FAA advises manned aircraft pilots operating near non-towered airports "to follow normal operating procedures and . . . to monitor the CTAF for any potential UAS activity." FAA, AIM § 7-5-5 c., *Unmanned Aircraft Systems* (2016), at http://www.faa.gov/air_traffic/publications/media/AIM_Basic_4-03-14.pdf; and, if encountering a drone, to "be prepared for evasive action if necessary." *Id*. § 7-5-5 e. No recommendations address evasive action procedures. Moreover, collision avoidance training standards for airmen do not address drones. *See* FAA, Order 89002A CHG 2, *General Aviation Airman Designee Handbook w/Change 2* (Effective Jan. 5, 1016), at http://www.faa.gov/documentLibrary/media/Order/8900_2A_CHG-2.pdf (addressing collision avoidance as a "Special Emphasis Item" without mention of drones). *But see,* FAA, Advisory Circular, AC 91-ENGO, *Electronic News Gathering Operations* (Mar. 2016), at http://www.faa.gov/aircraft/draft_docs/media/AFS/AC_91-MPA_Coord_Copy.pdf ("ENG pilots must use caution to look for anything that could be a collision hazard . . . including other transient aircraft, manned or unmanned . . ." at ¶ 10).

[15] **See-and-Avoid:** The Euro. Cockpit Ass'n notes that a small drone, visible only at 65 feet out, is merely 0.3 seconds away from an aircraft flying at 130 knots. At https://www.eurocockpit.be/pages/remotely-piloted-aircraft-systems-drones. The FAA recognizes research demonstrating an average identification and reaction time of 12.5 seconds. "This means that a small or high-speed object could pose a serious threat if some other means of detection other than see and avoid were not utilized, as it would take too long to react to avoid a collision. This is particularly important with small Unmanned Aircraft Systems (sUAS)." FAA, Advisory Circular (Draft), AC 90-48D, *Pilots' Role in Collision Avoidance* (Mar. 2016), available at http://www.faa.gov/aircraft/draft_docs/media/afs/AC_90-48D_Coord_Copy.pdf.

Consider the safety schema for collision avoidance by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS), asserting see-and-avoid by the pilot as the "final safety barrier":

> Procedures for the avoidance of collisions are built up through multiple safety barriers. These include airspace classifications, rules of the air, flight planning and ATC. In addition, certain aircraft may be fitted with an approved Airborne Collision Avoidance System (ACAS) to advise the pilot of the presence of conflicting traffic and any action to be taken to avoid a collision occurring. The final safety barrier for collision avoidance rests with the pilots of both conflicting aircraft to 'see-and-avoid'. In the case of smaller aircraft not fitted with ACAS or operating in uncontrolled airspace, greater reliance is placed on the pilots' see-and-avoid capability.

JARUS, above note 7, p. 34. *See* EASA, *EASA creates task force to assess the risk of collision between drones and aircraft*, at https://www.easa.europa.eu/newsroom-and-events/news/easa-creates-task-force-assess-risk-collision-between-drones-and-aircraft. The FAA's basic see-and-avoid rule appears in 14 C.F.R. § 91.113: "(b) *General.* "When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft . . ." Available at http://www.ecfr.gov/cgi-bin/text-idx?SID=04441a137829316f210738303edabd73&mc=true&node=se14.2.91_1113&rgn=div8. *Cf.* Kevin W. Williams and Kevin M. Guldea, FAA Civil Aerospace Med. Inst., *A Review of Research Related to Unmanned Aircraft System Visual Observers* (Oct. 2014), at http://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201409.pdf (presenting factors affecting see-and-avoid, and guidelines for the use of visual observers).

There is a widely-held belief that the see-and-avoid safety mechanism provides an equivalent level of safety for small drones operating at low altitudes without detect-and-avoid, transponders, or other related technologies to assure separation from manned aircraft. Is this true?

Arguably, see-and-avoid between small drone and manned aircraft may not generally provide an equivalent level of safety (compared to see-and-avoid between two manned aircraft) for the following reasons:

a. *Too Small to See*: Manned aircraft are typically at least an order of magnitude bigger than many small drones, and small drones cannot effectively be seen by pilots. As an analogy, consider the extent of helicopter wire-strikes which occur with unacceptable frequency even where there are multiple observers on-board.

b. *Half the Eyes*: As a practical matter, see-and-avoid for small drones has the benefit of only half the eyes watching effectively for other aircraft (that is, only the drone operator or observer, not the manned pilot can see-and-avoid). This arguably might make it only half as effective.

c. *Degraded Visual Environments*: Drone operator see-and-avoid is handicapped by degraded visual environments, obstacles, varying altitudes (between drone and operator), and slopes that may reduce the ability to see approaching aircraft.

d. *Reduced Safety Margins:* The ability of drone operators to see-and-avoid other traffic deceases with distance between operator and drone.

e. *Areas of Reduced Buffer:* There is a safety gap beyond the extreme edge of line-of-sight operation, precluding effectiveness of see-and-avoid.

As a matter of completeness, consider the following perspectives concerning see-and-avoid from the Academy of Model Aeronautics:

> [T]he safety measures embodied in See & Avoid are applied differently in regards to manned vs. unmanned encounters, and it could be argued that this suggests a diminution of See & Avoid in the customary sense. However, there are numerous scenarios and circumstances in manned aircraft encounters in which one or the other pilot is unable to see the other aircraft and there is no suggestion that this diminishes the safety aspect of See & Avoid. I would not suggest that the variation to See & Avoid presented in manned vs. unmanned encounters diminishes the safety factor involved.
>
> AMA's position is that the UA pilot should assume that the manned aircraft pilot will not see his aircraft. Or if he does, he won't see it in time to effectively avoid a collision. The UA pilot should and must take the responsibility for collision avoidance.

> That having been said, the UA pilot and/or his observer actually has a better and less distractive field of view. He also has the added sense of being able to hear an approaching aircraft. And, for the most part, has a much more maneuverable aircraft that can effect course changes and descend very quickly. Moreover, in a worst case scenario, the UA pilot has the option of destroying (and in AMA's eyes must destroy) the unmanned aircraft if necessary in order to avoid a collision with the manned aircraft. (See AMA's See & Avoid guidelines . . .)
>
> From an aeromodelling standpoint, See & Avoid starts with selecting a safe place to fly and maintaining vigilance and a heightened situational awareness when in areas where encounters with manned aircraft are likely. Unfortunately, the new purposeful use of UAS presents a challenge in this regard in that the purposeful use of the device often times takes place in locations where people and property that can get hurt are located, places where model aircraft typically are not flown, and at times in areas where encounters with manned aircraft are likely. This is why the AMA has developed and advocated for more detailed guidelines for the purposeful use of UAS (drones).

Email from Rich Hansen, AMA to Michael Baum (May 11, 2016).

[16] *See* NASA ASRS, Search Request No. 7223, above note 2 (reporting diverse manned aircraft-drone sightings and incidents, disproportionately at altitudes exceeding 1,000 AGL); FAA, *UAS Sighting Report,* Aug. 21, 2015 - Jan. 31, 2016, at http://www.faa.gov/uas/media/UAS_Sightings_report_21Aug-31Jan.xlsx; and Arthur Holland Michel and Dan Gettinger, *Analysis of New Drone Incident Reports* (Mar. 28, 2016), at http://dronecenter.bard.edu/analysis-3-25-faa-incidents/ (nine out of ten incidents occurred above 400' AGL; with an average altitude of 3,074 ft. MSL; 47% of such incidents involved single-engine prop aircraft); and, FAA, UAS Events List (Nov. 2014-2015), at http://www.faa.gov/uas/media/UASEventsNov2014-Aug2015.xls (listing pilot, air traffic and citizen reports of possible encounters with drones).

There is a well-recognized need for rigorous validation of reported incidents. *See, e.g., W. Hulsey Smith and Freddie L. Mann III, AeroKinetics, The Real Consequences of Flying Toy Drones in the National Airspace System* (2015), at https://aerokinetics.com/wp-content/uploads/2015/11/STUDY_RealConsequencesOfToyDrones.pdf ("Toy drones pose a catastrophic threat to manned rotorcraft in all phases of flight, including cruise, based upon their typical operating altitudes."). *But see,* Eli Dourado, et al., *Do Consumer Drones Endanger the National Airspace? Evidence from Wildlife Strike Data* (Mar. 14, 2016), at http://mercatus.org/publication/do-consumer-drones-endanger-national-airspace-evidence-wildlife-strike-data (asserting "that the probability of collision remains at an acceptable level").

[17] For example, Congress required the FAA to issue a final rule for small drones by Dec. 2015. The General Accountability Office (GAO) stated, "If FAA takes 16 months, the final rule would be issued in late 2016 or early 2017, about two years beyond the requirement in the 2012 Act." GAO, *Unmanned Aircraft Systems,* GAO-12-981 (Sept. 2012), at http://www.gao.gov/assets/650/648348.pdf. Congressional hearings have been notably heated over such delays. "The regulatory bandwidth is very, very narrow," James H. Williams, Dentons, formerly FAA, Presentation at the AUVSI Xposition, New Orleans (May 2, 2016).

[18] *See Letter from Industry to Michael Huerta, Adm'r, FAA* (Sept. 30, 2015), available at https://higherlogicdownload.s3.amazonaws.com/AUVSI/b657da80-1a58-4f8f-9971-7877b707e5c8/UploadedImages/FAA%20Letter_93015.pdf.

[19] *See, e.g.,* ALPA, *Remotely Piloted Aircraft Systems, Challenges for Safe Integration into Civil Airspace* (Dec. 2015), at http://www.alpa.org/~/media/ALPA/Files/pdfs/news-events/white-papers/uas-white-paper.pdf?la=en ("There are not enough empirical studies to fully understand airspace, ATC [and] flight

operations wrapped in regulation . . . [and] the impacts of integrating UAS/RPAS."); Cpt. Thomas Rueder, Euro. Cockpit Ass'n, *Increasing number of drone operations and its impact on the safety and operations of rotorcraft*, EASA Rotorcraft Symposium, Cologne (Dec. 2015), at https://www.eurocockpit.be/sites/default/files/drones_threatens_helicopters_eca.ppsx (urging collision avoidance systems research, "linkloss", geo-fencing, and "aeronautic level of safety"); and BBC, *Drone near-misses prompt calls for plane strike research* (Mar. 2, 2016), at http://www.bbc.com/news/uk-35699396 (British Airline Pilots Ass'n urges British Dept. of Transport and the CAA to back collision research). Nonetheless, there are increasing significant research initiatives underway, such as via the Alliance for System Safety of UAS Through Research Excellence (ASSURE), at www.assureuas.org (detailing diverse drone safety research projects).

[20] For example, ASTM Committee F38 on Unmanned Aircraft Systems, Draft *Operational Risk Assessment* (ORA), WK49619 (2015). *See generally*, INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS 123-135 (Richard K. Barnhard, et al., eds., 2012), available at https://issuu.com/huxeo/docs/introduction_to_unmanned_aircraft_s (on safety assessments); FAA, *Unmanned Aircraft Systems Test Site, Other Transaction Agreement*, App. C, p. 32 (Feb. 14, 2013), at https://faaco.faa.gov/index.cfm/announcement/view/14348 (Risk Hazard and Maturity Approach applied to UAS applicants), and FAA, *Risk Management Handbook,* FAA-H-8083-2 Chg. 1 (Jan. 2016), at http://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/risk_management_hb_change_1.pdf.

[21] Drone safety initiatives by aviation NGOs include, in part, the following:

- The Aircraft Owners and Pilots Ass'n (AOPA) Air Safety Institute's video, *Collision Avoidance: See, Sense, Separate* (released Jan. 14, 2016) does not mention drones. At http://www.airsafetyinstitute.org/collision-avoidance/midairs. AOPA produced an online course entitled, *Unmanned Aircraft and the National Airspace System* focused on military drone safety (funded by the U.S. Dept of Defense and geared to military drones). At http://flash.aopa.org/asf/unmannedaircraft/index.cfm?_ga=1.104111619.2076797222.1451499428 (logon required). Its "Safety Considerations" section states, "Can They See Me? . . . YES." And, its "Flying with UA Ops Nearby" section states, "As you've learned throughout the course, unmanned aircraft don't just pop up in the sky unannounced." *Id*. This course is outdated and does not address model aircraft and certain other types of drones/safety hazards and operations. Additionally, AOPA "is preparing an education and self-certification program" for "all UAS operators." *AOPA's UAS Policy Position*, at http://www.aopa.org/Pilot-Resources/Aircraft-Ownership/Drones/AOPA-and-Drones/AOPAs-UAS-Policy-Position. Such education includes, *Best Practices for Flying your Drone within Five Miles of an Airport*, Mar. 2016, at http://www.aopa.org/Pilot-Resources/Aircraft-Ownership/Drones/UAS; and an April 2016 webinar focused on drone operator education. The Int'l Aircraft Owners and Pilots Ass'n (IAOPA) has not produced drone safety guidance.

- The Experimental Aircraft Ass'n (EAA) has partnered with the Acad. of Model Aeronautics (AMA) via MOU (May 24, 2015), at http://www.modelaircraft.org/news/AMAEAApartner.aspx ("Could EAA eventually form a Drone Division, paralleling its Vintage and Warbirds groupings? 'Possibly,' says Pelton." John Morris, *EAA Must Embrace Drones, Says Jack Pelton,* AVIATIONWEEK (Jul. 21, 2015), at http://aviationweek.com/oshkosh-2015/eaa-must-embrace-drones-says-jack-pelton). EAA and AMA executed a further MOU, enhancing collaboration on advocacy, include airspace matters. Jack Pelton, Pres., EAA, Presentation at the AMAExpo, Ontario, CA (Jan. 9, 2016). The AMA/EAA relationship is likely bolstered by collective fears of a low-altitude "airspace grab" to support drone delivery services such as by Amazon or Google. This concern is shared by other NGOs, including, e.g., the Helicopter Ass'n Int'l (HAI), "[w]e are fearful of losing access to airspace." Matt Zuccaro, Pres. and CEO, HAI, Presentation at the FAA UAS Symposium, Daytona Beach (Apr. 20, 2016).

- The Int'l Civil Avi. Org. (ICAO) has focused on cross-border operations. "Provisions to facilitate VLL [very low level] operations [below 500 AGL] are not [addressed]." ICAO, *Manual on Remotely Piloted Aircraft Systems (RPAS)*, Doc. 10019, § 10.6.1 (1st ed., 2015), at http://www4.icao.int/demo/pdf/rpas/10019_cons_en%20-%20Secured.pdf.

- The Nat'l Ag. Avi. Ass'n (NAAA) developed a video about drones at agaviation.org/uavsafety (focused on drone operation with mention of manned aircraft pilot avoidance).

- Other organizations have commented on proposed drone rules, and/or established drone working groups, but may not yet have materially addressed manned aircraft safety in the presence of drones. *See, e.g.*, The Air Line Pilots Ass'n (ALPA), *Keep America Flying, A Flight Plan for Safe and Fair Skies*, at http://www.alpa.org/~/media/ALPA/Files/pdfs/news-events/white-papers/keep-america-flying.pdf?la=en, and ALPA White Paper, *Remotely Piloted Aircraft Systems, Challenges for Safe Integration into Civil Airspace* (Dec. 2015), at http://www.alpa.org/~/media/ALPA/Files/pdfs/news-events/white-papers/uas-white-paper.pdf?la=en; The Nat'l Business Avi. Ass'n (NBAA), at www.nbaa.org/uas; The Helicopter Ass'n Int'l (HAI), at www.rotor.org/AboutHAI/Committees/UnmannedAircraftSystems.aspx; The Int'l Air Transp. Ass'n (IATA), at http://airlines.iata.org/topic/drones; and The Nat'l Ass'n of Flight Instructors (NAFI), at http://www.nafinet.org/news.aspx?id=630.

Close collaboration among pilot associations and government are important to advance flight safety education for pilots operating near drones.

[22] *See id.* (regarding EAA/AMA MOU and Amazon/Google airspace issues). *Cf.,* Amazon, *Revising the Airspace Model for the Safe Integration of Small Unmanned Aircraft Systems* (Jul. 2015), at https://www.documentcloud.org/documents/2182311-amazon-revising-the-airspace-model-for-the-safe.html, and Rene Marsh, CNN, *Google exec: Drone deliveries could come in one year* (Jan. 11, 2016), at http://www.cnn.com/2016/01/11/politics/google-drone-deliveries/ (Dave Vos, head of Google's Project Wing, asserting that drone deliveries could come in one year).

[23] Since manned aircraft cannot see-and-avoid small drones effectively, some stakeholders unwittingly acquiesce to or otherwise are resigned to accept current separation risks.

[24] **Status**: The guidance is proposed as a "stop-gap" measure pending deployment of effective technical and regulatory solutions to better deconflict and integrate manned aircraft and drones. *See* above note 13 (addressing technical considerations).

Documents: In concert with the release of this safety policy-oriented technical paper, the AMCC Permanent Editorial Board has prepared a safety awareness poster intended for the broader pilot community, at Appendix 1; and a brochure for manned aircraft pilots summarizing the safety guidance, at Appendix 2, herein.

Structure: The safety guidance is organized within the recognized phases of a risk-management process. Risk management is the process of understanding our operations, being aware of the potential hazards in those operations, evaluating the risks associated with those hazards, and being prepared to take appropriate action. In this process, the first two parts are preparatory, the third is what we do in real time, and the fourth is a follow up for continuous improvement of our level of safety:

> ***General Education and Preparation:*** In this phase, we review our typical flight operations and the environments we fly in and determine our vulnerability to potential conflicts with drone operations. Here we consider personal practices, what do we do to plan operations, remain vigilant, and respond where necessary? The results of our decisions are often called, "personal minimums," but possibly more accurately described as, "personal practices:" what do we always do, never do, or do depending on conditions?

> ***Preflight Operations:*** Here, we consider a specific operation that we're about to conduct. The first step is to determine if this is an operation that we've considered in our development of our personal practices or is this a unique operation or flying environment? Then we fill in the blanks for the specific flight. Are we going to be flying in an area where drone operations are likely? What sources of information are available? What will I do to respond to potential risks?
>
> ***In-Flight Operations:*** This is where the action is, but if we've considered potential risks thoroughly in the previous two phases, we'll be much better prepared. Managing risk real-time is dependent on situation awareness, being aware of things happening in the operation, conditions encountered in the environment (monitoring), understanding how these conditions may affect us (evaluation) and assessment of the potential impact of these conditions (anticipation of risk and action necessary).
>
> ***Post-Flight Operations:*** The experiences of the flight we've just conducted should be considered immediately or at least soon after the flight, while the flight is fresh in our minds as well as later, when we have time to reflect and consider the potential impact of what we've learned on future operations. This process closes the loop on the first two phases; did we encounter anything that hasn't been considered? Is there anything new in the flight environments that we frequent? Should we update our personal practices or preflight procedures? This is also where we have an opportunity to contribute to the risk awareness of other users, both in the manned and unmanned aviation communities.

Email from Don Arendt, PhD to Michael Baum (May 1, 2016).

[25] FAA, Air Traffic Org. Policy, Notice N JO 7210.891, *Unmanned Aircraft Operations in the National Airspace System (NAS)* (Nov. 25, 2015), p. 1, ¶ 5, at http://www.faa.gov/documentLibrary/media/Notice/Notice_UAS_7210.891.pdf (recognizing "limited and at times different performance characteristics [of drones] than manned aircraft"). *See* above text accompanying note 2 (re: incidents and collisions). "Drones can move in any direction, at any time, without a reason grounded in flight safety or aerodynamics as taught to manned pilots. . . it removes any experienced-based expectations and requires constant vigilance by pilots." Email from Harrison G. Wolf, Wolf Aviation Safety & Security to Michael Baum (May 16, 2016).

Bird Strikes Compared: Consider that unlike manned aviation that often trains pilots to anticipate and respond to bird strikes, advice on drone strike avoidance is generally unavailable. *See* Roger Nicholson, Ph.D., and William S. Reed, *Strategies for the Prevention of Bird-Strike Events*, Boeing AERO MAGAZINE, Mar. 2011, at http://www.boeing.com/commercial/aeromagazine/articles/2011_q3/4/ (addressing manned aircraft and bird strikes), Travis L DeVault, et al, *Speed kills: ineffective avian escape responses to oncoming vehicles*, Proc. R Soc Biol Med (Jan. 7, 2015), at http://rspb.royalsocietypublishing.org/content/282/1801/20142188 (asserting lack of time for collision assessment of fast-moving vehicles; avoidance behavior differing across bird species; and solitary vs. group behaviors), and Capt. Tim Canoll, ALPA Pres. (Mar. 23, 2016), at http://www.alpa.org/en/news-and-events/Blog/2016/03/23/advance-safe-uas-integration ("Comparing a small machine . . . to a bird provides no reasonable correlation . . . . Based on a lack of research and testing data, it is presumptuous to correlate UAS and bird strikes."). *See* Steven Mackay, *Engineering researchers seek remedies for threat posed by drones to commercial airlines*, PHYS.ORG (Oct. 28, 2015), at http://phys.org/news/2015-10-remedies-threat-posed-drones-commercial.html (simulation of engine ingestion threat to airliners), and Carl Smith, *MSU's Raspet test drone and aircraft collision,* THE DISPATCH (Apr. 28, 2016), quoting Dallas Brooks, Dir., Miss. State U. Raspet Flight Research Lab & Asso. Dir., ASSURE, at http://www.cdispatch.com/news/article.asp?aid=49819 ("Simulation only takes you so far.").

[26] *See* FAA, Order 2150.3B Chg 11, *Compliance and Enforcement Bulletin No. 2014-2* (effective Feb. 24, 2016), App. H, at http://www.faa.gov/documentLibrary/media/Order/Change_11_2150.3B.pdf ("There is

an increasing number of UAS operations conducted in the United States that are operated contrary to applicable statutory and regulatory requirements."). See above note 2 (re altitude incursions by drones).

[27] To the extent possible, seek to mitigate such risks by enhanced training. Nonetheless, consider the risks of creating additional surveillance burdens on manned pilots. "Cognitive capability is not unlimited. Would increasing scanning tasks during high-workload phases of flight lead to neglecting other important functions?" Email from Bill Rhodes, Ph.D. to Michael Baum (Feb. 24, 2016). *See generally*, above note 15 (addressing see-and-avoid practice and limitations).

Pilots should, "[c]ontinue to divide their attention and fly their planes. Do not allow drone risk mitigation to interfere with their normal duties as pilot in command. Many accidents have been caused by simple distractions. This is especially critical in the higher workload phases of flight where drones are more likely to be encountered, such as takeoff and landing." Email from Paul Duty, CFI, CFII, MEI, AGI, Gleim Publications, Inc. to Michael Baum (May 2, 2016).

[28] "Such training should include scenario-based training, including emphasis on control-surface degradation. It [has been proposed that this] can be accomplished by limiting available control deflection in both directions or in a single direction in aileron, elevator and rudder while maneuvering the airplane for an emergency landing under the supervision of a flight instructor. The instructor must use discretion in where and how to apply the scenario and control limits to ensure full authority of the controls is available when necessary." Email from Mike Shiflett, CFII to Michael Baum (Feb. 23, 2016).

Some reviewers query whether the safe execution of such maneuvers is beyond the capability of most instructors; others suggest the response is, or should be identical to that of manned aircraft. These concerns highlight the need for a guidance document to assist flight instructors safety teach limited control maneuvers, and that address both preflight safety briefings and emergency recovery procedures following collision with drones. For safety purposes, such guidance would prohibit the use of any device that intentionally limits control authority. Instead, limited control authority would be simulated via verbal instruction to use a fraction of available control authority (which can be returned instantaneously to normal, full-authority flight conditions).

These scenarios may also be taught in a flight simulator or flight training device (FTD) that is representative of the airplane to be flown. Additional scenarios involving crosswind landings, complete loss of control of a flight control, etc., can be included in the training. Simulation may also be used in lieu of training in an aircraft were a flight instructor or pilot determines that experience, aircraft, or weather conditions are unsuitable to maintain safety and effectiveness.

[29] **NOTAMs:** Checking NOTAMs is increasingly important especially when flying near public events. *See, e.g.*, http://www.1800wxbrief.com/, http://www.faa.gov/air_traffic/publications/notices/, and http://tfr.faa.gov/tfr2/list.html. Recognize, nonetheless, that certain events, including those with as many as 29,999 people, rarely trigger a NOTAM. *See, e.g.*, FDC NOTAM 4/3621, FDC Part 1 of 3, *Special Security Notice Sporting Events* (Oct. 27, 2014), at http://tfr.faa.gov/save_pages/detail_4_3621.html (invoked only for use of stadiums with seating capacity of 30,000 or more people, and even then, only for a limited list of sporting events). Also, many COAs require the filing of NOTAMs. And, "[f]lights outside of Class A airspace require that a NOTAM be issued by the proponent." FAA, Notice N JO 7210.891, § 9.a(11), above note 6.

Chart Supplements U.S.: The Chart Supplements U.S. (incorporating the Airport/Facilities Directory - A/FD) is the FAA's "main conduit of UAS operational information." Email with Langston Majette, ATO UAS Integration Team (Mar. 7, 2016). *See* http://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/, and Charting Notice (Mar. 31, 2016), at https://www.faa.gov/air_traffic/flight_info/aeronav/safety_alerts/media/CS_16-02_CN_IACC8_Title_Change.pdf (Notice of name change from "A/FD" to "Chart Supplements U.S."). Nonetheless, there is reason for NOTAMs to serve as the main conduit—expediency.

On-Line Resources: For example, ForeFlight's airport "Comments" feature includes some drone safety entries, such as a San Carlos Airport (KSQL) Comment stating: "Caution: Intensive Unmanned Aircraft System (UAS or drone) operations approximately 1 nm radius of VPWAM and 3.5 nm SE of Rwy 30." In contrast to Charting Supplements U.S. listings, ForeFlight Comments are typically implemented within 24 hours and thus may provide an expedient, non-exclusive tool for unofficial yet timely notifications. *See generally*, http://www.seeandavoid.org/ (claiming to be "the most up to date and reliable source for Mid Air Collision Avoidance information"), and Flight Service resources, below note 30.

[30] **Airport/Pilot Associations:** As local interested parties, airport associations are well-positioned to help identify drone activity proximate to airports, catalyze coordination between ATC, airport management, and other stakeholders, serve as key advocates for drone safety, and promulgate drone safety information.

Charted UAS Procedures: UAS instrument procedures may vary considerably from corresponding manned aircraft procedures (e.g., may typically contain some separate waypoints, Terminal Area Departure Points, Flight Termination Points, an Emergency Safe Altitude, missed approach, and lost communication information). Familiarity with applicable UAS procedures may enhance pilot situational awareness. *See* Tom Baker, Joint Test Dir., Avi. Rulemaking Comm., Unmanned Aircraft Systems (UAS) National Airspace System (NAS) Flight Operations Standardized Procedures (SP – UNFO SP initiative), Apr. 29, 2015, at http://www.faa.gov/air_traffic/flight_info/aeronav/acf/media/Presentations/15-01_Mil_UAV_Procedures_Burrows.pdf.

Flight Service: *See* Lockheed Martin Flight Service's "UAS" webpage, at https://www.lmfsweb.afss.com/Website/uoa (offering enhanced commercial drone flight planning and notification capabilities). *See, e.g.*, Flight Service's Adverse Condition Alerting Service, that it asserts "will significantly contribute to knowing where UAS operations are along route of flight, and includes both NOTAM'd and non-NOTAM'd areas." Email from Mike Glasgow, LMFS (Apr. 17, 2016). *See also,* Rich Tuttle, *Full Service,* UNMANNED SYSTEMS MAGAZINE, pp. 14-16 (Jan. 2016), at 14-16, available at http://www.mazdigital.com/webreader/33730?page=16 (describing LM Flight Service drone capabilities, and plans to notify pilots should drones fly-away "[o]nce an operator contacts Flight Service by pressing a button on an app or through the UAS ground control station." *Id.* at 15). Purportedly, drone operators will enter fly-away/lost link preconfigured user profiles (programmed action upon fly-away/lost link), and such information will be made available to all pilots. Flight Service also facilitates NOTAM data for other service providers, such as SkyVector, at www.skyvector.com (trademarked "DROTAMs" described as NOTAMs defining UAS operating areas).

[31] "When a facility has knowledge (e.g. via a COA, hobbyist calling, visual observation, etc.) of a UAS operation occurring within their area of jurisdiction, the FLM/CIC [Front Line Managers/Controllers in Charge] will *use their best judgment* to determine if manned aircraft operations should be made aware of the UAS Activity." FAA, Notice N JO 7210.891 (Nov. 25, 2015) § 9.i(4), p. 8, above note 6 (emphasis added). Moreover, model aircraft operators are generally not obligated to file NOTAMs for their operations. *See generally*, below note 51 (use of NOTAMs), and below note 49 (use of ATIS to apprise pilots of local drone operations). Due to the accelerating volume of low-altitude (under 400 AGL) NOTAMs addressing drones, such NOTAMS may no longer issue in the near future.

[32] **Site Activity:** For example, complete an Academy of Model Aeronautics (AMA) "Charter Club Search" of model aircraft sites at http://www.modelaircraft.org/clubsearch.aspx (enter the zip code proximate to the area of interest). *See also*, above note 29 (re NOTAMs).

Lost Link Loiter Points: *See* FAA, Order 8900.1, Vol. 16-7-1-7 B.1, *Flight Standards Information Management System, Unmanned Aircraft Systems, Safety Risk Management, Lost Link Procedures*, at http://fsims.faa.gov/PICDetail.aspx?docId=8900.1,Vol.16,Ch7,Sec1 (addressing lost link procedures and "Lost Link Points (LLP), Divert/Contingency Points (DCP), and Flight Termination Points (FTP)."). "In the event of a contingency divert or flight termination, operations will be conducted in Class A Airspace

(CAAS) and Special Area of Operations (SAO) to the maximum extent possible to reduce the risk of collision with nonparticipating air traffic." *Id*. at Vol. 16-7-1-7 B 1 c (Contingency Planning). And, "unless otherwise authorized . . . [l]ost link orbit points will not be contained within any published holding area, airway, jet route, T-route, or other Area Navigation (RNAV) published route." *Id.* at Vol. 16-7-1-7 B.1 d 3.

Consider that: aircraft utilizing LLLPs may not have detect-and-avoid capability; multiple aircraft could potentially utilize the same LLLP; and weather conditions may impede LLLP operations.

The FAA requires that ATC specialists have Lost Link Procedures "available in [their] simplest form, to determine the actions a UA will take in these scenarios." FAA, Notice N JO 7210.891, § 9.a(3), p. 4, above note 6. One study reported that about 10% of flights lost data-link, and recommended to inform the public of LLLPs "so that unnecessary panic and concern can be avoided," ACRP Report 144, above note 12 at p. 16. Making such data available to manned aircraft pilots for flight safety would certainly appear no less meritorious.

Squawk code 7400 is under development for lost link situations. *See* Doug Davis, Northrop Grumman, *ANSP Guideline for RPAS Operation*, CANSO Global ATM Operations Conf., Madrid (Mar. 6-7, 2014), at https://www.canso.org/sites/default/files/8.%20%20UAS%20SG%20-%20Best%20Practice%20and%20ICAO%20UAS%20Group%20Update%20-%20ANSP%20Guideline%20for%20RPAS%20Operations%20by%20Doug%20Davis.pdf.

[33] The FAA has established an interim policy for holders of COAs: a "Blanket COA" permitting, *inter alia*, reduced lateral distance restrictions from airports and heliports (Mar. 2016). *See* http://www.faa.gov/news/updates/?newsId=82245, and http://www.faa.gov/documentLibrary/media/Notice/Notice_UAS_7210.891.pdf. Note that certain model aircraft distance restrictions are set in statute miles versus commercial restrictions in nautical miles. "It is anticipated that UAS will routinely operate as closely as next door to an airport when operating below glideslopes and pathways." Email from Leonard Ligon, UAS Airspace integration, Operations & Logistics, UTM, NASA Ames Research Center, to Michael Baum (May 11, 2016).

[34] FMRA, Special Rule on Model Aircraft, § 336(a)(5), above note 1.

[35] *See* FAA, Sectional Aeronautical Chart Legend, at https://maxaerodemo.files.wordpress.com/2014/05/sectionalchartlegend.pdf. Remarkably, there are "only 3 portrayals of the UAS symbol [in the entire NAS]." Email from Katie E. Murphy, Supervisory Aeronautical Info. Specialist, Aeronautical Info. Serv., FAA to Michael Baum (Feb. 10, 2016). Moreover, charting remains non-standard (e.g., Beale Air Force Base (KBAB) does not display "UA" symbology on sectional charts but instead presents a text box stating, "CAUTION: Unmanned aircraft activities all altitudes.").

> The current symbology was approved for charting UAS activity in/around 2010. However, there were never any hard requirements established to determine whether any activity qualifies for chart depiction or not. As of now, the vast majority of the UA symbols on the charts represent UAS operations associated with the FAA's key initiatives. We are currently collaborating internally to develop policy and requirement for the use of this symbol. This will provide for standardization across our VFR charts, and will help eliminate the unstandardized use of the boxed notes that appear on the charts. A lot of these notes were added prior to the creation/approval of the UA symbol. These notes were results of direct requests from Air Traffic facilities, and the role of the charting section was to publish them exactly as they were requested.

Email from Langston Majette, FAA, ATO UAS Integration Team to Michael Baum (Mar. 7, 2016).

UA chart symbology is, of course, a short-term fix. The proliferation of drones may make drone operations so prolific that charts become unduly cluttered with UA symbology.

[36] As an example, some drones have start-up and departure protocols that require complete ground separation from all vehicles and people. And, immediately upon inclement weather (including high winds), pilots should anticipate multiple drone return-to-base operations. Nonetheless, "UAS operations should not impede, delay, or divert manned aircraft operations." FAA, *UAS in the NAS*, ¶ 9.a(2), above note 1.

[37] Consider giving wider berth. C2 radio spectrum for most small civilian drones is unprotected and thus susceptible to interference, hijacking, and lost link. Moreover, upon lost link, drone algorithms and strategies are inconsistent: some execute a "fly home" routine, some land, some transit to a predetermined "lost link loiter point," and yet others have no such contingency capability. *See* Bina Pastakia, et al., FAA, *UAS Operational Assessment: Contingency Operations, Simulation Report,* DOT/FAA/TC-TN15 /55 (Sept. 2015), at http://www.tc.faa.gov/its/worldpac/techrpt/tctn15-55.pdf (considering, *inter alia*, lost link procedures). *See also,* Bill English, NTSB, Interview with Paul Bertorelli, Avweb at AUVSI Xposition, New Orleans, at http://cdn.avweb.com/media/podcast/2016-05-04_BillEnglish.mp3 (stating that most drone incidents are "pretty much just fly-aways."). Additionally, satellite-based drone communications "may result in latency issues." FAA, Notice N JO 7210.891 § 9.a(4), above note 6 at 4.

FAA Admin. Michael Huerta has recognized C2 and detect-and-avoid as two of the "bigger challenges". Presentation at AUVSI Xponential, New Orleans (May 2, 2016). And, Randy Willis, Manager, FAA Air Traffic Organization, Emerging Technologies Team (Strategic Operations - Unmanned Aircraft), asserting that "[d]etect-and-avoid is still a concept." *Id*. Note that upon loss of C2, ATC may know more about certain drones than about manned aircraft to the extent that drone operators telephone ATC. Steven Pennington, Exec. Dir., Policy Bd. for Fed. Avi., Presentation at AUVSI Xposition, *id*. (May 3, 2016).

Information Security: Neither ASTM F38 nor RTCA SC 228 has a work group focused on information security standards for drones. Some experts suggest that NextGen security work product will be adequate to support drone security; others urge a need for focused, specific InfoSec standards. Among the InfoSec initiatives, Aircraft Systems Information Security Protection (ASISP), http://www.faa.gov/regulations_policies/rulemaking/committees/documents/index.cfm/document/information/documentID/2042.

Among the security standards frequently cited and/or potentially relevant to drone security C2 are: [*TBD*]

- FIPS 140-2, Security Requirements for Cryptographic Modules, at http://csrc.nist.gov/publications/fips/fips140-2/fips1402.pdf;
- ARINC 842, Guidance for Using Digital Certificates, at ___
- Suite of RTCA Aeronautical System Security Standards, SC-216, at http://www.rtca.org/content.asp?pl=108&sl=33&contentid=82;
- RTCA-DO-200A - Standards for Processing Aeronautical Data, [ ]

The small commercial drone industry has increasingly begun addressing drone information security. *See e.g.,* Jared Ablon, et al., Airmap, *Robust and Scalable UAS Registration: Key Technology Issues and Recommendations* (2016), at https://airmap.app.box.com/v/airmap-white-paper-uas-registr (proposing a high-level security architecture for small drones); and Google Project Wing's recent job posting seeking candidates who can "[u]se well-known policies and procedures to create, manage, distribute, use, store, and revoke digital certificates and manage public-key encryption for operators and aircraft." Available at http://www.suasnews.com/2016/05/project-wing-looking-somebody-aviation-experience/.

[38] Low altitude helicopter flight causing "late appearance in the field of view" together with the "low noise signature of modern helicopters" may result in a "pre-warning-time too short for a proper collision

avoidance by the RPA-operator." Rueder, above note 19. *See generally,* FAA, AIM § 4-3-23 c, at http://www.faa.gov/air_traffic/publications/media/AIM_Basic_4-03-14.pdf (describing the voluntary safety program, "Operation Lights On" to enhance see-and-avoid capability). The FAA has approved commercial exemption for night time operations. *See* FAA Exemption No. 16341, re Industrial Skyworks (USA), Inc., Reg. Docket No. FAA-2014-1060 (Apr. 18, 2016), at http://www.faa.gov/uas/legislative_programs/section_333/333_authorizations/media/Industrial-Skyworks-16341.pdf. Pending legislation and rules will likely further authorize such operations. *E.g.*, S.2658, below note 56.

[39] Pilots should recognize that drone contingency operations (such as upon lost link or fly-away) may "contribute to an overall increase in the air traffic controllers' workload [and] contribute to reduced levels of system safety." Pastakia, at p. vii, above note 37 (yet, simulations did not uncover significant impact on system safety).

[40] Many private airports and heliports have never filed a FAA Airport Master Record 5010. One expert found 35 hospital heliports in Tennessee without any FAA record of their existence. Email with Rex Alexander (Apr. 10, 2016). In such cases, the heliport owner must request the FAA to conduct an airspace study (via FAA Form 7480-1), and submit considerable documentation. The entire process can exceed two years. Where an Airport Master Record is on file with the FAA, the owner must ensure that it reflects current information and is routinely verified and updated. *See* FAA, Form 5010-1, *Airport Master Record, Document Information*, at http://www.faa.gov/forms/index.cfm/go/document.information/documentID/185474; FAA, *Airport Data and Contact Information*, at http://www.faa.gov/airports/airport_safety/airportdata_5010/; and *Airport IQ 5010*, at http://www.gcr1.com/5010web/ (Airport Master Records and Reports finder). All private airports and heliports intended for flight operations should maintain a current FAA Form 5010 on file with the FAA. Many aviation databases and charts rely on such records, and serve as an aide to situational awareness.

[41] Some drone experts advise that drones remain "extremely temperamental" and may fly in unanticipated ways, changing flight path abruptly. *See* above note 37 (re: inconsistent algorithms and strategies), and below note 57 (re: autonomous operations).

Predictability:

> If a drone operator is using visual contact with his/her UA to maintain visual separation from manned aircraft, then he/she needs to be able to predict how the manned aircraft will maneuver. It's incumbent upon pilots, then, to follow known traffic patterns.
>
> For example, a drone operator with an airport manager's permission to operate near the approach end of a runway for real estate photography might think that upon sighting an airplane approaching that runway that the correct avoidance tactic is to fly the drone to the side opposite that runway's base leg. If the pilot maneuvers to enter a left base when that runway's pattern calls for right traffic, the drone operator's best efforts at avoidance are thwarted. I'm sure you've seen pilots fly a "backward base" out of ignorance or selfish convenience—I see it all the time where I normally fly. The see and avoid responsibility goes both ways; pilots need to fly in a manner that drone operators can anticipate their actions.

Email from Thomas Turner, CFII to Michael Baum (Mar. 2, 2016).

[42] NMAC reports "provide information for use in enhancing the safety and efficiency of the National Airspace System . . . by the FAA to improve the quality of FAA services to users and to develop programs [to reduce] NMAC occurrences." FAA, AIM, § 7-6-3, Near Midair Collision Reporting, at www.faa.gov/air_traffic/publications/media/AIM_Basic_4-03-14.pdf. "A near midair collision is defined as an incident associated with the operation of an aircraft in which a possibility of collision occurs as a result

of proximity of less than 500 feet to another aircraft, or a report is received from a pilot or a flight crew member stating that a collision hazard existed between two or more aircraft." *Id.* Post-flight reporting is addressed in Sect. 4, herein.

[43] Helpful identifying criteria may include: time, location, altitude, heading, speed, color, shape, number of rotors, manufacturer, model, and description of the activity (such as applications). *See* Int'l Society of Air Safety Investigators, *Unmanned Aircraft System Handbook and Accident / Incident Investigation Guidelines* (Jan. 2015), available at http://isasi.org/Documents/EventsAndAlerts/UAS%20Handbook%201A%20BW.pdf; and FAA, *FAA, DHS, CACI, UMD Perform UAS Detection Work* (Feb. 18, 2016), at https://www.faa.gov/news/updates/?newsId=84810 (detection and identification of "rogue drones").

[44] *See* above note 42 (regarding NMAC reports). *See also,* FAA, Near Mid-Air Collision System (NMACS), at http://www.asias.faa.gov/pls/apex/f?p=100:33:0 (reporting form available within the FAA Avi. Safety Info. Analysis and Sharing (ASIAS) system). It is important that pilots provide accurate information.

[45] *See* FAA, Order JO7210.632, *Air Traffic Organization Occurrence Reporting* (Jan. 30, 2012), at http://www.faa.gov/documentLibrary/media/Order/JO7210.632.pdf (now including a unique entry designation for "Hazardous and/or Unauthorized UAS Activity"), and FAA Form 7210-13, at http://www.faa.gov/documentLibrary/media/Form/FAA%20Form%207210-13.pdf (required to be filed by ATC upon loss of separation or ostensibly following a drone-relevant safety matter). "All [ATO/air traffic control] employees must ensure that all known unauthorized UAS activities through either direct involvement or observation, are reported." FAA, Notice N JO 7210.891, § 9.i, p. 8, above note 6. *See also* FAA, Order JO 7200.20, *Voluntary Safety Reporting Program* (VSRP), at http://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/322841 (Air Traffic Organization personnel "may always file a VSRP report when they observe a safety problem or experience a safety-related event."). Finally, a. "[f]acility air traffic managers must ensure that the operational supervisor/controller-in-charge promptly reports any suspicious aircraft/pilot activities to the Domestic Events Network (DEN) Air Traffic Security Coordinator (ATSC). . . . 10. Any reported or observed unauthorized unmanned aircraft activity or remote controlled model aircraft that deviates from normal practice areas/flight activities would be considered suspicious or a safety hazard." FAA Order JO 7210.3Z CHG 1 (May 26, 2016), § 2-1-28 a, b. 10, at http://www.faa.gov/documentLibrary/media/Order/7210.3Z_FAC.pdf.

[46] The ASRS *General Form* is available at https://titan-server.arc.nasa.gov/HTML_ERS/general.html.

[47] *See* 49 C.F.R. Part 830.5a, Immediate notification (upon "aircraft accident" per 49 C.F.R. Part 830.2, applies to drones). NTSB, Notification and Reporting of Aircraft Accidents, Unmanned Aircraft Accident definition, 49 C.F.R. § 830.2, at http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49cfr830_main_02.tpl (restricting notification requirements to aircraft with a maximum gross takeoff weight of 300 lbs. or greater, and "sustained substantial damage"—curtailing NTSB data collection). *See* NTSB, *Interpretation of Notification Requirements To Exclude Model Aircraft*, 80 Fed. Reg. § 176 (Sept. 11, 2015), at http://www.ntsb.gov/news/press-releases/Documents/FR_model_aircraft_20150911.pdf (noting drone weight threshold for notifications as similar to the maximum weight of powered ultralight vehicles per 14 C.F.R. § 102.1(e)). The NTSB mandate does not generally extent to model aircraft.

Note that "it is likely that existing required reports, including near-midair collision reports, hazardous air traffic reports, and traffic alert and collision avoidance system events, capture most safety-related events that are likely to be associated with UAS operations." 75 Fed. Reg. § 15953, 15954 (Aug. 24, 2010), at http://www.ntsb.gov/legal/Documents/NTSB_830_revision_Aug2010.pdf.

[48] Many § 333 exemptions require notification precipitating from, for example: "[a]ny incident, accident, or flight operation that transgresses the lateral or vertical boundaries of the operational area as defined by

the applicable COA [and] must be reported to the FAA's UAS Integration Office (AFS−80) within 24 hours." FAA, Exemption No. 11433 (to Cape Productions), Reg. Docket No. FAA–20 15–0223 (Apr. 24, 2015), at http://www.faa.gov/uas/legislative_programs/section_333/333_authorizations/media/Cape_Productions_Inc_11433.pdf. Additionally, ensure timely updates have been submitted to FAA 5010 Airport Master Records for private facilities. FAA, Airport Safety, Airports, at http://ipv6.faa.gov/airports/airport_safety/. *See* above note 40.

As a matter of completeness, reports may include Unidentified Flying Object (UFO) Reports. *See* FAA AIM § 7-6-4. And, the FAA maintains a hotline for incident reporting at 1-866-835-5322. Finally, the Academy of Model Aeronautics (AMA) instructs its members to notify the AMA in the event of a perceived "near miss with a manned aircraft." AMA, *"SEE AND AVOID" GUIDANCE*, ¶ B.4, available at http://www.modelaircraft.org/files/540-D.pdf (with no mention of external reporting mechanisms). The AMA asserts that it has neither received any such report(s), nor instructs its members to make reports to non-AMA entities. Telephone Interview with Ilona Maine, Safety and Member Benefits Dir., AMA (Feb. 22, 2016). Finally, *see* __ Fed. Reg. __ (FR No. 2016-10976), *Unmanned Aircraft System (UAS) Event Reporting System (UETS)* (posted May 10, 2016), at https://www.regulations.gov/#!documentDetail;D=FAA_FRDOC_0001-13649 (requesting public comment; subsequently withdrawn [publication date May 17, 2016], at http://federalregister.gov/a/2016-11573 because "the document contains errors and needs further clarification.").

[49] Consider urging that where appropriate, hazardous local drone sites and activity become the subject of Automatic Terminal Information Service (ATIS) notification. *See* FAA, Order JO7001.65T (Feb. 11, 2010), at http://tfmlearning.fly.faa.gov/Publications/atpubs/ATC/atc0209.html (facilitating inclusion of "[o]ther optional information as local conditions dictate . . . on the ATIS message." *Id.*).

[50] Airport and tower managers may believe they are without authority to object (or take effective action) in response to model aircraft operator (or other drone operator) notifications of planned operations within 5 SM of an airport reference point (ARP). Despite the need for further coordination within its walls, the FAA asserts that, "[i]f the model aircraft operator provides notice . . . objected to by the airport operator, the FAA expects the model aircraft operator will not conduct the proposed flights [and will] consider [such] flying . . . over the objections of . . . airport operators to be *endangering the safety of the NAS*." FAA, *Interpretation of the Special Rule for Model Aircraft* (Jun. 19, 2014), pp. 13-14, at http://www.faa.gov/uas/media/model_aircraft_spec_rule.pdf (emphasis added). The *Special Rule for Model Aircraft* appears in FMRA § 336. Furthermore, "if the airport operator or the air traffic control facility believes the operation could impact safety, *the facility may deny the operation* and notify the UAS operator of the specific objection." FAA, Notice N JO 7210.891, p. 3, above note 6 (emphasis added). The "airport operator can serve as a *key enforcer* and safety monitor . . ." (emphasis added). Transp. Res. Bd., ACRP Report 144, *Unmanned Aircraft Systems at Airports: A Primer* (2015), p. 48, at http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_144.pdf. The FAA's impending issuance of Part 107 and FAA reauthorization implicating small UAS may help clarify these issues.

[51] Airports should further consider the safety mitigations described in the [draft] ASTM F38 *Specification For Operation Over People*, WK52089; and the Micro Unmanned Aircraft Systems Aviation Rulemaking Committee (ARC), *ARC Recommendations, Final Report* (Apr. 1, 2016), at http://www.faa.gov/uas/publications/media/Micro-UAS-ARC-FINAL-Report.pdf. Additionally, e.g., consider the "best practice [for airport personnel] when . . . made aware of a proposed model aircraft flight within five statute miles . . . [and thereby] Issue a Notice to Airmen (NOTAM), if necessary," FAA, *Frequently Asked Questions (FAQs) about the Use of Model Aircraft Near an Airport*, Question 9, at http://www.faa.gov/airports/special_programs/uas_airports/model_airplane_faqs/. This FAQ does not yet include drone guidance. Advisory Circular, AC 150/5300-13A Chg 1, Airport Design (Feb. 26, 2014), at http://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5300-13A-chg1-interactive.pdf (stating with regard to guidance, "Unmanned Aircraft Systems (UAS). Contact the appropriate FAA Airports office for guidance." At ¶ 209.d.).

Absent formal FAA safety risk assessment guidance with respect to planned drone operations within 5 SM of an airport, and perhaps for commercial flight under a revised "blanket COA" (permitting operations within 2 NM of certain airports at or below 200 AGL- issued Jul. 2015), at http://uavus.org/wp-content/uploads/2015/10/Section_333_Blanket_200_COA_Effective_7-1-2015.pdf, airport and tower operators should consider site-specific procedures governing nearby drone operations. Such decisions should be undertaken within the context of a safety management system (SMS). "Developing and implementing an SMS that integrates UAS safety processes is a sound method of protecting the airport and gaining the confidence of the surrounding communities." Transp. Res. Bd., above note 50 at p. 45. "SMS will [also] be a SARP [Standards and Recommended Practice] in ICAO for RPAS." Randy Willis, Mgr., FAA Air Traffic Organization, Emerging Technologies Team (Strategic Operations - Unmanned Aircraft) (May 4, 2016).

Until national guidance becomes available for airport and tower personnel, the following safety guidance schema (which can be structured as a non-exclusive checklist) is offered for consideration and possible selective integration into local procedures.

> In addition to other requirements, model aircraft operations may be permitted in the vicinity of an airport if the following criteria are met:
>
> 1. for model aircraft operators, membership in a nationwide community-based organization, and operations in compliance with its guidelines;
> 2. the use of standard operating procedures (consistent with the above-referenced guidelines);
> 3. FAA registration for model aircraft operators, [or commercial operator's license, respectively];
> 4. the presence of a supplemental observer;
> 5. the presence of appropriate tools for immediate notification to airport and tower in the event of a fly-away or other emergency;
> 6. drone operator familiarity with local airspace, relevant flight paths of manned aircraft, and any safety issues presented in a safety briefing by the airport or tower personnel;
> 7. adherence to applicable rules, clearances (where applicable), and commands issued by airport or tower personnel; and
> 8. where a drone operator seeks flight within 5 SM of the airport under or abeam published instrument approaches and active approach paths:
>   a. equipment utilizing flight-termination or "return-to-home" capability invoked by operator command upon loss of separation or drone malfunction; such capability must not interfere with manned flight operations; and
>   b. equipment constraining altitude to a predetermined maximum value.

There is potential education/safety value in socializing such criteria with drone operators even where airports and towers require little or no verification from drone operators. In any event, the approach adopted should be *risk-based* and consider recognized safety criteria, including but not limited to: kinetic energy of the drone, location and proximity to structures, congested areas, special use airspace (SUA), persons on the ground, known failure or malfunction modes, known hazards, severity and likelihood thereof, and proposed risk mitigations. Regarding model aircraft, FAA Dep. Admin. Mike Whitaker noted, "[w]e think each drone registrant owns an average of 1.5 drones, and they last about 1.5 flights." Presentation at the Aero Club of N. CA, NASA Ames (April 28, 2016).

Consider location criteria used by the six Federal Test Sites, including "the population density and air traffic density of the surrounding area of any proposed location as well as the potential impact areas in the event of incidents such as 'fly away' . . . " FAA, *Unmanned Aircraft Systems Test Site, Other Transaction Agreement* (Feb. 14, 2013), p. 5, at https://faaco.faa.gov/index.cfm/announcement/view/14348. [Federal Test Sites are authorized per FMRA

§ 332(c) Pilot Projects]. Additionally, airports and towers should consider issuing, where appropriate, NOTAMs regarding model aircraft operations near airports.

52 *See* above note 45 (describing FAA *Mandatory Occurrence Reports*).

53 Recognize that local government may exercise certain control over property within its jurisdiction to assure public safety. *See, e.g.,* FAA, *State and Local Regulation of Unmanned Aircraft Systems (UAS) Fact Sheet*, FAA Office of the Chief Counsel (Dec. 17, 2015), at http://www.faa.gov/uas/regulations_policies/media/UAS_Fact_Sheet_Final.pdf. *See also,* below note 56 (addressing airspace, zoning and land use).

54 As a practical matter, an effective "technology solution" is likely to be nuanced and not monolithic. To supplement cooperating surveillance technologies (see above note 13), technologies responding to non-cooperative surveillance targets are needed, including for authenticated, authenticated but fly-away, and rogue drone targets. This may lead to costs to be borne, in part, by manned aircraft. In this regard, consider the following views with technology implications. The Int'l Fed. of Air Line Pilots' Ass'ns (IFALPA) presents a "non-burdening" approach in the form of three "demands". Drone integration should not: (a) create changed procedures, (b) *require additional equipment,* and (c) deny airspace for manned aviation. Cpt. Thomas Mildenberger, *IFALPA's Views: Integrating RPAS into Common Airspace*, INTERPILOT (Issue 4, 2015), p. 13, at http://ifalpa.org/interpilot/2015-4/mobile/index.html#p=13 (emphasis added).

Separately, Frank Hofmann, Panel Member, ICAO UAS Study Group, asserts four preconditions to the safe integration of drones into the NAS:

> 1) their introduction will not require additional equipage for GA aircraft, 2) no new Class G or E airspace will be lost due to RPA operations and that they will only operate in areas marked on maps, 3) areas and times of RPA operations not be NOTAM'd since doing so is a clear statement that their operations are a danger to GA operations, and 4) RPA are not to be permitted in Class G and E airspace until their ability to detect and avoid has been amply demonstrated and documented.

Email from Frank Hofmann to Michael Baum (Feb. 14, 2016). Hofmann urges that this approach seeks to shift the burden to unmanned aircraft for any safety compromise.

55 **Orientation Flights:** Pilots should encourage UAS operators to take "a couple of orientation flights. Nothing beats seeing firsthand what we see from the aircraft." Email from Larry Brinker, Esq., Exec. Dir. & Gen. Counsel, NUAIR Alliance to Michael Baum (Feb. 20, 2016). For such flights, Brinker proposes a flight profile of 500 to 1,000 feet AGL to demonstrate the difficulty seeing obstacles on or near the ground, together with flight at low VMC to demonstrate diminished slant-range visibilities and other impediments to see-and-avoid. Indeed, the "obligation [of the operator of] a plane under robot control to keep a proper and constant lookout is unavoidable." Brouse v. U.S., 83. F. Supp. 373, 374 (N. D. Ohio 1949), available at http://www.leagle.com/decision/194945683FSupp373_1368/BROUSE%20v.%20UNITED%20STATES.

Notifications: It has been urged by some reviewers that airport associations and "ambassadors" should maintain a database of local drone groups and operators to facilitate notification of safety seminars and other events relevant to the drone community.

56 Provision 5.i contains many limitations, effectively preventing a blanket or gratuitous prohibition of drone operations from occurring. For example, the provision requires that the location of its effect must: (1) contain an identifiable, specific "exigent safety hazard"; (2) be "near" an airport or heliport; and (3) be limited to activity on the ground—*not* in airspace. Thus, the provision is specific, highly limited in scope, geographical reach, and time, thereby addressing only critical safety issues while minimizing the impact on drone operations. It does not seek a blanket prohibition of drone operations.

The FAA's Fact Sheet seeks to prevent a "patchwork quilt" of differing restrictions on "the control of 'navigable airspace'." Above note 53. As mentioned above, the provision expressly excludes application to airspace and overflight, and expressly recognizes Federal preemption of airspace. Furthermore, the provision is in keeping with the FAA's view that "[l]aws traditionally related to state and local policy power - including land use, zoning, privacy, trespass . . . -generally are not subject to federal regulation." FAA Fact Sheet. *Id*. And, provision 5.i seeks the appropriate application of *current* law—it does not advocate new law or regulation. Its "footprint" is highly constrained, and further addresses ground activity only, akin to take-offs and landings. During the FAA UAS Symposium, breakout session panels on "Airspace Authorities" and "Airports Issues" where held, where one panelist (with apparent consensus with the entire panel) underscored that "one area not preempted is take-off/Landing." Daytona Beach (Apr. 20, 2016).

Assuring a safe, seamless, and centralized NAS is essential and must remain an immutable goal. "The United States Government has exclusive sovereignty of airspace of the United States [and its citizens have] a public right of transit through the navigable airspace." 49 U.S.C. § 20103(a) and (b), at https://www.gpo.gov/fdsys/pkg/USCODE-2011-title49/pdf/USCODE-2011-title49-subtitleVII-partA-subparti-chap401-sec40103.pdf. And, it has been asserted that "federal preemption is essential so that UAS integration will be accomplished pursuant to uniform rules across the country [rather than] a complicated patchwork of laws that may erode, rather than enhance, air safety." Letter to Members of the U.S. Senate from Aviation Industry Associations (Apr. 12, 2016), available at https://www.nbaa.org/advocacy/letters/20160412-association-letter-uas-regulations.pdf. Nonetheless, to the extent current Federal airspace rules leave an exigent drone safety gap, other (non-conflicting) mechanisms, such as measured and legal local (*exclusively* ground-based) controls, may be helpful. Provision 5.i, above, encourages *consideration* of local action to the extent its undertaking is *measured*, and limited to real property restrictions on the ground—*not* otherwise affecting airspace. Consequently, this provision affirmatively avoids any interference with Federal control of airspace.

Control of the ground is not generally the subject of Federal NAS preemption. Nonetheless, the precise limitations of Federal vs. state control of (very) low-altitude airspace remain in play. *See* United States v. Causby, 328 U.S. 256, 264 (1946), available at https://supreme.justia.com/cases/federal/us/328/256/case.html (recognizing "the airspace is a public highway. [I]f the landowner is to have full enjoyment of the land, he must have exclusive control of the immediate reaches of the enveloping atmosphere."). *See also,* Gustafson v. City of Lake Angelus, 76 F.3d 778 (6th Cir. 1996), available at http://caselaw.findlaw.com/us-6th-circuit/1140229.html ("designation of plane landing sites is not pervasively regulated by federal law, but instead is a matter left primarily to local control."). It has been argued that "[t]he FAA's authority over safety 'still leaves a lot of room for states to act, and they have,' said Stephen Martinko," [fmr. transport. staff member in Congress; now a gov't affairs counselor, K&L Gates LLP], Bart Jansen, *State drone laws could clash with federal drone policy*, USA TODAY, Mar. 13, 2016, at http://www.usatoday.com/story/news/2016/03/13/state-drone-laws-could-clash-federal-drone-policy/81604344/. *See generally*, McCarren Int'l Airport v. Sisolak, 137 P.3d 1110 (Nev. 2006), available at http://www.leagle.com/decision/20061247137P3d1110_11245/McCARRAN%20INT& (thoughtful discussion addressing ownership of the low level airspace).

Indeed, the FAA recognizes that the following are included within the purview of permissible state and local police power, and "generally not subject to federal regulation": "land use, zoning, privacy, trespass, and law enforcement operations." FAA, *State and Local Regulation of Unmanned Aircraft Systems (UAS) Fact Sheet*, above note 53. [The proposed safety guidance neither addresses nor controls the design, manufacture, testing, licensing, registration, certification, operation, or maintenance of an unmanned aircraft system, including airspace, altitude, flight paths, equipment or technology requirements, purpose of operations, and pilot, operator, and observer qualifications, training, and certification. *Cf*. S.2658 – the FAA Reauth. Act of 2016 §§ 2142(a-c) (addressing Federal preemption concerning UAS "design, manufacture, testing", etc., and preserving state and local authority, including for nuisance and reckless endangerment with regard to UAS), at https://www.congress.gov/bill/114th-congress/senate-bill/2658/text.]

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[57] "Reducing the human footprint via autonomy is an economic [necessity]." Paul McDuffee, VP of Gov't Relations, Insitu, Presentation at the FAA UAS Symposium, Daytona Beach (Apr. 19, 2016). Consider that certain autonomous capabilities may exacerbate (or mitigate) drone predictability. And, *emergence*—capabilities that enable drones to learn from experience and problem-solve, reaching solutions attributable to humans—may further exacerbate (or mitigate) such unpredictability. *See* Ryan Calo, *Robots in American Law*, U. of Wash. School of Law Research Paper No. 99, 40 (Feb. 16, 2016), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2737598 (considering the definition, characterization and future legal status of robots/drones). *See also,* NASA Unmanned Aircraft System (UAS) Traffic Management (UTM), at http://utm.arc.nasa.gov/index.shtml (presenting programmatic research and prototyping of low-altitude traffic management infrastructure and services); and SUAS NEWS, *DAR Announces Plans for First Fully Autonomous Drone Network* (May 5, 2016), at http://www.suasnews.com/2016/05/dar-announces-plans-first-fully-autonomous-drone-network/?utm_source=sUAS+News+Daily&utm_campaign=f9a50bfc7b-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_b3c0776dde-f9a50bfc7b-303675929&mc_cid=f9a50bfc7b&mc_eid=a9df228121.

NB: The PEB recognizes that this paper does not materially address the operation of drones beyond the operator's visual line-of-sight (BVLOS), nor those operating autonomously.

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