



# Autonomous and Remotely Piloted Vehicles in our Airspace: IFR, VFR or something else?

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# Small UAS Commercial Operating Rules (14 CFR Part 107)

## What they Are

- Airspace-sensitive (class G)
- Altitude Constrained (below 400' AGL)
- Dependent on Trained Operators (Remote Pilot Certificate)
- Line-of-sight based for collision avoidance
- Avoidable by exception (waivers)
  - Points to the rules highly constrained nature
  - Waivers (in my experience) are hit or miss

### Can existing Flight Rules and restrictions work for UAS?

- Class A-G airspace
- IFR/VFR

## What they Are *Not*

- IFR *or* VFR: require visual contact for separation, but not PRIMARY visual reference for orientating and navigation
- Sufficient for all *Small* UAS Operations
- Anywhere near sufficient for all UAS ops

### Small UAS ops - different than other A/C:

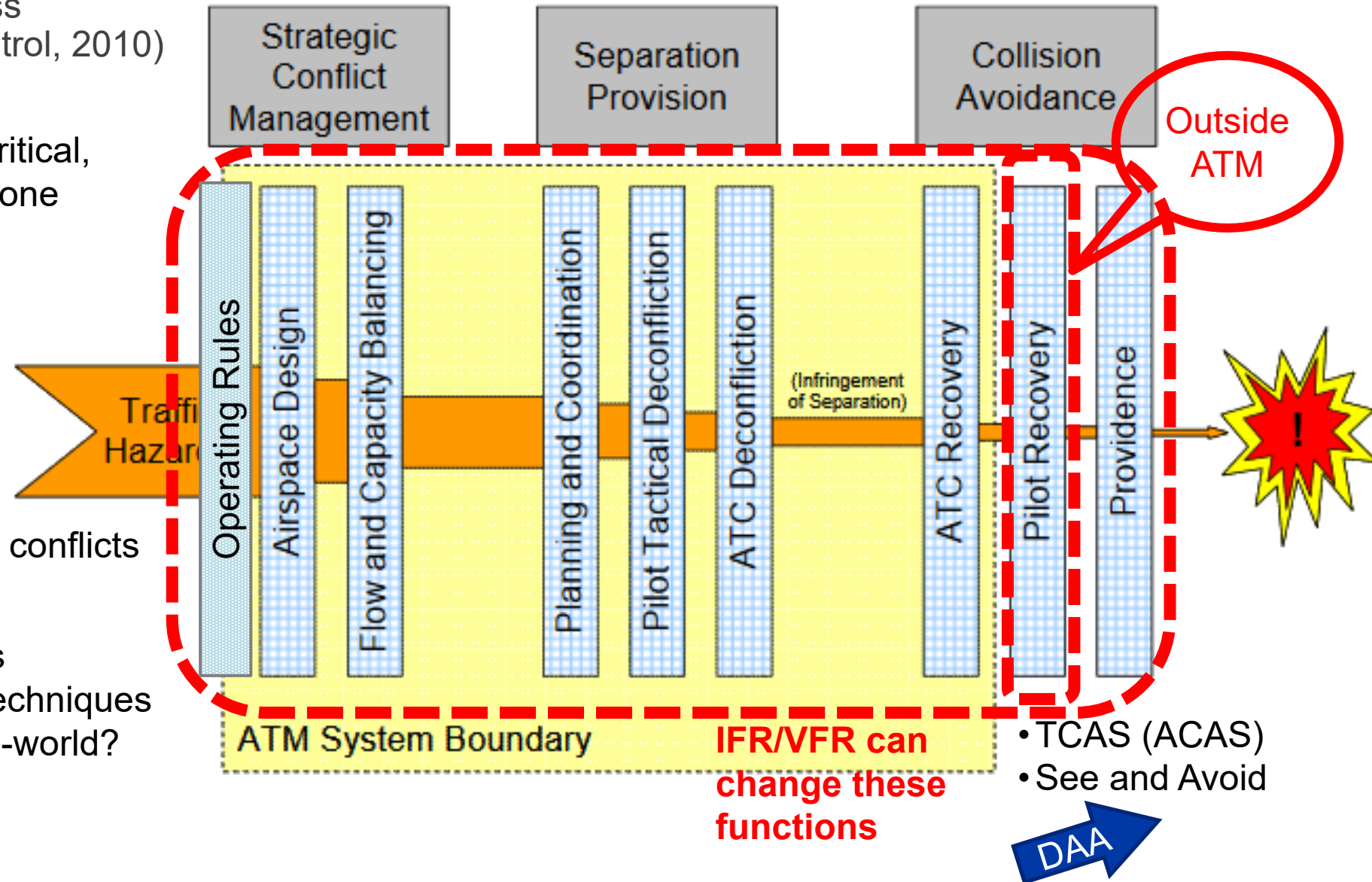
- Extremely easy to operate
- Cost of entry is 1/25 or less than aircraft
- Substantial issues with privacy
- Risk is to others, not pax/crews!

**UAS are likely to be in the  
SAME airspace as other aircraft,  
so how to regulate?**

# How Is Air Traffic Safely Managed Today ?

One Model that Looks Across the Spectrum (from Eurocontrol, 2010)

- Collision Avoidance is Critical, however not sufficient alone
- DaA in lieu of SaA: Can we integrate UAS in the earlier barriers also?
- Flight Rules provide an additional barrier that reduces the potential for conflicts
- Are today's airspace design, operational rules and flow management techniques fully transferable to UAS-world?



# Operating Rules Make Airspace Safer

No single source - Confluence of many protections, including:

## 1) **Basic Operating Guidance**

2) **Airspace Design** - protection where needed (for high risk or high frequency traffic)

3) **IFR / VFR** (instrument/visual flight rules)

**Let's look at three major contributors to NAS safety**  
(complimentary to tactical collision avoidance)

# Operating Rules Make Airspace Safer

Operating Guidance and Rules-of-the-Road: Layers of Safety – When the Sky isn't "Big" enough

## 1) Basic Operating Guidance

➤ **Structure** - minimizes interactions & makes you more predictable and visible • • •



Be  
Seen!

- ❖ Cardinal Altitudes (east: west 1000' separation, IFR:VFR +500' separation)

- ❖ Traffic Patterns

- ❖ Charted procedures: structures traffic and minimizes instruction

➤ **Right of Way Rules** – If there is a traffic conflict, who moves, and to where?

- ❖ Aircraft in Distress

- ❖ Head-on: give way to the right

- ❖ Overtake to the right

- ❖ Converging pair

- Category (by maneuverability: balloon>glider>airship>airplane/helicopter)
- Aircraft (same category) on right of has right-of-way

- Not relevant - if you're not traffic-aware!
- "See and Avoid" always in play when weather allows (IFR **or** VFR)
- Should be little traffic "to avoid" in positively-controlled airspace



What's that?

# Operating Rules Make Airspace Safer

No single source - Confluence of many protections, including:

## 1) Basic Operating Guidance

- Rules of the road to make traffic less complicated or local density more easily-managed
  - Cardinal Altitudes (east: west 1000', IFR:VFR +500' ;91.159/179)
  - Traffic Patterns
  - Charted procedures
- Unambiguous Right-of-Way Rules (14 CFR 91.113)
- NOTAMS for unusual traffic density or patterns
- *See and Avoid* whenever possible (in visual met conditions - VMC)

## 2) Airspace protection where needed (for high risk or high frequency traffic)

- Minimizes complexity, cost, encumbrances, etc. for less demanding airspace
- **Positive Controlled, Controlled, Uncontrolled Airspace**
  - Commensurate mandatory ATC participation: by Clearance, with Contact, or None
  - Commensurate equipage: Communication, Navigation and Surveillance requirements
  - Defined as Class A thru G and Special use Airspace



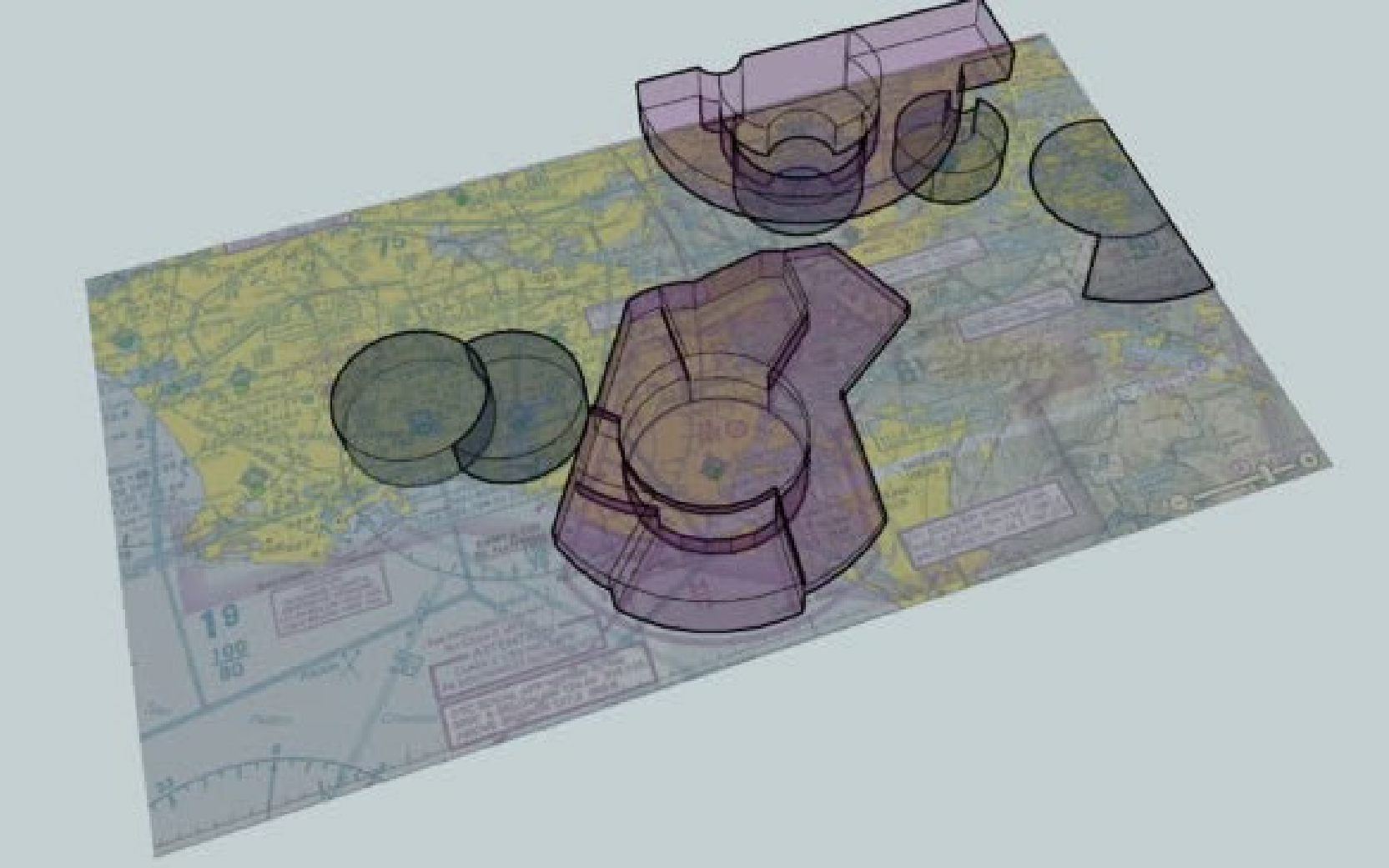
# Airspace Designed Around Flows Flows in Controlled Airspace

Form-Follows-Function in Airspace design



# Airspace Designed Around Flows Flows in Controlled Airspace

Form Follows Function in Airspace design



- **Positive Controlled** airspace engulfs high-density and commercial air traffic corridors
- **Controlled** airspace enables IFR traffic separation assurance
- **Uncontrolled** airspace minimizes ATC interaction with low-density traffic
- **Rules of the road** organize traffic for aircraft not using ATC services



# Current Operating Rules Make Airspace Safer

No single source - Confluence of many protections, including:

## 1) Basic Operating Guidance

- Rules of the road to make traffic less complicated or local density more easily-managed
  - Cardinal Altitudes (east: west 1000', IFR:VFR +500' ;91.159/179)
  - Traffic Patterns
  - Charted procedures
- Unambiguous Right-of-Way Rules (14 CFR 91.113)
- NOTAMS for unusual traffic density or patterns
- *See and Avoid* whenever possible (in visual met conditions - VMC)

### ***Why Choose IFR over VFR?***

- WX below VMC minima
- Operations Spec
- Airspace access
- Layer of Safety
  - “forced” ATC participation

## 2) Airspace protection where needed (for high risk or high frequency traffic)

- Minimizes complexity, cost, encumbrances, etc. for less demanding airspace
- **Positive Controlled, Controlled, Uncontrolled Airspace**
  - Commensurate mandatory ATC participation: by Clearance, with Contact, None
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  - Defined as Class A thru G and Special use Airspace

## 3) IFR / VFR (instrument/visual flight rules)

# Today, Aviation Operates either IFR or VFR



IFR - Instrument Flight rules

FAA definition:

Rules and regulations to govern flight under conditions in which flight by outside visual reference (alone) is not safe.



VFR- Visual Flight Rules

FAA definition:

Rules and regulations to govern flight under conditions in which the view outside of the aircraft is the primary source for **orientating** the aircraft, **navigation**, and providing separation from traffic and terrain.

Visual Separation is only one use of visual conditions for VFR flights  
→ Visual Separation is a task for IFR flights too!



# Why Flight Rules Matter



Flight Rule designation is one of many foundations of Air Traffic safety: Enables Air Traffic Services where traffic is more dense and complicated

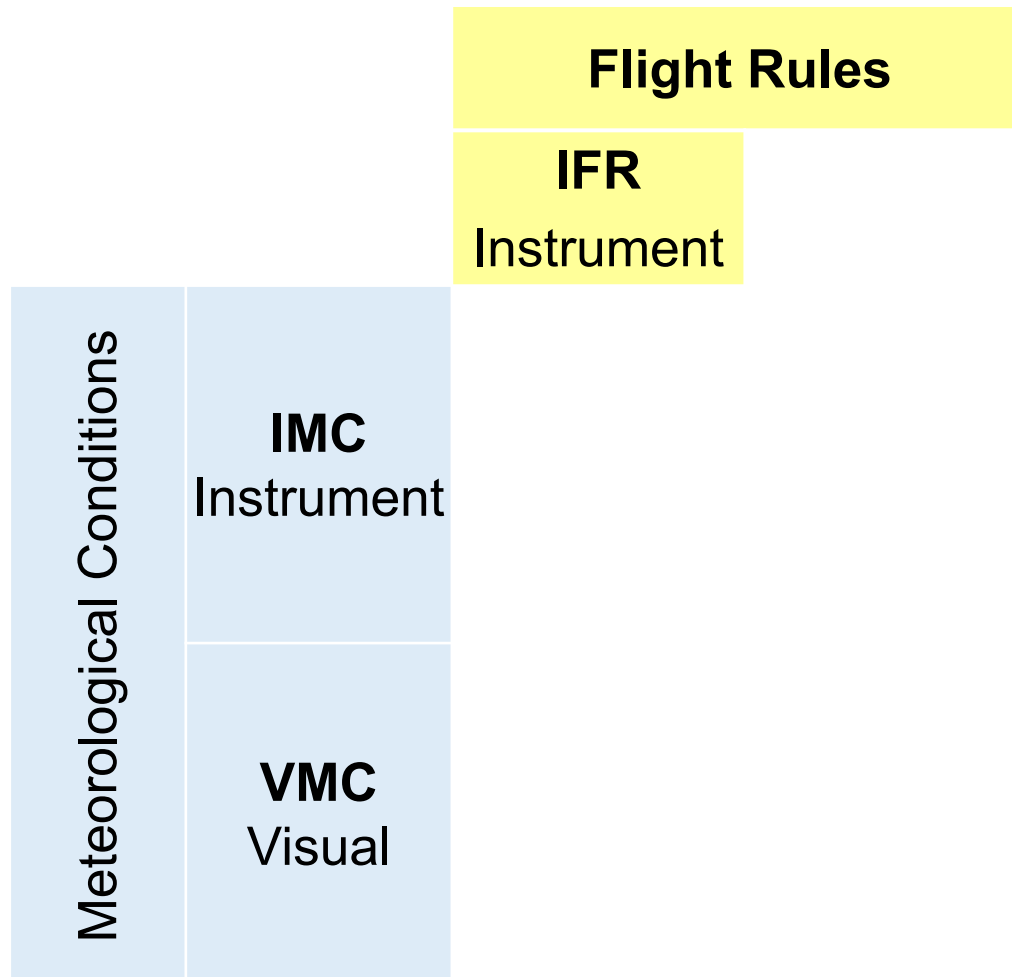
Air Traffic Services only where necessary provides more flexibility and access for operators, and less expense for an ATSP

Helps to accommodate ALL the different missions in the air - ***efficiently***



**Thought Experiment:**  
Imagine a “Clearance” or sharing your “intent” e.g. a “flight plan” for a ferry reservation...  
...or for ALL your car trips....  
Or for taxis vs. buses....

# IFR/VFR and the Relation to IMC/VMC





# IFR/VFR and the Relation to IMC/VMC

		Flight Rules
		IFR Instrument
Meteorological Conditions	IMC Instrument	Yes
	VMC Visual	Yes

## Instrument Flight Rules (IFR)

- Must be on a flight plan
  - Provides intent to ATC
  - Continuous communication
- ATC Separation with ***all participating*** traffic
- IFR in VMC or IMC
  - In VMC - “see and avoid”
  - In IMC - access and weather rules limit encounters with non-participating aircraft

# IFR/VFR and the Relation to IMC/VMC

		Flight Rules	
		IFR Instrument	VFR Visual
Meteorological Conditions	IMC Instrument	Yes	No
	VMC Visual	Yes	Yes

## Visual Flight Rules (VFR)

- Some VFR on a flight plan, some use *Flight Following* advisory, **others no ATC**
- ATC clearance may be required;
  - Airspace dependent
  - ATC separation with some participating traffic in certain airspace
- VFR in VMC only
  - In VMC - “see and avoid”
  - In IMC – n/a

# IFR/VFR and the Relation to IMC/VMC

If we can “Sense” in all weather, Should “VFR” be allowed for UAS?

Could IFR be allowed with little ATM changes?

		Flight Rules		New Rules?
		IFR Instrument	VFR Visual	UAS Unmanned
Meteorological Conditions	IMC Instrument	Yes	No	No (107) (UTM ?)
	VMC Visual	Yes	Yes	Yes ?

## UAS Operations

- Could UTM allow Small UAS without line-of-sight, or in IMC?
- Could we continue to allow operators to visually separate traffic (Part 107) without UTM “managing” low airspace?
- Can large or fast UAS operate IFR with either remotely piloted or automated ATC response capability?
- How to accommodate UAS in dense or high-risk areas – e.g. (packages down your street)?

# See and Avoid: What is it's contribution to Safety?

Is the  
glider  
turning  
towards  
you or  
away?





# See and Avoid: What it it's contribution to Safety?

Are you  
sure?

Did you see  
the threat?

And...  
You had  
advantages

- Severe clear!
- You knew this was a set-up, and could have guessed that someone else was out there



# See and Avoid is Hard, and is the LAST Defense: IFR or VFR

While required whenever the weather allows traffic to be seen,  
“see and avoid” is only one of many mitigations for collision

- Collisions are rare: in the US ~10/year of 12,000,000 General Aviation Flights ( $8 \times 10^{-7}$  per flight)
- Most mid-air accidents happen where mitigations are intended to protect against them;
  - 50% within 5 NM of an airport
  - 95% at or below 3,000' and in **daylight, VMC**
  - Other areas of concentrated traffic problematic, e.g. waypoint (VOR : old-school) crossings
- Often, accident investigations uncover existing operational mitigations were not exercised:
  - No self-announcing on CTAF
  - Non-standard patterns
  - See-and-avoid failed due to closure geometry and aircraft configuration (high/low wing)





# See and Avoid is Hard, and is the LAST Defense: IFR or VFR



20+ Miles Visibility – Low ceiling



# See and Avoid is Hard, and is the LAST Defense: IFR or VFR



10 Miles Visibility





# See and Avoid is Hard, and is the LAST Defense: IFR or VFR



5 Miles Visibility

# Airspace Integration: New Operating Rules or Airspace?

## In this Example: Multiple Violations / Failures

- **Vertical Airspace Restrictions**

- ✓“Drone” was ~1,000 above the allowed altitude

- **No-Fly Regions**

- ✓“Drone” was within Heathrow no-fly area

- **Line of Sight Required**

- ✓Not likely at location/altitude of encounter

- **Visual Separation**

- ✓“Drone” didn’t yield
- ✓Airplane didn’t (couldn’t?) see and avoid

Forensics: Maybe wasn’t a drone after all (plastic bag?!)...but there are many actual sightings in Class A/B airspace

There are clearly problematic UAS operations today.

Are they due to insufficient detect and avoid, OR improper adherence to rules/airspace constructs?

🕒 October 16, 2017: 11:02 PM ET



# Airspace Integration: Progress

- ✓ Ongoing: define/provide “detect and avoid” to be BETTER than “see and avoid” in all airspace

The requirement for all traffic to “see and avoid” implies that we must continue to develop robust “Detect and Avoid” technologies to integrate UAS into the airspace.

Working on it....

*but meanwhile...*



# Airspace Integration: Progress, and More Questions

- ✓ Ongoing: define/provide “detect and avoid” to be BETTER than “see and avoid” in all airspace
- Can IFR operations be managed as they are today, but with a mix of manned, remotely operated, and automated vehicles? Could airspace be designed to envelop desired IFR-UAS operations?
- Is there a role for “VFR” or similar rules for unmanned or remotely piloted aircraft with DAA?
  - Can we expand the envelope of vehicles allowed under rules like Part 107?
  - Should flight plans or other ATC contact sometimes be required? Could/should this be shared?
  - Do we need to regulate/specify minimum requirements for VFR-like functions other than “detect and avoid”, e.g. navigation (i.e. RNP) and orientation (minimum control and pilotage?)
- Does control of “low-altitude” airspace for Small UAS awareness of or separation from other traffic demand a (new?) *controlled airspace* designation (authority for UTM in an integrated NAS)?  
Is VFR/IFR traffic guaranteed awareness, priority and separation from UAS in Class G airspace?
- Is traffic control necessary in *Uncontrolled* airspace?
  - Could “detect and avoid” protect as least as well as “see and avoid” today?
  - Would we not designate more restrictive airspace in areas of congestion or complexity?

