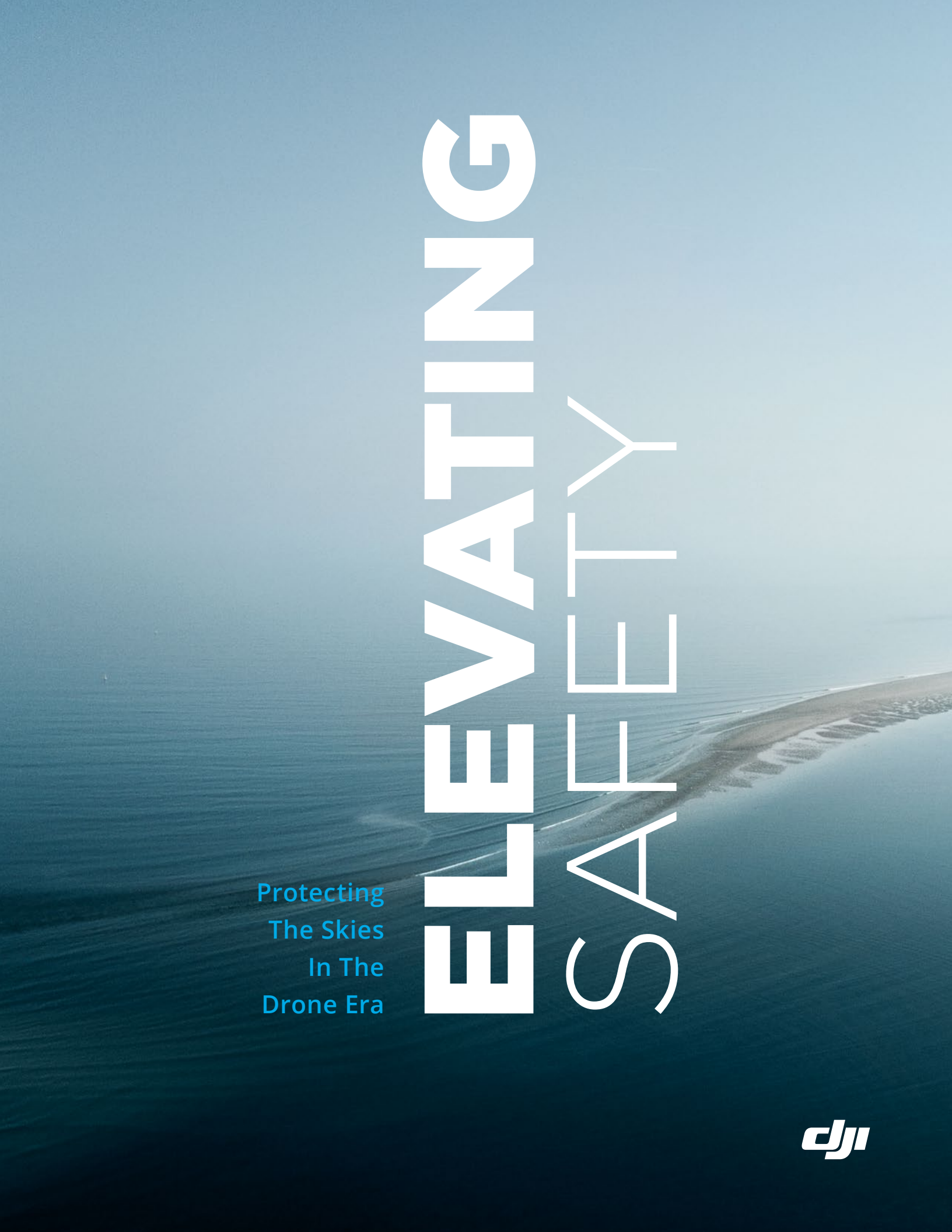


ELEVATING SAFETY

Protecting
The Skies
In The
Drone Era

Elevating Safety:
Protecting The Skies In The Drone Era

DJI's plan for data-based, real-world solutions to maximize safety, encourage innovation, minimize conflicts and help society.

A DJI Technology White Paper
May 2019

dji.com/flysafe

INTRODUCTION
DJI'S PLAN TO IMPROVE DRONE SAFETY

The drone era is here. Just a few years ago, spotting a drone in the skies was rare; today, improved technology and rapid adoption have made drone flights routine and unremarkable. Businesses and governments have all embraced affordable drone technology as a way to do their work faster, cheaper, safer and more efficiently. Drones helped Parisian firefighters stop the blaze that threatened to destroy Notre Dame,[1] they are mapping radiation in parts of Chernobyl where no human can enter,[2] and they have helped rescue at least 231 people from danger around the world.[3] Innovators, artists and academics are developing new ways to use drones in everyday tasks. Millions of drones are now in use around the world, millions more are projected to join them in coming years, and almost all of them fly without incident or complaint.

This strong safety record has been achieved through diligent efforts from drone manufacturers, regulators and drone pilots themselves. In the early years of drone adoption, with limited historical data or research studies to refer to, many of their efforts amounted to common-sense ideas driven by cautious guesswork. At one extreme, safety gaps emerged only after unusual but isolated incidents, such as when a drone accidentally landed on the White House lawn.[4] At the other extreme, potentially lifesaving applications were broadly grounded by a bureaucracy unprepared to approve them.[5] But over time, regulators around the world have taken steps to help society benefit from drones, and drone pilots have largely complied with requirements to register their drones, obey flight limitations and follow other safety measures.

DJI is charting a path for ensuring drones remain a safe addition to the airspace.

With this research paper, DJI charts a path for ensuring drones remain a safe addition to the airspace.

We have identified 10 clearly beneficial steps for ourselves, our industry, and our government partners that should be implemented without delay.

These 10 steps will impose some burdens on drone pilots, the drone industry and the governments that oversee them. Done right, DJI believes these burdens are reasonable in order to maintain the admirable safety record of drones, enshrine safety as a key factor in future development of drones and associated systems, build public confidence and trust in these new technologies, and ensure their continued acceptance in the skies.

In three parts, this paper: (1) lays out an overview of drone safety research and development efforts to date, including the enhancements we believe have already contributed substantially to the safety of drone operations; (2) undertakes a broad and deep search for data and reliable information with which to determine what safety enhancements DJI should develop next; and (3) explains in detail DJI's new commitments to safety and our call for industry peers and government partners to take their own measures and join our efforts.

1 theverge.com/2019/4/16/18410723/notre-dame-fire-dji-drones-tracking-stopped-thermal-cameras 2 news.sky.com/story/chernobyl-nuclear-fallout-zone-mapped-by-drones-11714118 3 dji.com/newsroom/news/drones-rescued-at-least-65-people-in-previous-year; DJI continually updates this count as new reports emerge. 4 bbc.com/news/technology-31023750 5 See for example: chron.com/news/houston-texas/article/EquuSearch-sues-feds-to-use-drones-in-searches-5419606.php

1 DJI will install AirSense ADS-B receivers in all new drones above 250 grams

2 DJI will develop a new automatic warning for drone pilots flying at extended distances

3 DJI will establish an internal Safety Standards Group to meet regulatory and customer expectations

4 Aviation industry groups must develop standards for reporting drone incidents

5 All drone manufacturers should install geofencing and remote identification

6 Governments must require remote identification

7 Governments must require a user-friendly knowledge test for new drone pilots

8 Governments must clearly designate sensitive restriction areas

9 Local authorities must be allowed to respond to drone threats that are clear and serious

10 Governments must increase enforcement of laws against unsafe drone operation

PART ONE
DJI'S COMMITMENT TO SAFETY AND OUR PRIOR SAFETY ENHANCEMENTS

As the largest manufacturer of personal and professional drones,[6] DJI has taken a leadership role from the start in developing technology to ensure drones remain a safe addition to the airspace.

DJI has innovated solutions to many of the leading concerns about the safe management of low-altitude airspace.

DJI has added safety features to our aircraft – without any government mandate or legal requirement to do so – because we want our customers to be responsible participants in the airspace. DJI has innovated solutions to many of the leading concerns about the safe management of low-altitude airspace. Each of these safety enhancements has been developed to address safety concerns that either seemed obvious to us, or that came to our attention as we watched our technology in use. In our global educational efforts about the challenges of drone safety, it has become evident to us that these efforts are not widely known or understood. For purposes of evaluating steps we can take in the future, we provide an overview here of major safety features we have previously developed and deployed.

GEOFENCING

DJI was the first company to use on-board GPS receivers to automatically disable its drones from flying in sensitive locations, which is known as "geofencing." Some of the earliest locations where we implemented this technology over six years ago were airports, given the obvious risk presented by unauthorized drones in nearby airspace. In the past four years we have twice released major upgrades to this feature. In 2016, we expanded the geofenced zones to include prisons, nuclear power plants and FAA temporary flight restrictions.[7] In 2018, we changed the shape of our zones from simple circles to three-dimensional "bowtie" shapes inspired by ICAO and FAA aviation safety principles, to better protect airborne traffic to and from airport runways.[8] This safety feature helps prevent our users from inadvertently flying in high-risk, sensitive locations without authorization.

ALTITUDE LIMITS

DJI drones come with automatic altitude limits to prevent them from flying higher than altitudes aviation authorities consider safe. Legal altitude limitations vary by region, and even the FAA's regulations permit flight at higher altitudes when the drone is over tall structures. But for the vast majority of operations, this feature allows for plenty of innovative operations while guarding against careless or reckless flight at altitudes that could pose increased risks to traditional aircraft.

REMOTE IDENTIFICATION

DJI's AeroScope system is the first widely available remote identification solution, allowing airport operators, law enforcement, safety agencies and other authorities to automatically determine the location, direction, altitude and serial number of DJI drones in the area, and showing the location of the drone pilot.[9] This solution is in use in at least 20 airports in the United States alone, as well as 13 large U.S. sporting venues and dozens of other facilities where safety and security are top concerns. AeroScope has helped protect the public at large gatherings such as urban New Year's Eve celebrations, sports victory parades and marathons.[10] DJI has led the industry by voluntarily creating this functional remote identification solution, years ahead of anticipated regulatory requirements.

6 While DJI does not disclose sales or market share, this Skylogic research report is generally regarded as reliable: droneanalyst.com/2018/09/18/new-report-benchmarks-drone-industry-and-refutes-hyperbole 7 dji.com/newsroom/news/dji-go-app-now-includes-geo-geofencing-system 8 dji.com/newsroom/news/dji-refines-geofencing-to-enhance-airport-safety-clarify-restrictions 9 dji.com/aeroscope 10 DJI does not identify AeroScope customers unless they choose to disclose their use of the system. One public example is detailed here: dji.com/altitude/aeroscope-orchestrating-the-sky

OBSTACLE SENSING

DJI first introduced computer-vision obstacle sensing technology with the Phantom 4 drone in 2016. We implemented this technology as soon as it was small enough and ready to help address one of the obvious potential drone safety issues: pilot error. Drones that crash into obstacles pose an immediate risk to themselves, and they can also damage property, vehicles or people nearby. Our latest drones, such as the Mavic 2 series, provide obstacle sensing protection in all six flight directions. By investing in the many sensors and processors needed to achieve this functionality, we put safety first.

RETURN-TO-HOME

A drone that has lost contact with its ground control station, or which has critically low battery power remaining, presents an obvious safety risk. In these situations, DJI drones automatically return to their takeoff point, known as the home location, rather than linger in the skies or exhaust their batteries and fall. We have upgraded this feature over time to enhance the ability of the drone to sense obstacles in the path of the flight home. Our users have posted dramatic videos online showing how this feature has helped prevent crashes and safely return their drones to pilot control and a safe landing.[11]

AIRSENSE

DJI's newest professional-level drones include a system called AirSense, which receives Automatic Dependent Surveillance-Broadcast (ADS-B) telemetry signals from airplanes and helicopters and uses them to warn drone pilots of potential hazards from traditional aircraft flying at low altitudes. Automatic warnings sound when low-altitude traffic approaches a drone, alerting our professional customers to nearby air traffic they may not be aware of. This enhancement leverages existing aviation technology to provide substantially greater awareness of nearby air traffic to our customers.

KNOWLEDGE QUIZ

Intuitively, and in our discussions with regulators around the world, we came to appreciate that knowledge of the rules is a substantial contributor to operational safety. Indeed, commercial drone pilots in the U.S. are fully qualified to operate once they have simply passed an FAA knowledge test. Leveraging our own ground control station software, we developed and implemented a Knowledge Quiz to assure that our customers, whether licensed or not, and regardless of the purpose of their operation, know the basic rules of safe operation. New pilots of DJI drones in several major countries must successfully answer questions about their national drone safety rules before they can take their first flights.

These innovations required significant investments of time, money, and effort from DJI's engineering and policy teams, and have distributed safety technology to drone operations around the world. While there is no way to measure the number of drones that didn't crash into buildings or enter sensitive airspace, it seems certain that DJI's advanced technology, coupled with its substantial market presence, have helped provide tangible protection for drone operations, and have greatly enhanced the safety of the vast majority of operations around the world. Nonetheless, our identity is rooted in never remaining satisfied with the status quo, and constantly pushing ourselves to do better.

11 See some spectacular examples at these links: youtube.com/watch?v=K_p2g1RBlRw and youtube.com/watch?v=STesLapyiLw

PART TWO
THE SEARCH FOR MEANINGFUL DATA TO INFORM OUR NEXT SAFETY EFFORTS

DJI wants to do even more to make drones safer – and to make safer drones. As drones become a common tool for professional tasks, as well as a popular category of consumer electronics, we want to focus our efforts on the areas where new safety features can do the most good. In recent months, we have reflected on our safety efforts to date and have asked ourselves what we can do better, and what we should do next.

To inform our next steps on safety, we sought to move beyond intuition by analyzing actual data about unsafe drone use. We expected this work to lead us to clear answers about some remaining drone safety risks we could address. Unfortunately, almost all of the data available turned out to be unreliable as a basis for determining what safety scenarios exist that we can attempt to address.

We sought to analyze actual data about unsafe drone use. Unfortunately, almost all of the data available turned out to be unreliable.

FAA DRONE SAFETY REPORTS: UNRELIABLE SOURCES OF DATA

The most obvious source of potentially useful data is the U.S. Federal Aviation Administration (FAA). It collects reports from pilots, air traffic controllers and the general public of drones that may have interfered with traditional aircraft and makes the data available on its website.[12] These figures are routinely cited in media coverage as "close calls" [13] or "close encounters" [14] with drones, by commentators who say a fatal drone collision is inevitable,[15] and by airplane pilots who say the number of reports proves that drones are dangerous.[16]

The key problem with using this data to determine the most effective future areas for drone safety efforts is that it is almost worthless for deriving useful conclusions. There is little independent evaluation of whether reported incidents truly posed a safety risk. The resulting statistics have been used to scare the public and advocate for strict drone restrictions, but those conclusions fall apart under close scrutiny. Three separate groups have analyzed the FAA's data and concluded the vast majority of those incidents do not indicate an imminent safety risk – and many of them may well have been authorized, safe drone operations.

The FAA began systematically tabulating reports of drone incidents in 2014, and made those reports public the following year with a press release that referred to them as "close calls." [17] The Academy of Model Aeronautics (AMA) analyzed all 764 records in an initial release of FAA data and concluded that just 27 of them could be a "near miss." "Only a fraction of the records were legitimately reported 'close calls' and 'near misses.' Some didn't involve drones at all," the AMA reported.[18] The AMA reached similar conclusions about the FAA's drone sighting reports in 2016[19] and 2017,[20] concluding that true near-misses represented just a tiny fraction of the reports, while many of them did not clearly identify that a drone was involved or that it was doing anything wrong.

The FAA has tried to clarify the purpose of the database, to little effect. It never used the phrase "close calls" again after the initial release, and now calls them "possible encounters." [21] In February 2017, the FAA explicitly addressed mistaken reports, saying "to date the FAA has not verified any collision between a civil aircraft and a civil drone. Every investigation has found the reported collisions were either birds, impact with other items such as wires and posts, or structural failure not related to colliding with an unmanned aircraft." [22]

12 Reports are available at this link: faa.gov/uas/resources/public_records/uas_sightings_report/ 13 10news.com/news/team-10/san-diego-has-high-number-of-drone-close-calls 14 abc3340.com/news/abc-3340-news-iteam/planes-having-close-encounters-with-drones-near-alabamas-busiest-airport 15 theguardian.com/commentisfree/2016/mar/07/drones-near-miss-heathrow-disaster-unregulated-accident-terror-aircraft 16 dailymail.co.uk/news/article-3948122/Drones-56-near-misses-aircraft-just-year-Pilots-warn-matter-time-one-causes-fatal-collision.html 17 faa.gov/news/updates/?newsId=83445 18 modelaircraft.org/sites/default/files//AMAreleasesanalysisofFAAsnearmissdata.pdf 19 amablog.modelaircraft.org/amagov/files/2016/06/AMA-Analysis-FINAL-6-1-16.pdf 20 modelaircraft.org/sites/default/files/UASSightingsAnalysisbyAMA5-10-17.pdf 21 faa.gov/news/updates/?newsId=85229 22 faa.gov/news/updates/?newsId=87565

One prominent aviation safety analyst, former U.S. National Transportation Safety Board (NTSB) member John Goglia, reviewed the summary and a sampling of incidents within it, and was unimpressed:

> It's impossible to know in the vast majority of these sightings whether the pilots saw a drone or something else. ... In fact, in several of the reports, the pilots themselves state they are unsure if what they saw was a balloon or a drone. Reporting drone sightings that cannot be verified and appear to have no safety impact doesn't make much sense. At a minimum these reports should be screened to eliminate those sightings that are too speculative to reach conclusions about and focus on the handful that appear to have potential safety impacts.[23]

"Reporting drone sightings that cannot be verified and appear to have no safety impact doesn't make much sense."

The Unmanned Aircraft Safety Team (UAST) has also found flaws in the FAA reports.[24] The UAST is an industry-government partnership created by the FAA in 2016 to support the safe integration of drones into the national airspace by developing an industry-led set of data-driven safety enhancements.[25] It analyzed 3,417 drone sighting reports submitted to the FAA and concluded that while very few of them appeared to pose a risk, the data was too variable to be used as a basis for any conclusions or decisions:

> The current structure, inconsistency and unrefined nature of the sightings reports disproportionately exacerbate concerns about manned-unmanned interactions and do not provide industry or government with actionable data on which to base safety enhancements and regulatory or operational decision-making.[26]

The UAST study makes clear that a "drone sighting" report alone is not enough to establish the risk of a drone operation, and recommends more work to standardize and improve the quality of such reports. That includes defining the thresholds and standards for submitting "drone sightings," identifying consistent data to be collected for each one, and educating traditional aircraft pilots about drones to allow them to more accurately describe what they see.

In May 2018, the U.S. Government Accountability Office reviewed the reported incidents, interviewed FAA officials and concluded that "the extent that these reports represent actual incidents of unsafe use is unclear":

> FAA and some aviation industry stakeholders also told us that the reliability of many of the reports is questionable; FAA explained that this is because pilots can have difficulty positively identifying objects as small UAS, given their small size, their distance from the observed position, the speeds at which a manned aircraft and a UAS are operating, or the various factors competing for the pilot's attention.
>
> FAA also told us that some of the reports, despite the reporting pilots' concerns, may have involved UAS operating in a safe and authorized manner.[27]

EUROPEAN DRONE SAFETY REPORTS: ALSO BUILT ON UNINFORMATIVE DATA

With no authoritative set of legitimate American drone safety incidents to work from, DJI turned to other countries in search of more helpful data and found the same problems: Lots of unverified reports, plenty of media speculation, but very little information that

23 forbes.com/sites/johngoglia/2017/02/26/latest-reports-prove-faa-should-just-stop-tracking-pilot-drone-sightings/#2ffc55311708 24 Drones are also commonly referred to as "UAS" (for Unmanned Aircraft System) and "sUAS" (for small UAS). This white paper uses the term "drone" whenever possible for the sake of acronym reduction. 25 unmannedaircraftsafetyteam.org/ 26 unmannedaircraftsafetyteam.org/wp-content/uploads/2018/01/UAST-Sightings-Executive-Summary-2017.pdf 27 gao.gov/assets/700/692010.pdf, pp. 11-12

can be used to formulate plans to make drone flight safer. Few countries provide a searchable database of reported drone incidents, but several European safety agencies have published seemingly authoritative reports based on what they admit is deeply flawed data.

In 2016, the European Union Aviation Safety Agency (EASA)'s "'Drone Collision' Task Force" published an analysis of European drone incidents that acknowledged its flaws:

> [T]he quality of the data available for this analysis is not to the highest standards. ... Many of those reports contain sightings of drones, and most of them are considered to be real drone sightings, but due to the speed of the aircraft and the sudden appearance of these objects, as well as human limitations, it is recognised that in some cases, the perceived drone could be in fact some other object like a bird or a plastic bag.[28]

The report was based on a non-public database of European aviation incident reports,[29] preventing the kind of independent evaluation of the evidence that was performed on FAA data. It did provide details on five incidents that it described as "collisions between non-commercial aircraft and drones." [30] Yet two of those incidents explicitly involved traditional radio-controlled model aircraft, while two involved radio-controlled model gliders. The fifth was a pilot who heard a loud bang against his small plane while flying at 2,500 feet elevation over Norway and said, without proof, that he struck a drone. Even the Norwegian safety investigation agency noted the lack of evidence: "After landing, the small plane was inspected without any damage being found. The pilot assumes that the drone hit the left chassis." [31]

Another EASA report, based on much of the same data, explicitly noted that past reports of drone incidents may spur pilots to report unidentified objects in the skies as drones:

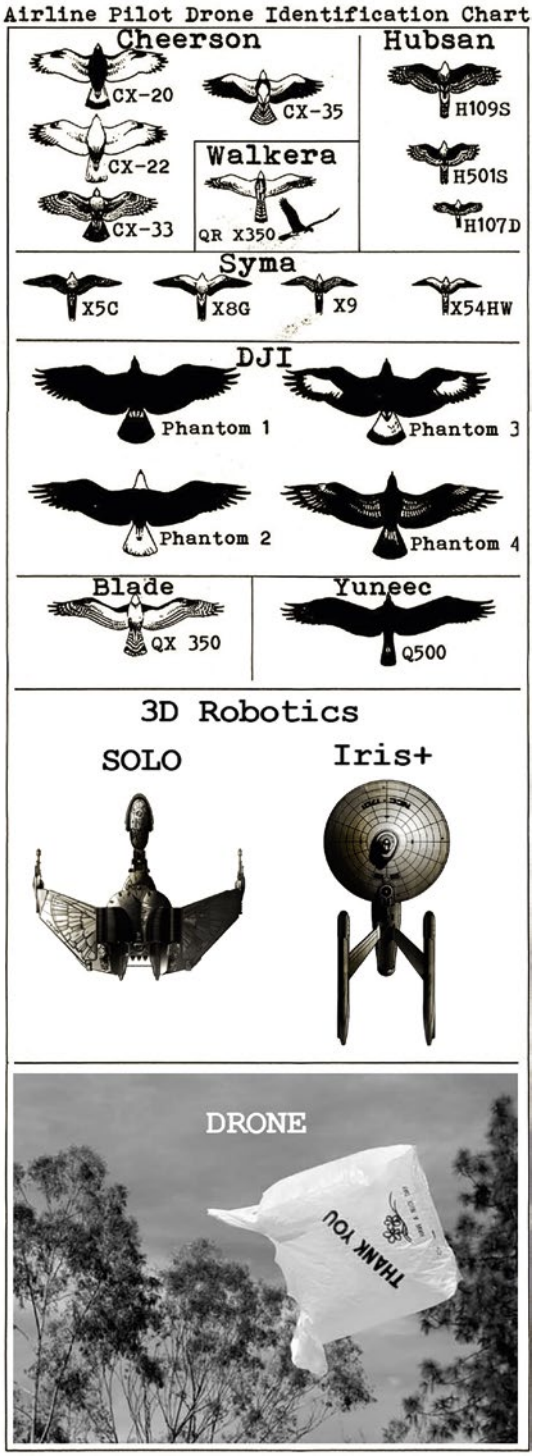
> Recent publicity of the risk of UAS collisions has meant that there are often occurrences reported as involving UAS that may well have been another object or a bird. In most cases it is very difficult to positively identify exactly if a UAS was involved. However, all such potential cases are included in this analysis.[32]

"There are often occurrences reported as involving UAS that may well have been another object or a bird."

Some forward-looking authorities have tried to impose standards on those reports: The Civil Aviation Administration of China used visual perception tests to develop a standardized reporting form for airline pilots to detail sightings of suspected drones.[33] Their "Drone encounter report" asks pilots to note the relative position and altitude of drones, but cautions that a multirotor drone half a meter in size cannot be spotted more than 1,000 meters away, while a 1.5-meter drone can be detected as far as 1,500 meters away. [34] Similarly, the UAST is working with both the drone and traditional aircraft industries to develop reporting requirements and educational materials to better assess reports of drone sightings.[35]

Yet there are indications that some airplane and helicopter pilots acknowledge an inclination to report an airborne anomaly as a drone, no matter what it actually is. Internet message boards for pilots have shown an image called "Airline Pilot Drone Identification Chart," [36] showing 18 birds, two movie spaceships and a plastic bag, each facetiously labeled as a "drone." [37]

28 easa.europa.eu/sites/default/files/dfu/TF%20Drone%20Collision_Report%20for%20Publication%20(005).pdf, pp. 5-6 29 ec.europa.eu/jrc/en/scientific-tool/eccairs-european-central-repository-aviation-accident-and-incident-reports 30 easa.europa.eu/sites/default/files/dfu/TF%20Drone%20Collision_Report%20for%20Publication%20(005).pdf, pp. 6-7 31 aibn.no/Om-oss/Nyhetsarkiv/Havarikommisjonen-har-iverksatt-forundersokelse-i-forbindelse-med-at-et-smafly-sondag-30-august-ca-kl-19-kolliderte-med-en-drone-over-Vasser-Tjome-kommune-Vestfold (through Google Translate) 32 easa.europa.eu/sites/default/files/dfu/UAS%20Safety%20Analysis.pdf, p. 4 33 pilot.caac.gov.cn/jsp/airmanNews/airmanNewsDetail.jsp?uuid=18cd251c-f8d8-4392-a241-6ede17023b02&code=UAV#down 34 pilot.caac.gov.cn/servlet/FileUploadManagerServlet?method=noDownload&UUID=d38bf7b8-8aa1-4c49-9c82-42c0c4d00245 35 unmannedaircraftsafetyteam.org/is-an-industry-government-partnership-committed-to-ensuring-the-safe-operations-of-unmanned-aircraft-systems/ 36 pprune.org/rumours-news/587121-drone-near-miss.html 37 reddit.com/r/pilotslounge/comments/4fun5l/drone_identification_guide_for_airline_pilots/



U.K. AIRPROX REPORTS: A RESPECTABLE VENEER ON UNRELIABLE DATA

Perhaps the best data reporting comes from the United Kingdom, where the Airprox Board collects reports of midair "aircraft proximity" incidents which may have led to a decrease in safety.[38] Where possible, the board makes careful distinctions between drones, balloons, model aircraft and unknown objects, but acknowledges that the reports from airplane and helicopter pilots may be purely subjective:

> SUAS Airprox usually involve only a fleeting encounter wherein the reporting pilot is often only able to give an outline description of the other air vehicle; as a result, the distinction between a drone, model aircraft and object is often down to the choice of wording by the reporting pilot. UKAB policy is to review the associated description and, if the reporting pilot has positively described something with drone-like properties (e.g. '4 rotors') then that is taken at face-value as a drone; if the reporting pilot can only vaguely describe 'an object' then that is classified as an unknown object.[39]

"The distinction between a drone, model aircraft and object is often down to the choice of wording by the reporting pilot."

That policy has effectively tied the hands of the Airprox Board, which is duty-bound to treat each report seriously even if its claims are wildly implausible. These reports are then often reported by the press as drone incidents that have been reviewed and seemingly

This chart appeared on internet message boards for airplane and helicopter pilots, an apparent joke that anything they saw in the skies could be reported as a drone.

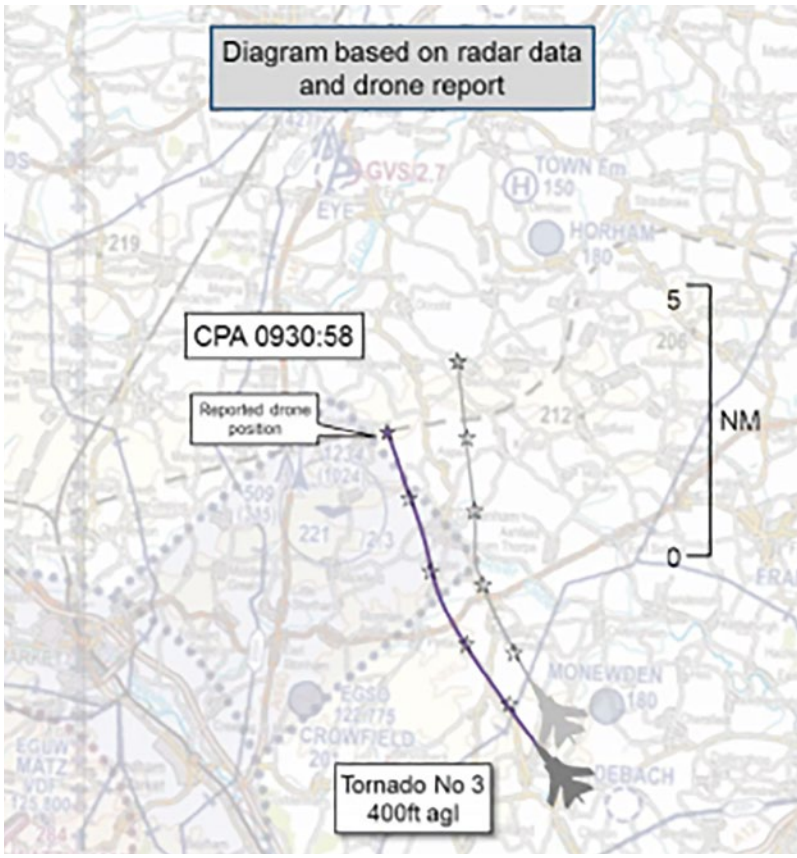
38 airproxboard.org.uk/home/ 39 airproxboard.org.uk/uploadedFiles/Content/Standard_content/Analysis_files/Book%2033-final.pdf, p. 32

confirmed by a government agency, lending them unwarranted credibility. For example, in February, the cabin crew of a Virgin Atlantic flight to London claimed to spot two small drones just 90 feet away – at 14,000 feet elevation. As critics quickly noted, it is inconceivable that two drones could fly almost three miles above the earth in tight formation – and could be reliably identified and located by someone glancing out a side window at hundreds of miles per hour.[40] Nonetheless, news accounts called it a "shocking near-miss," and the airline demanded tougher drone laws.[41]

With such loose standards for inclusion, no room for independent judgment and an underlying climate of drone hysteria, it is perhaps not surprising that the number of Airprox reports involving drones has skyrocketed, from zero in 2013 to 126 in 2018.[42] This unquestioning stance has even prompted a backlash from an online group calling itself the Flight Safety Board, which applies a pseudoscientific "Reality Check" scoring system to judge the likelihood that Airprox drone reports really occurred.[43]

The overall number of serious non-drone Airprox events has also been increasing, and has also prompted skepticism. When the BBC investigated the growing trend, one Royal Air Force colonel said many Airprox reports were unlikely to have occurred as described: "So when we see in reports people saying this person was 300 ft or 500 ft away in actuality we find the person was actually a mile or a mile-and-a-half away." [44]

Meanwhile, some well-documented Airprox incidents were reported by drone pilots who said they were flying legally and responsibly when traditional aircraft swooped in at high speed and low altitude. In one case in July 2018, a drone pilot was performing an agricultural survey 328 feet above ground when he saw a Royal Air Force Tornado jet approaching in formation at 517 mph and 400 feet altitude. Investigators determined little could have been done to avoid a collision.[45] The board wrote, "The drone pilot is to be commended for his prompt action in descending his drone once he detected the presence of the Tornados." [46] It was still recorded as an Airprox involving a drone, feeding a narrative that drones cause safety risks.[47]



This map from the UK Airprox Board shows how a low-flying military jet almost collided with a drone that was flying legally and responsibly.

NEWS REPORTS: WIDESPREAD REPORTS OF INCREDIBLE ENCOUNTERS

While governmental drone safety data sets are demonstrably unreliable, news accounts of particular drone sightings, near-misses and collisions often turn out to be spectacularly worse. Some of the most

40 heliguy.com/blog/2019/04/25/were-drones-really-to-blame-for-near-miss-with-plane/ 41 dailymail.co.uk/news/article-6943187/Virgin-Atlantic-jet-carrying-264-passengers-came-SECONDS-crashing-two-drones.html 42 airproxboard.org.uk/Reports-and-analysis/Statistics/Airprox-involving-UAS-Drones/ 43 flightsafetyboard.org.uk/reality-check-system/ 44 bbc.com/news/uk-45394789 45 bbc.com/news/uk-england-suffolk-46633952 46 airproxboard.org.uk/uploadedFiles/Content/Standard_content/Airprox_report_files/2018/Airprox%20Report%202018160.pdf 47 airproxboard.org.uk/Reports-and-analysis/Monthly-summaries/2018/Monthly-Meeting-November-2018/

widely-shared stories of drones interfering with airplanes and helicopters rely on a single split-second observation, with no physical evidence or other corroboration, much less an objective evaluation of risk – yet are treated as a confirmed example of extreme danger.

At least six times, news reports have claimed a drone hit an airplane, but authorities later concluded there was never a drone involved.

Romeoville, Illinois, August 2015

The pilot of a small twin-engine plane reported hitting an unidentified object. Photos of damage to the plane's deicing boot circulated online with claims that it showed damage caused by a drone.[48] Under a microscope, however, investigators found proof that the plane had struck a bird, not a drone.[49]

London, April 2016

A British Airways pilot reported hitting a drone at 1,700 feet while landing at Heathrow Airport.[50] This news was conveyed around the world,[51] even though no physical evidence confirmed a drone strike, and the plane was cleared to continue flying. CNN published commentary using the incident to claim that "tragic conflicts with reckless operators are inevitable."[52] Days later, the U.K. Transport Minister said the "drone" could have been a plastic bag.[53]

Mozambique, January 2017

An airliner suffered damage to its radome (the nose cone at the front of an airplane) while landing. The crew heard a loud bang and reported they had struck a drone. After dramatic photographs and news traveled around the world,[54] Mozambique's aviation regulator concluded the radome collapsed because of structural failure, not any foreign object.[55]

Sedona, Arizona, February 2017

A pilot reported that a drone struck the propeller of his small plane near the local airport. When the FAA told a local TV station that its inspectors found no evidence of any collision, the airport manager replied, "Is the FAA wrong here? I won't say they are wrong, but you told me a drone hit a plane, that is what reported to us, that is what we have seen."[56]

Adelaide, Australia, July 2017

The pilot of a small propeller plane reported striking a drone while landing, prompting angry denunciations about unsafe drone pilots.[57] Investigators later used DNA tests from the wing to determine it had actually struck a bat, most likely a grey-headed flying fox.[58]

This damage to an airliner in Mozambique was at first blamed on a drone, but it resulted from structural failure.

Waihi, New Zealand, March 2018

The front windshield of nationally-known broadcaster Rod Vaughn's small plane suddenly shattered during flight, forcing him into a dangerous crash landing in a nearby field. He and his son were injured and the plane flipped upside down. Vaughn told the country's media that the only plausible explanation was that a drone had collided with his plane.[59] A flight instructor backed up his assertion, and many observers called

48 flyingmag.com/technique/accidents/faa-investigating-reported-uav-collision-piper-twin 49 app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20150827X82014&AKey=1&RType=Final&IType=IA 50 bbc.co.uk/news/uk-36069002 51 cnn.com/2016/04/17/europe/london-heathrow-drone-strikes-plane/index.html 52 edition.cnn.com/2016/04/18/opinions/drones-planes-accidents/ 53 telegraph.co.uk/news/2016/04/21/drone-believed-to-have-hit-british-airways-flight-may-have-been/ 54 usatoday.com/story/news/2017/01/06/african-airline-reports-drone-collision-passenger-jet/96237622/ 55 avherald.com/h?article=4a319157&opt=0 56 fox10phoenix.com/news/arizona-news/sedona-airport-warns-drone-pilots-to-stay-away-after-alleged-collision-with-private-plane 57 au.news.yahoo.com/investigation-underway-into-collision-between-plane-drone-near-parafield-airport-36355404.html 58 abc.net.au/news/2017-07-21/suspected-drone-strike-on-plane-turns-out-to-be-bat/8732174 59 nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12022573

for New Zealand to pass tougher laws against drones.[60] One year later, New Zealand's Civil Aviation Authority proved no drone was ever involved, saying the windshield shattered on its own after being weakened by prolonged exposure to sunlight.[61]

For regulators, elected officials and drone companies trying to make drones safer, inaccurate news stories like those aren't just misleading. They harm the process of improving safety, because they focus attention on outrageous events that didn't happen, instead of on aviation risks that may be less sensational but much more prevalent. Judging by news coverage alone, for example, one of the biggest "drone" hazards to aviation may really be balloons:

Boston, January 2015

A United Airlines pilot landing at Logan Airport spotted something above his plane at 7,000 feet. The news headline said "Drone sighted by pilot," but the pilot's radio call to air traffic controllers told a different story: "Something just flew by us, about 100 feet above us. I don't know if it was a balloon or a drone." [62]

Los Angeles, March 2016

A Lufthansa flight reported encountering a drone at 5,000 feet while landing at Los Angeles International Airport. One U.S. senator called it "one more incident that could have brought down an airliner." [63] However, recordings later revealed that while the Lufthansa pilots never mentioned spotting a drone, air traffic controllers warned other planes of a "bunch of balloons in that area" at 4,500 to 5,000 feet.[64]

Toronto, November 2016

Two Porter Airlines flight attendants were injured when their plane suddenly took evasive action to avoid an object 9,000 feet above Lake Ontario.[65] "The pilots' initial assessment was that it looked like a balloon. After debriefing, there is potential that the object was a drone," an airline spokesman said at the time.[66] Canadian safety investigators later said the unidentified object was probably not a drone.[67]

Auckland, New Zealand, April 2018

Airport ground crews spotted what they believed was a drone overhead, prompting the airport operator to stop all arrivals and departures for their safety. Police officers arrived and determined the airborne object was actually a balloon.[68]

The Christmas 2018 shutdown of London's Gatwick airport in response to reports of drone sightings drew international coverage, even though no solid evidence of any drone incursion has yet emerged – and local police have acknowledged that there may never have been drones in the area at all.[69] Within the month that followed, airports in England,[70] Brazil[71] and America[72] shut down traffic in response to reports of drones nearby. None of those sightings were ever confirmed either, and there is strong reason to doubt some of them ever occurred.[73]

COLLISION RESEARCH: OFTEN UNINFORMATIVE, BUT GENERALLY REASSURING

The glut of inaccurate information is not limited to external reports of drone incidents. In July 2017, the U.K. Department for Transport and Military Aviation Authority, as well as the British Airline Pilots' Association (BALPA), jointly released an 18-page summary of a report on drone collisions.[74] After firing projectiles at aircraft windscreens and building computer models, they concluded that a drone could penetrate an airliner's windscreen, and said "the rise in the number of reported encounters between drones and manned aircraft and the evidence from this study and others does suggest that more needs to be done." [75] The claims received widespread news media attention, not just in the U.K. but worldwide.

60 adls.org.nz/for-the-profession/news-and-opinion/2018/5/25/drone-debate-reaches-new-heights/ 61 caa.govt.nz/assets/legacy/Accidents_and_Incidents/Accident_Reports/ZK-LFD-safety-brief.pdf 62 wcvb.com/article/drone-sighted-by-pilot-landing-at-logan/8054718 63 reuters.com/article/us-california-drone-lufthansa-idUSKCN0WL01B 64 soundcloud.com/user-418101943/klax-final-mar-18-2016-2000z 65 cbc.ca/news/canada/toronto/tsb-toronto-risk-collision-1.3850218 66 theguardian.com/world/2016/nov/14/toronto-airport-drone-incident-injuries-canada 67 toronto.citynews.ca/2016/11/23/object-caused-near-collision-porter-plane-not-drone/ 68 nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12033169 69 news.sky.com/story/some-gatwick-drone-sightings-may-have-been-police-drones-chief-constable-says-11593854 70 bbc.com/news/uk-46803713 71 g1.globo.com/sp/sao-paulo/noticia/2019/01/09/presenca-de-drone-no-entorno-de-congonhas-fez-aeroporto-fechar-por-20-minutos-na-terca.ghtml 72 nytimes.com/2019/01/23/nyregion/newark-airport-drones.html 73 washingtonpost.com/transportation/2019/01/23/did-pair-drones-interfere-with-flights-newark-airport-or-was-it-something-else/?utm_term=.0d475b02e074 74 gov.uk/government/publications/drones-and-manned-aircraft-collisions-test-results 75 assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/628092/small-remotely-piloted-aircraft-systems-drones-mid-air-collision-study.pdf, p. 18

Yet even as BALPA said the report justified strong restrictions on drones,[76] the U.K. government refused to release the full report.[77] When a journalist obtained a copy, it revealed the public claims were untrue: "In reality, the full study … found that for airliners, the risk posed was far less alarming than both the union and the Department for Transport had claimed. Instead of penetrating cockpit windows, rigorous tests … found that drone-airliner collisions will crack but not penetrate such windows." [78]

Another report drew widespread media attention for video of a drone striking an airplane wing in a laboratory, but the testing protocol was clearly rigged to gain publicity without scientific rigor or to inform a serious discussion about real-world risks. The University of Dayton Research Institute fired a drone and a simulated bird at the wing, at speeds far above what they would encounter in real life, but only released a video of the drone collision – even though the bird "did more apparent damage" to the wing.[79] DJI documented the testing flaws in detail and demanded the withdrawal of the video,[80] but it has been viewed more than 850,000 times[81] and is routinely cited in major media articles about drone safety.[82]

Despite those misleading claims, other research into drone risks has found unobjectionable results. The U.K. Civil Aviation Authority (CAA) surveyed existing literature about the risks of drones weighing less than 2 kg (4.4 lbs.) striking airplanes and helicopters and concluded both the likelihood and potential severity of such a collision were quite small.[83] And an earlier study extrapolated from FAA wildlife strike data to conclude that drones pose much less risk to aircraft than the 10 billion birds in American skies: "Contrary to sensational media headlines, the skies are crowded not by drones, but by fowl." [84]

Research by the FAA's ASSURE Center of Excellence determined that, even in a worst-case scenario, a quadcopter drone would not penetrate the windshield of an airplane or cause an uncontained failure if ingested into an airliner's engine.[85] And at the low altitudes where most drones operate and are often limited by safety features such as altitude limitations, airplanes fly at slower speeds which ASSURE found correlate with the lowest levels of damage in a collision. Unlike the University of Dayton Research Institute, ASSURE released data to the public for independent review.

As a matter of comparison, small aircraft crash hundreds of times a year in the U.S. alone, killing their occupants and sometimes people on the ground.[86] At this writing, no one in an airplane has ever died because of a collision with a drone. Yet even unfounded fears of the severity of collisions can gain far more public attention than actual fatal incidents involving traditional aircraft.

DRONES AT HIGH ALTITUDES: THE HIGHER THE REPORT, THE LOWER THE RELIABILITY

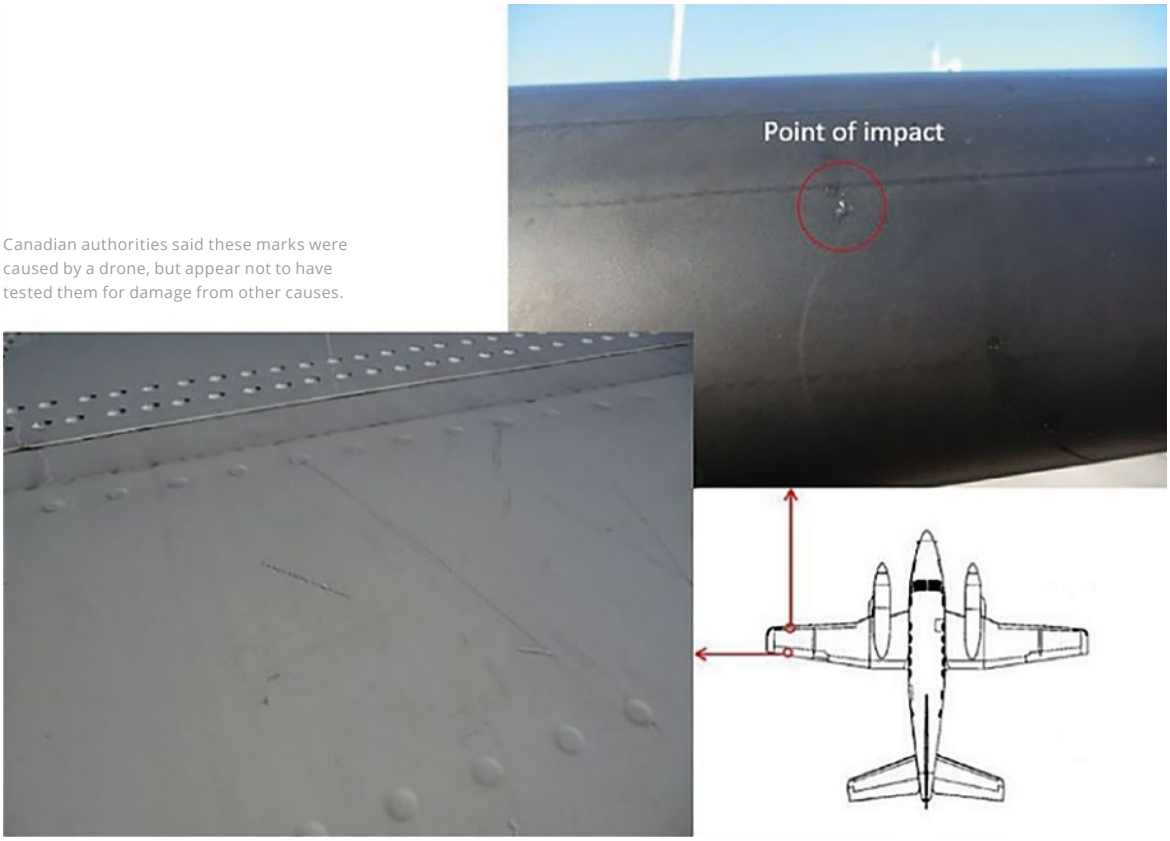
Airplane and helicopter pilots have no standardized system for reporting drone altitude – even to answer a basic question such as whether it was measured above ground level or above sea level. This provides little help to the authorities who receive those reports, and have said the higher in the sky an incident purportedly occurred, the less likely it was to have really occurred. Critics have documented the obvious flaws in using pilots' reported encounters as the basis for documenting air safety risks, noting that a series of Airprox reports of drones at extremely high altitudes are unlikely to have been truly caused by drones.[87] EASA has also advised skepticism about reports of drones above 6,000 feet included in their statistics: "Indeed, some of the reports of near-misses with UAS have occurred at altitudes where UAS are not normally able to operate," [88] they wrote. "[T]hese occurrences were not confirmed as being with a UAS beyond all doubt and may involve birds or other objects." [89]

76 balpa.org/Media-Centre/Press-Releases/Act-now-on-proven-drone-collision-threat-say-pilot 77 theregister.co.uk/2017/07/27/drone_test_results_wont_be_released_dft/ 78 theregister.co.uk/2018/01/04/qinetic_drone_collision_study_airliner_windows/ 79 udayton.edu/blogs/udri/18-09-13-risk-in-the-sky.php 80 dji.com/newsroom/news/dji-demands-withdrawal-of-misleading-drone-collision-video 81 youtube.com/watch?v=7gt8a_ETPRE 82 See for example express.co.uk/news/uk/1069108/heathrow-drone-sighting-what-could-a-drone-strike-do-to-a-plane 83 publicapps.caa.co.uk/docs/33/CAP1627_Jan2018.pdf 84 mercatus.org/publication/do-consumer-drones-endanger-national-airspace-evidence-wildlife-strike-data 85 assureuas.org/projects/deliverables/sUASAirborneCollisionReport.php?CFA=1 86 faa.gov/news/fact_sheets/news_story.cfm?newsId=21274 87 hackaday.com/2016/05/02/debunking-the-drone-versus-plane-hysteria/ 88 easa.europa.eu/sites/default/files/dfu/UAS%20Safety%20Analysis.pdf, p. 3 89 easa.europa.eu/sites/default/files/dfu/UAS%20Safety%20Analysis.pdf, p. 15

For regulators, elected officials and drone companies trying to make drones safer, inaccurate news stories aren't just misleading. They harm the process of improving safety, because they focus attention on outrageous events that didn't happen, instead of on aviation risks that may be less sensational but much more prevalent.

One of the most notorious examples came when a small propeller plane carrying six passengers reported colliding with a drone "about the size of a dinner plate" at least 2,000 feet above Quebec City in October 2017.[90] No one was injured, the plane was immediately returned to service, and the only physical evidence of any collision was two photographs that later emerged of small marks on the wing and de-icing boot.[91] There was no indication they were ever tested for bird DNA, damage from ground equipment or any other cause. However, the Canadian Transport Minister called a rare Sunday news conference three days later to declare it Canada's first drone collision with a commercial aircraft, and said it validated his decision to issue stronger drone restrictions.[92] Canadian safety investigators never found any additional proof that a drone struck the plane, but it has since been widely cited by news media[93] and an airline pilots' union[94] as North America's first drone collision with an airplane.

To be clear, some irresponsible drone pilots have clearly circumvented both the law and the built-in restrictions on their drones to fly far above the legal altitude limit, as a search of online drone videos shows. But the sheer number of reported drone incidents from high altitudes – the UAST study found 70 % of FAA reports were above 400 feet[95] – should raise questions about how reliable they are: It implies that people routinely fly drones at unsafe and illegal altitudes all over the world, despite built-in features to discourage and prevent that – and that airplane pilots routinely spot them accurately.



Canadian authorities said these marks were caused by a drone, but appear not to have tested them for damage from other causes.

90 aero-news.net/index.cfm?do=main.textpost&id=fca4bcf0-d04b-4fa2-9d5f-5aa5e4ffe88b 91 bst-tsb.gc.ca/eng/rapports-reports/aviation/2017/a17q0162/a17q0162.asp 92 canada.ca/en/transport-canada/news/2017/10/statement_by_ministeroftransportaboutadroneincidentwithapassenge.html 93 cbc.ca/news/canada/nova-scotia/drones-illegal-airports-aircraft-flying-safety-1.4842502 94 alpa.org/news-and-events/news-room/2018-02-20-alpa-urges-transport-canada-take-effective-measures-protect-public-drones 95 unmannedaircraftsafetyteam.org/wp-content/uploads/2018/01/UAST-Sightings-Executive-Summary-2017.pdf, p. 5

There are indications that some aviation stakeholders have a healthy skepticism about drone sighting reports at high altitude. While airline pilot organizations have been some of the most vocal groups decrying drone risks,[96] several U.S. airline pilots told a writer that drones were low on their list of potential hazards – including one who said, tellingly, "I'm more worried about being replaced by a drone than I am about being hit by one." [97]

Some professionals who deal with drone reports have indicated they understand the limitations they present. The chairman of German air traffic services responded to news that drone incidents had increased by saying, "The number was lower than we had expected in view of the number of drones sold." [98] A French journal for police officials noted that many reports they received of drone incursions were in fact false alarms.[99] And in Australia, the chief executive of the Civil Aviation Safety Authority said in November 2018 that the number of reported drone incidents in that country appeared to have plateaued, thanks in part to a strong educational campaign among drone users.[100]

WAS IT REALLY A DRONE? THE SKIES ARE CROWDED WITH BIRDS, BALLOONS AND EVEN UFOS

If pilots are over-reporting drone incidents in the air, what are they really seeing? The most obvious candidates for misidentification are birds. Since 1990 the U.S. Department of Agriculture has recorded more than 200,000 incidents of aircraft striking wildlife.[101] U.S. civilian flights reported 14,661 collisions with wildlife in 2018, an average of more than 40 every day.[102]

At certain angles, birds and drones can appear similar in shape, size and color. Here, a DJI Phantom 4 and a northern gannet, a type of North Atlantic seabird, are both pictured over water.

96 alpa.org/news-and-events/news-room/2017-11-29-alpa-highlights-faa-study-unsafe-uas 97 slate.com/articles/technology/future_tense/2015/09/are_we_overreacting_about_drones_and_passenger_planes.html 98 slashcam.com/news/single/Fewer-drone-incidents-in-Germany-last-year-than-ex-14327.html 99 helicomicro.com/2018/05/18/gendarmerie-survols-drones/ 100 australianaviation.com.au/2018/11/drone-incidents-have-plateaued-casa/ 101 faa.gov/airports/airport_safety/wildlife/media/significant-wildlife-strikes-1990-Dec-2018.pdf 102 usatoday.com/story/news/nation/2019/02/06/bird-strikes-airplanes-wildlife-federal-aviation-administration-data-sully-sullenberger/2613893002/

Birds are a known hazard for small airplanes and helicopters, with a death toll in the hundreds,[103] and the FAA's Aeronautical Information Manual explicitly warns that migrating waterfowl are present more than a mile above the earth's surface:

> The altitudes of migrating birds vary with winds aloft, weather fronts, terrain elevations, cloud conditions, and other environmental variables. While over 90 percent of the reported bird strikes occur at or below 3,000 feet AGL [above ground level], strikes at higher altitudes are common during migration. Ducks and geese are frequently observed up to 7,000 feet AGL and pilots are cautioned to minimize en route flying at lower altitudes during migration.[104]

In addition to birds, pilots may spot one of the 900 weather balloons launched twice daily around the world,[105] or they may be confused by optical illusions that alter the perception of other lights at night. "On a clear night, distant stationary lights can be mistaken for stars or other aircraft. Cloud layers or even the northern lights can confuse a pilot and indicate a false visual horizon," the FAA notes in one handbook.[106] Further, sightings of "unidentified flying objects" (UFOs) have fallen as the number of reported drone sightings has grown.[107] Technology writer Faine Greenwood suggests this may reflect a natural human tendency to seek an explanation for something that seems otherwise inexplicable: "Drones provide people with a good way of saying that they saw something odd in the sky without forcing them to publicly claim that they saw an honest-to-God UFO." [108]

STUDIES RAISE DOUBTS ABOUT SIGHTING REPORTS

One other factor in evaluating reports of drone incidents deserves mention. Professional airplane pilots earn a presumption of authority in their observations over thousands of hours of flight time. Yet as shown below, academic research provides strong evidence that the account of an airplane pilot alone may not be sufficient to establish that a drone was flown in close proximity to a traditional aircraft:

Human perception does not allow pilots to reliably spot other nearby airplanes, much less drones. Pilots cannot reliably distinguish between airplanes, birds, balloons, airborne debris or drones at nearby distances.

Observers on the ground or in the air cannot reliably determine the distance to an airborne object, much less the amount of vertical or horizontal separation between that object and another aircraft.

Pilots of airplanes moving at 150 mph or faster often have less than a fraction of a second to identify unexpected objects near them, and human reaction time cannot reliably allow them to determine what that object is.

Aviation experts have long realized the limits of "detect and avoid," the well-established requirement for airplane and helicopter pilots to keep a vigilant lookout for other aircraft. Long before the advent of drones, a 1991 Australian Transport Safety Bureau research report warned, "The physical limitations of the human eye are such that even the most careful search does not guarantee that traffic will be sighted." [109] Against that backdrop, researchers have begun studying the limits of pilots' ability to spot drones, especially small, popular consumer drones smaller than one meter across.

One study of human visual acuity concluded aircraft pilots had less than a 10 percent chance of spotting a small drone nearby, even in ideal conditions.[110] It modeled the behavior of the human eye and how a variety of drones would appear in different scenarios to reach general conclusions about their visibility:

103 faa.gov/airports/airport_safety/wildlife/ 104 faa.gov/air_traffic/publications/media/AIM_Basic_dtd_10-12-17.pdf, section 7-4-1-b (p. 519) 105 weather.gov/bmx/kidscorner_weatherballoons 106 faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook/media/12_afh_ch10.pdf p. 3 107 syracusenewtimes.com/close-encounters-ufos-getting-harder-find/ 108 slate.com/technology/2019/01/drone-paranoia-gatwick-heathrow-airport-sightings-ufos.html 109 atsb.gov.au/media/4050593/see_and_avoid_report_print.pdf, p. vii 110 commons.erau.edu/cgi/viewcontent.cgi?article=1349&context=edt, p. iv

> Very small sUAS aircraft are unlikely to be visible in time to avoid a collision. This is true at any of the airspeeds used in this study's scenarios. The mean probability of sighting a sUAS aircraft drops quickly as the sUAS vehicle becomes smaller and as the manned aircraft speed increases.[111]

Yet careful attempts to understand the science of spotting drones can conflict with all-too-human assumptions about the art of spotting drones. One remarkable study of pilot perception flew a small airplane hundreds of feet away from two types of drones in a safe and highly-structured pattern, with a minimum of 200 feet of vertical separation at all times.[112] The airplane pilots misjudged the distance to a nearby drone by an average of 0.2 to 0.25 statute miles (1,056 to 1,320 feet).[113] In two cases, airplane pilots estimated they were directly adjacent to the drone, but GPS data later showed they were 0.19 and 0.22 statute miles (1,003 and 1,162 feet) apart.[114] One other finding from that study is highly relevant for evaluating "drone sighting" reports:

> Despite the experimental pilots being aware of the positive vertical separation engineered into the experiment, several participants reported still perceiving the UAS to be in such proximity that they felt a collision was imminent. One participant even performed an evasive climbing maneuver to avoid the UAS.[115]

THE SUBSET OF CREDIBLE REPORTS: ACTIONABLE DATA FROM VERIFIED INCIDENTS

The NTSB, which investigates aviation incidents in the U.S. and is involved in many probes by other countries, has evaluated the evidence closely and has never confirmed any report of a drone colliding with an airliner.[116] Helicopters, however, are more likely than airplanes to fly in unexpected patterns at low altitudes far from airports. The world's only confirmed drone collisions, as well as several "near misses" backed by clear and explicit evidence, have been with helicopters at relatively low altitudes:

Maulden, U.K., April 2017

A drone pilot hovering 350 feet over a field heard a helicopter approaching and began to descend, until his spotter saw the helicopter emerge below the drone, just above the treeline. He described it as a military helicopter flying at treetop level, which passed below his drone at a high rate of speed. The Airprox Board assigned its second-highest risk category to the incident, but said "both aircraft were entitled to operate in the area." [117]

New York, September 2017

A drone pilot improperly flew his drone farther than he could see, after sunset, in an area covered by an FAA temporary flight restriction. A U.S. Army Black Hawk helicopter struck the drone 274 feet above New York harbor, and investigators used a piece of the drone that wedged in the helicopter to identify the owner. The helicopter blade was damaged, but it landed without incident.[118]

Petah-Tiqwa, Israel, August 2018

An agricultural spraying helicopter collided with a drone mapping a nearby construction site. The drone wedged in the helicopter's spray gear but the helicopter was undamaged. The chief investigator said this pointed to the challenge of keeping drones and helicopters safely separated: "[B]oth operators were working in accordance to the aviation law and by the published regulations. They were properly licensed and adhered to the working altitudes approved and authorized." [119]

Hollywood, Florida, August 2018

A video posted on YouTube showed a scenic beach view from a drone, interrupted by a helicopter that

111 Ibid., pp. 110-11 112 pdfs.semanticscholar.org/1377/91d6e97746b59ac25c17f42d40c7dc0a2a11.pdf, p. 13 113 commons.erau.edu/cgi/viewcontent.cgi?article=1142&context=ijaaa, p. 16 114 Ibid., p. 16 115 Ibid., p. 18. 116 ntsb.gov/_layouts/ntsb.aviation/index.aspx
117 airproxboard.org.uk/uploadedFiles/Content/Standard_content/Airprox_analysis/2017/201705%20May%20Drone%20Report%20Sheet.pdf, p. 10
118 ntsb.gov/investigations/pages/2017-dca17ia202ab.aspx 119 aiai.mot.gov.il/NOTES/NAI_1256.pdf

suddenly flew directly below at extremely close range. The person who posted the video claimed to be flying below the FAA's 400-foot altitude limit for drones, but did not notice the helicopter approaching.[120]

Niagara Falls, New York, March 2019

Another YouTube video emerged showing a helicopter flying directly below a drone at uncomfortably close range. The person who posted the video wrote, "I made a mistake. I thought I was safe to fly since I was not in a No Fly Zone ... I did not think of what was going on around the area." [121]

These incidents indicate that in some rare instances, at low altitudes, even a well-meaning drone pilot may not see or hear an approaching helicopter in time to maneuver out of its way. Moreover, the wide variety of locations is striking: the British countryside, the harbor of America's largest city, a construction site adjacent to an orange field, a Florida beach, and a famous tourist attraction straddling an international border.

The likely severity of such potential collisions is not well known. Although research by the FAA's ASSURE Center of Excellence concludes that small drones will not cause catastrophic damage to a jet aircraft, and even BALPA's testing showed no windshield penetration for such aircraft, we are unaware of similar testing involving drone collisions with helicopters. Our discussions with researchers suggest that modeling the dynamics and likely consequences of such collisions would be very complex. This uncertainty creates the prospect that drone collisions may pose substantial risk of damage to helicopters.

MEANINGFUL DATA EXISTS, AND CAN DRIVE THE NEXT STEPS

Our search for data that can help drive safety enhancements has shown that while the most widely-cited reports are unhelpful at best, there are important and actionable insights to be gained from the most reliable data available. Fear-driven news stories focus on the sensational possibility of a drone striking a jet at high altitude or at a major airport, but drone safety efforts can evidently do the most good by focusing on the risk of collisions with helicopters a few hundred feet above the ground, in a wide variety of locations.

Drone safety efforts can evidently do the most good by focusing on the risk of collisions with helicopters.

DJI is putting this insight to work. In the next part of this white paper, we enumerate concrete steps that will help address these legitimate concerns. The evidence suggests ways to improve drone safety, and we will do what is in our power to make it happen.

120 youtube.com/watch?v=UQYDRUg3Ra0 121 niagara-gazette.com/news/local_news/faa-investigating-near-miss-involving-drone-over-falls/article_0ae75d67-918b-5236-8ddd-abfd1859032e.html

PART THREE

BETTER DATA ILLUSTRATES KEY WAYS FORWARD

Despite all the well-documented problems with existing drone safety data and anecdotal reports, DJI refuses to accept the idea that nothing more detailed can be done, or that we must wait for regulations to be developed to implement improvements. We want to focus our research, development, education and advocacy on solutions that offer the highest likelihood of helping improve safety. In this section we outline our plans, based on the available data, and suggest 10 steps for how we, and everyone with a stake in aviation safety, can work toward this goal.

I. DJI COMMITMENTS

The clearest lesson from the evidence available to DJI is that we must continue to lead the industry in developing voluntary technological solutions to help ensure drone pilots stay aware of their surroundings, the limits of their aircraft, and other nearby air traffic. In particular, the number of confirmed collisions and near-collisions with helicopters points to the need to provide drone pilots more awareness of other air traffic approaching at low altitudes, anywhere drones are flying.

DJI has done this for professional drone pilots with the AirSense ADS-B receiver system in our Matrice 200 series and Mavic 2 Enterprise series drones. ADS-B In is already a proven technology in airplanes and helicopters, and one study found the likelihood of an aviation accident fell by more than half for small aircraft equipped with ADS-B receivers.[122] The FAA will require ADS-B transmitters in all traditional airplanes and helicopters flown in controlled airspace in the U.S. starting in January 2020.[123] Other countries are moving toward increased ADS-B usage as well, and in some cases have set mandates that match the FAA's.[124] DJI now commits to widely deploying ADS-B In technology in our future consumer drones.

1 DJI will install AirSense ADS-B receivers in all new drones above 250 grams

Traditional aviation has adopted simple and reliable collision avoidance technology called Automatic Dependent Surveillance-Broadcast (ADS-B). An increasing number of airplanes and helicopters carry ADS-B transmitters that send their location, speed, altitude and other telemetry to air traffic controllers on the ground as well as other aircraft around them, to increase pilot awareness and decrease the risk of collision.

DJI has developed AirSense, a system that receives ADS-B signals from nearby aircraft, displays the aircraft on the display screen of a drone's remote control, and provides automatic alerts in the event potential collision paths are detected by the technology. This feature was first introduced in 2017, but only for drones designed for professional operations. Now that we have a more informed risk picture, **DJI will install the AirSense ADS-B feature on every new drone it releases after January 1, 2020, that weighs more than 250 grams.**[125] Adding this capability to consumer-sized drones will be an engineering challenge for models already under development, but we believe the added safety it provides will be worth it.

Another common factor in some confirmed incidents has been the substantial distance between the drone and the person flying it. In the helicopter collision over New York harbor, for example, the drone was 2.5 miles from its pilot,[126] clearly farther than the pilot could see by his own admission. While many drones have the

122 aopa.org/news-and-media/all-news/2019/april/18/study-shows-accidents-less-likely-with-ads-b-in 123 faa.gov/nextgen/equipadsb/ 124 aopa.org/go-fly/aircraft-and-ownership/ads-b/where-is-ads-b-out-required 125 Drones weighing less than 250 grams are widely considered by regulators to pose negligible risk. Those drones and/or their pilots are, or will soon be, generally exempt from registration in the U.S., Canada, the U.K., continental Europe and Australia. Drones this small also have no anticipated space to add ADS-B antennas. 126 app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20170922X54600&AKey=1&RType=HTML&IType=IA

technical capability to fly several miles from their pilots, and FAA regulations allow long-distance flight when visual observers are used, the FAA and other regulators' basic rules require operators to keep drones within their visual line of sight. Researchers at Embry-Riddle Aeronautical University who studied 30 days of data provided by their DJI AeroScope system said 5.5 % of flights may have been conducted beyond visual line of sight. Although they could not definitively say those flights violated FAA regulations, this small but significant number of flights raises concern that pilots may not always follow visual line of sight principles.[127]

There is no simple distance-based guide for the limits of a drone pilot's vision, which can depend on surroundings, size of the drone, terrain, atmospheric conditions, individual visual acuity, time of day and other factors. Nonetheless, DJI is developing an algorithm for its flight software to help remind drone pilots to keep their drone within visual line of sight.

2 DJI will develop a new automatic warning for drone pilots flying at extended distances

Most aviation regulators require drone pilots to keep their drones within visual line of sight, so they can steer clear of obstacles and detect other aircraft in time to avoid them. While there are no standards prescribing exactly how far drone pilots can fly safely using their vision alone, some academic research suggests the ability to perceive and visually pilot drones falls significantly when the drone is further than several hundred meters away.

All aviation circumstances are different, and some pilots use technology, dedicated airspace, or visual observers to fly at extended distances from the ground control station. Nevertheless, **DJI will develop an algorithm to automatically remind drone pilots to always fly within visual line of sight by displaying a warning** in DJI's flight control apps when drones fly a significant distance from the ground control station. The warning activation point will account not only for the drone's absolute distance from the pilot, but potentially other factors such as the relative angle of view relative to the pilot, which could play a role in visibility.

While these first two steps focus on the actions of drone pilots, a full safety review must also involve drone equipment. Aviation safety regulators have largely steered clear of requiring drone manufacturers to meet rigorous certification requirements, as airplanes and helicopters do, because these risks remain very low, and drone technology is changing so rapidly. We support these basic principles, which have enabled many safe and innovative operations. However, regulators rightly have stronger performance expectations for drones that are used in more complex, higher-risk operations.

As national aviation authorities explore the optimal safety expectations for drones, manufacturers that want their products to be used in complex operations must be prepared for a higher level of scrutiny. This has been most apparent in Canada, where manufacturers must comply with a safety assurance framework in order for their products to be used in advanced operations.[128] If other nations adopt similar systems, the drone industry may well adopt practices that differ from traditional aviation, but provide achievable standards on reliability, accuracy and documentation, via testing and more performance standards.

127 commons.erau.edu/cgi/viewcontent.cgi?article=1327&context=ijaaa, p. 17 128 dji.com/newsroom/news/dji-drones-comply-with-new-transport-canada-requirements-for-advanced-operations

3 DJI will establish an internal Safety StandardsGroup to meet regulatory and customer expectations

As drones have evolved from a nascent experimental technology to a widely-adopted tool, expectations for their reliable operation in complex operations have increased. Performance requirements for drones should of course be far less rigorous than those for aircraft that carry people, but in complicated operations that pose higher levels of risk, regulators will inevitably seek to protect public safety through performance standards, maintenance procedures and data analysis.

DJI will create an internal Safety Standards Group to meet these growing expectations. This group, a major expansion and formalization of our existing product quality testing team, will research and develop standards for DJI drone performance, reliability and maintenance. It will also establish procedures for testing products and retaining their data, and collect and analyze reports of product failures to identify factors that may affect flight safety.

II. INDUSTRY INITIATIVES

DJI is proud of our efforts to encourage safe drone flight, and in this section, we identify the most important steps other companies can take to help uphold broad safety expectations.

It is long past time for the traditional and drone aviation communities to develop common and accepted practices for collecting, analyzing and acting on reports of drone interference in the skies. Airplane and helicopter pilots need rigorous standards for reporting what they perceive as drone sightings and evaluating whether they pose any risk. Airports must develop protocols to evaluate the validity of nearby drone reports and respond with minimal disruption. Aviation safety bodies must create standards for determining whether an object that flies near, or strikes, a traditional aircraft is a drone, a bird or something else.

The widespread adoption of remote identification systems will help: Even a relatively small sample of remote ID data is far more reliable than the hundreds of pages of split-second impressions and long-distance hunches found in FAA and Airprox reports. But eyewitness claims will still need to be evaluated – some of them discredited, others acted upon. This is especially crucial for collision reports. Given the number of reports that turn out not to be drones, every reported drone collision should be subjected to rigorous investigation, including for evidence of a bird strike. As the number of drones and the number of reports continue to rise, it is incumbent on industry stakeholders to act.

4 Aviation industry groups must develop standards for reporting drone incidents

Our analysis has shown that anecdotal reports of drones being flown in unsafe or illegal ways are notoriously inaccurate and rarely reliable. Yet if these claims can be collected rigorously, reported and investigated in a standardized way, they have the potential to offer helpful data on drone use and misuse, and to lead DJI and others to develop further safety mitigations, even in advance of new regulations.

Industry groups must develop workable science-based standards for reporting drone

incidents, with rigorous methods for obtaining detailed information while filtering out claims that have little or no bearing on safety. This will require a collaborative effort between everyone with a stake in the safety of the skies, including drone manufacturers and pilots, airports and airlines, professional and private pilots, and many others. Forums such as the FAA's Drone Advisory Committee or the UAST can be leveraged to accelerate the creation of these reporting and investigation standards. The process will be complicated, but doing so will finally allow reported drone incidents to play a role in data-based safety efforts.

One of the most effective tools to prevent drones from flying too close to airplanes and helicopters is DJI's geofencing restrictions near airports. It seems incontrovertible that providing a default restriction in very high-risk locations provides a substantial margin of safety. While DJI has recently deployed its third generation of geofencing technology, other manufacturers of off-the-shelf, technologically capable drones appear to believe they have no responsibility to create default restrictions for where their products can fly.

As pioneers in drone flight, we understand the intellectual appeal of this posture; as airspace participants who have studied the risks up close, we believe the time for philosophical objections to default flight limitations for off-the-shelf products has passed. Basic restrictions for the most sensitive flight locations should be included in every moderately sophisticated drone product. (Toys and "traditional" model aircraft have rarely been implicated in safety risks, and we see no need to apply these standards to them. They should apply to drones that can fly far from their pilots, navigate autonomously, send a long-range video signal or otherwise raise concerns about safety and accountability.) Of course, a process for "unlocking" those restrictions should be made available for users who take extra steps to indicate their flight authorization. There is no "right way" to do this, and we encourage market-based innovation. But given the sophistication of today's drone products, choosing not to implement geofencing is wrong.

Similarly, other drone manufacturers should join DJI in implementing basic remote identification solutions for their products. While there is no industry consensus about how remote ID should work, who should bear its costs and how to protect the data it collects, DJI created its own solution and is also participating in the ASTM process to develop remote ID standards that can be broadly implemented.[129] This will allow other companies to meet common industry expectations with their own solutions, even before the FAA and other global aviation regulators implement "official" requirements.

5 All drone manufacturers should install geofencing and remote identification

Geofencing and remote identification are two key technologies to protect airports, stadiums, prisons, critical infrastructure and other sensitive locations. Geofencing uses satellite navigation networks like GPS to identify those areas and restrict drones by default from flying in them without additional steps. Remote identification gives authorities real-time information about the location, altitude, speed and direction of a drone, as well as the serial or registration number of the drone and the location of its pilot.

DJI has taken an enormous step forward for drone safety by deploying our GEO 2.0

129 astm.org/DATABASE.CART/WORKITEMS/WK65041.htm

geofencing system worldwide in all our drones and deploying our AeroScope remote identification system in airports, stadiums and other sensitive locations around the world. Other manufacturers have taken different approaches. We believe the risks of unrestricted drone flight are clear enough, and public expectations about drone safety are high enough, that **all manufacturers of moderately sophisticated off-the-shelf drones should install some form of geofencing system and remote identification capability on their drones now.** We welcome collaboration with other companies on various approaches to remote identification, as well as the UAST's effort to set industry-wide geofencing best practices. As standards-setting bodies develop inexpensive ways to implement remote identification, we urge our peers in the industry to implement these functions well before regulations require them.

III. GOVERNMENT INITIATIVES

Voluntary safety steps initiated by the drone industry are extremely important, and can often be implemented more easily and effectively than government mandates. But some issues do require the authority of government to be truly effective. In this section, we identify five key steps that apply to regulators and policymakers around the world.

Remote identification provides a relevant example. While industry-led remote ID efforts provide an enormous benefit to air safety, an optional system is not enough. DJI believes it is reasonable for governments to require all moderately sophisticated drones to transmit remote ID, allowing authorities to accurately monitor the location, altitude, direction, and speed of airborne drones, as well as other parameters such as the pilot's location and the drone's serial number or registration information.

Remote ID will provide a far more accurate picture of drone activity, and will provide actionable information about how to improve drone safety. But the FAA's process for requiring remote ID has inexplicably slipped, with proposed rules now scheduled to be released by mid-July 2019.[130] Given the pace of government rulemaking, implementation is likely to be years away. The U.K. CAA is already seeking public comments on how best to achieve "electronic conspicuity," their term for remote ID, and is asking for all submissions to be received by May 25, 2019.[131]

6 Governments must require remote identification

The single strongest tool to monitor drone use in sensitive airspace is remote identification, which allows authorities to identify drones in a selected area and track their movements, as well as locate the pilot. DJI's AeroScope provides this information for DJI drones, and other companies and consortiums have demonstrated other approaches.

Many important remote identification issues must be resolved, including how to transmit the data, who will have access to it, which drones must comply, how to protect drone operator privacy, and how to minimize the burdens it imposes on drone cost, weight and battery life. **DJI calls on regulators around the world to accelerate the process of resolving these issues and mandating remote identification.** A fully functioning remote identification requirement will provide immediate safety and security

130 transportation.gov/regulations/report-on-significant-rulemakings, "March 2019 Significant Rulemaking Report," p. 26 131 consultations.caa.co.uk/corporate-communications/e-conspicuity-solutions/user_uploads/cap1777_electronicconspicuity_call.pdf, p. 9

benefits, and can for the first time generate comprehensive reliable data on drone flights near sensitive locations.

The simplest way for drone pilots to avoid unsafe situations is to always follow the appropriate rules for safe flight. DJI has developed a Knowledge Quiz for drone pilots in several countries, who must correctly answer simple questions about safe drone operation in DJI's flight control software before they can operate their first flights with a DJI drone. This gives new drone pilots an opportunity to understand the requirements for safe flight and demonstrate a basic understanding of them. The quiz content varies from country to country, and is developed in consultation with each nation's aviation regulator.

Obeying drone rules does not eliminate every possible unsafe hazard, but it prevents many potentially unsafe activities before they can start. Technology can help warn drone pilots when they are at risk of running afoul of those rules, but educating them about the rules first is more effective. As with any set of expectations, whether formal laws or societal behaviors, people are more likely to follow rules that make intuitive sense, seem fair, and are easy to obey. Drone regulations should incorporate this assurance of education and knowledge.

7 Governments must require a user-friendly knowledge test for new drone pilots

The overwhelming majority of drone pilots ant to fly safely and responsibly, without entering restricted airspace or raising any concerns. They bear the ultimate responsibility for making smart flight decisions, and to do that, they need to understand the laws, regulations and good practices of flying drones.

While professional drone pilots must pass tests of aviation and drone knowledge in some countries, recreational pilots have not been subject to similar requirements. **DJI believes all pilots of moderately sophisticated drones must be required to pass a reasonable, easily-accessible, electronic or online test of basic safety information before they are allowed to fly.** This test should be focused on the main rules of safe operation and be able to be completed in a short amount of time, to encourage compliance. DJI already requires this for pilots in several countries, and we stand ready to help governments implement mandatory tests on our products as soon as possible.

There is broad agreement that it is reasonable for governments to prohibit unauthorized drone flights in areas that pose the most risks, such as above prisons, occupied stadiums, nuclear plants and airport runways. However, reasonable people can disagree about the appropriate offsets from those locations, as well as how to treat other locations that are clearly sensitive but not as potentially dangerous. Drone pilots might have different opinions on those topics than security officers.

While DJI encourages dialogue on these topics, and may well opine strongly on them, we recognize that ultimately the national government in each jurisdiction must weigh competing interests and strike an appropriate balance. The sooner this process begins, the more governments will improve safety by setting clear standards for pilots and enforcers alike.

8 Governments must clearly designate sensitive restriction areas

Many governments have established no-fly zones or other drone restrictions on clearly sensitive locations such as major airports and nuclear power plants, but there are few clear standards for addressing the countless other locations that warrant higher scrutiny of nearby drone flights. **Governments must create simple, fair and reasonable processes to designate critical infrastructure and similar sensitive sites where drone flights should be barred** without special permission.

With clear guidance on facility boundaries and offsets, drone manufacturers can geofence those locations, and authorities can monitor incursions more easily. Drone users may well disagree with authorities about the sensitivity and risk of some locations, and those concerns must be addressed through an appropriate review process before they are implemented. But the process of identifying those locations and determining appropriate restrictions must be accelerated.

For the people in charge of protecting large gatherings of people, airport runways, critical infrastructure and other extremely sensitive locations, a strong set of rules will never be enough to provide them full confidence that they are protected from malicious drone activity. A thriving cottage industry has emerged of systems that claim to be able to detect, disable or destroy drones that pose a clear threat. In many jurisdictions around the world, though, these systems are illegal to operate, because they intentionally interfere with radio communications as well as aircraft in flight.[132] In some cases, laws created for an entirely different purpose or technology could be interpreted to apply to drones, although that was not the intent of lawmakers at the time.

Even for authorities who are willing to ignore a legal risk to prevent a life-or-death risk, there are no established standards for when a situation rises to that level of response, or who is liable if something goes wrong. In Venezuela in 2018, for example, authorities claimed to have successfully interdicted an explosive-laden drone flying toward their president at an outdoor speech – but the drone instead crashed into an apartment building and sparked a fire.[133] Law enforcement and security officials who must make immediate decisions to respond to the most worrisome drone sightings deserve better tools.

9 Local authorities must be allowed to respond to drone threats that are clear and serious

National aviation regulators set the rules for drones, but when a drone appears to be flown in an unsafe or threatening manner, local police officers are often the first ones challenged to respond. They rarely have guidelines for how to do so, and in some cases may arguably be prohibited by law from interfering with a drone in flight.

This situation is untenable. Some companies sell products they claim can disable, destroy or take control of a drone in flight, but using them without clear legal authority creates its own risks. Antiquated rules about "aircraft" were not created for, and do not necessarily apply to, small battery-powered drones. **Local authorities need legal processes allowing them to act**

132 jrupprechtlaw.com/drone-jammer-gun-defender-legal-problems#affect 133 bellingcat.com/news/americas/2018/08/07/drones-attack-maduro-caracas/

in the rare cases when an airborne drone appears to pose a clear threat. Developing a balanced system that protects the public and drone pilots alike will be complex, but governments must start that process now.

The steps outlined above will greatly improve drone safety by outlining clear expectations for drone pilots as well as the people who respond to reports of drone incidents. Yet better rules and laws will mean nothing unless they are enforced.

Local authorities can already respond to some offenses committed by drones by using local laws against unlawful surveillance, trespass, harassment, interfering with emergency services and other crimes. National aviation authorities, however, have not shown a similar commitment to enforcing legal restrictions against drone flights in restricted airspace, above standard altitude limits, or too close to traditional aircraft. While taking action against unsafe drone operators may be a novelty for some regulators, it needs to happen.

Like other technology companies, DJI complies with subpoenas and warrants from law enforcement in cases of potential misuse of drones. We provide such information frequently, but have seen very few reported examples of subsequent enforcement. Even two of the most widely-cited incidents of clearly improper flight have led to no apparent enforcement against the pilots. The NTSB publicly identified the drone pilot responsible for the 2017 helicopter collision over New York harbor,[134] but there is no record of the FAA or prosecutors taking action against him. The next year, video emerged from what appeared to be a racing-type drone intentionally flying over an airliner landing in Las Vegas.[135] The recreational drone community was outraged and, according to our own sources, local pilots identified the suspect as someone known to them. Yet even when the entire drone industry demanded punishment, no enforcement action appears to have been taken.[136]

10 Governments must increase enforcement of laws against unsafe drone operation

Deterring the small minority of drone pilots who intentionally fly unsafely or illegally requires a clear expectation that authorities will find them and punish them. Remote identification systems that are already available can play a key role in identifying drone operators who fly in restricted areas or otherwise violate laws, but if the behavior is not punished, the laws against misusing drones are toothless.

In a few instances, we have observed aviation authorities fail to take action against identifiable pilots who have engaged in clear and prominent misconduct. **Aviation authorities and prosecutors must enforce laws against clearly unsafe drone operation,** in order to punish the small number of drone pilots who deliberately engage in risky behavior, to set an example for the vast majority of drone pilots who follow the law, and to reassure the public they have the tools to keep the skies safe. When authorities do enforce these laws, they must ensure the public is made aware of those actions to provide a credible deterrent.

134 The pilot's name is included in this document in the NTSB docket: dms.ntsb.gov/public/60500-60999/60650/610456.pdf 135 flyingmag.com/faa-investigating-video-drone-flying-dangerously-close-to-airliner 136 thedronegirl.com/2018/02/06/vegas-drone-pilot-frontier/

CONCLUSION
THE RISKS OF DOING NOTHING

The 10 steps listed above are key elements in DJI's vision for how the growing number of drones in the skies can maintain and even improve on their already admirable safety record. Implementing them will require political will, as well as time, money and effort from DJI and other drone manufacturers. Many substantive disagreements over how to regulate drone safety must still be resolved – even as rapid innovation threatens to leapfrog discussions already underway.

But there is no other option. People who care the most about drones must set forward-looking and evidence-based expectations for safe flight, or else policies may be shaped by the uninformed opinions of people who care the least – or by what they fear the most. The chairman of the U.S. House Transportation and Infrastructure Committee recently warned that that one catastrophic incident involving a single drone could ignite a public demand to ground all drones.[137] Sensational news stories, knee-jerk political reactions, and policymaking by anecdote all pose a critical risk to the full flowering of drone technology and the benefits it brings. As others have noted, effective safety measures are based on "credible risks, rather than extraordinary anecdotes that incite fear." [138]

Sensational news stories, knee-jerk political reactions, and policymaking by anecdote all pose a critical risk to the full flowering of drone technology and the benefits it brings.

The drone industry and its regulators must improve the quality of drone incident data available for analysis, before society instead demands action based on the flimsy and unreliable evidence people see in the news. In the aftermath of the Gatwick airport shutdown, for example, 38 percent of U.K. residents polled said they supported a total ban on drones.[139] A 2017 survey in the U.S. found two-thirds of respondents concerned about drones, with more than half of them listing potential interference with airplanes as the reason for their concern. Almost half of respondents would support a municipal ban on drones in their own community.[140]

This is, literally, dangerous. Drones are a net benefit for safety, and slowing their adoption for beneficial purposes would impose a real cost on society. Drones are used to inspect cell towers, power pylons, wind turbines and other elevated structures that previously required workers to climb to perilous heights,[141] which will surely help reduce the unacceptably high death counts for communication tower workers.[142] Public safety agencies and helpful bystanders alike have used drones to rescue hundreds of people from peril around the world, and in many cases have saved the lives of people who would have otherwise perished. Drones create jobs, spur new businesses and provide enjoyment, and they also help nonprofits improve human, animal and environmental health.[143]

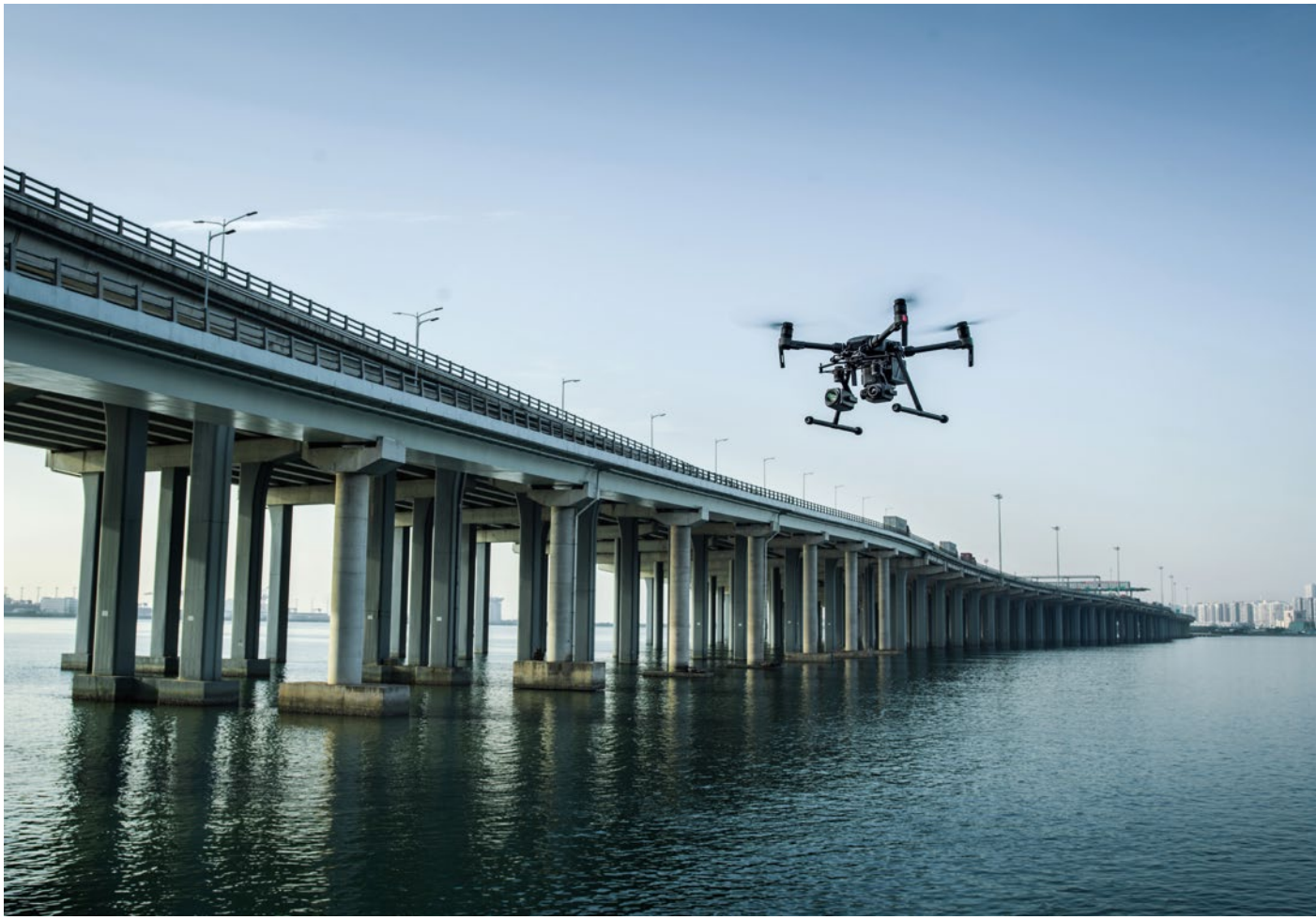
The National Academies of Sciences, Engineering, and Medicine agrees that curtailing drone use would hurt safety overall by depriving society of those benefits. "[W]hen discussing the risk of introducing drones into the National Airspace System, it is necessary to consider the increase in risk to people in manned aircraft and on the ground, as well as the various ways in which this new technology may reduce risk and save lives," a National Academies committee reported last year.[144] It recommended more detailed and holistic studies of risk to accelerate the safe adoption of drone technology, and also noted the FAA's conservative approach to rulemaking. DJI believes the regulations in place have already done an excellent job of managing risks, and together with the safety enhancements and other initiatives identified here, will create a balanced approach to safety and security.

137 reuters.com/article/us-usa-drones/u-s-must-prevent-air-accidents-involving-drones-lawmaker-warns-idUSKCN1PX2AV 138 thehill.com/opinion/technology/375600-lets-not-ground-drones-because-of-a-few-close-calls 139 parliamentstreet.org/wp-content/uploads/2019/01/Drones-4-U-FINAL.pdf 140 polls.saintleo.edu/saint-leo-university-poll-shows-fascination-with-drones-continues/ 141 blog.dronedeploy.com/increasing-jobsite-safety-with-drones-30139b7aa8ce 142 osha.gov/doc/topics/communicationtower/index.html 143 modernhealthcare.com/article/20180609/NEWS/306099951 144 nap.edu/read/25143/chapter/2, p. 1

Forward-thinking regulators understand the challenge ahead. “Opinions about drones are still being formed. That’s in our favor. And we can make the most of that opportunity by being responsive,” Daniel Elwell, the FAA Acting Administrator, said last year.[145] In the past, reports of unsafe drone activity have spurred more sightings and fears, creating a self-reinforcing negative cycle regardless of what really happened. Going forward, improved standards, technology and measurement for drone safety can finally focus attention on identifying events that truly occurred and learning from them.

With the safety vision outlined in this research paper, DJI calls on everyone concerned with safe integration of drones in the airspace to make the most of this opportunity. Regulators and elected officials must develop rigorous standards for tracking real drone incidents and debunking false ones. Manufacturers must improve their voluntary technology and educational efforts. DJI commits to undertake substantive work to make its robust drone safety systems even stronger.

Taking these actions will not be easy.
Ignoring them would be worse.



145 https://www.faa.gov/news/speeches/news_story.cfm?newsId=23095

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dji.com/flysafe