COMMITTEE ON AERONAUTICS NEWSLETTER

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IN THIS ISSUE:

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We are very pleased to present this thirteenth issue of our Committee's newsletter. It is the first newsletter during Racquel and Sarah's term as Co-Chairs. This newsletter would not be possible without the amazing contributions of all our members, each of whom gets our utmost thanks from the bottom of our hearts. We especially want to thank Alan D. Reitzfeld, former chair of the Committee, for all that he has done to build and grow this Committee.

The prior issues are posted (by year) on the Committee's section of the New York City Bar's public website (click on the "News & Media" button): http://www.nycbar.org/member-and-career-services/committees/aeronautics-committee. We hope that our Committee Members and Alumni (and other readers accessing this Newsletter on the Bar's website) continue to find each issue very interesting.

Our Committee focuses on a wide variety of aerospace issues, including topics covered in our 19 subcommittees (see p. 3). The Committee usually meets monthly from September through June, with guest speakers on legal and/or technical aerospace issues. It is a vibrant group, and membership has grown substantially over the last few years.

Due to the COVID-19 pandemic and quarantine, our Committee's meeting has been held via video conference, and shall continue to be held via video conference for the foreseeable future.

Please stay tuned for more information about activities of the Committee on Aeronautics.

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[1] Racquel Reinstein is an attorney working for the Port Authority of New York and New Jersey. She also is mom to an adorable toddler named Zoe and newborn named Devorah, and enjoys reading about aviation regulations in her spare time.

[2] Sarah Passeri is a partner in Holland & Knight LLP's Litigation Practice Group. Ms. Passeri's practice focuses on aviation and complex litigation matters, as well as asset-based financing, leasing, acquisitions, sales and securitizations, with a particular emphasis on aviation and equipment finance. She has experience flying single-engine aircraft.

SUBCOMMITTEE LIST

SUBCOMMITTEE	CHAIR
Airline Business Subcommittee	Gene K. Kaskiw
Airport Travel, Safety and Funding Issues	Yuliya Khaldarova
Aviation and Government Contracting	Ian Massar
Aviation Finance Subcommittee	Michael P. Peck
Aviation Insurance Subcommittee	Sophia L. Cahill
Aviation-Related Intellectual Property Subcommittee	Jeff Tsai
Canadian Comparative Air Law Subcommittee	Jeffrey Derman
Commercial Airline Casualty Subcommittee	Erin Applebaum
Corporate/Private Jet Charter Subcommittee	Susan Sullivan Bisceglia
Cybersecurity and Aviation Subcommittee	Rebecca Tingey
Drone/UAS Regulation & Licensing Subcommittee	Michael Davies
Federal Preemption Subcommittee	Philip Weissman
Fuel Subcommittee	Patrick Ryan Morris
General Aviation Subcommittee	Albert J. Pucciarelli
International Aviation Treaties Subcommittee	Christopher B. Kende
Subcommittee on Commercial Space Flight	Austin C. Murnane
Subcommittee on ICAO Developments	Maria C. Iannini
Subcommittee on Rotary-Wing Aviation	Jonathan Callaway
Technical Advances in Aviation Subcommittee	Jenny A. Urban

COMMITTEE NEWS

Michael Peck recently completed an L.L.M. degree in Air and Space Law at McGill University's Institute of Air & Space Law in Montréal, Québec.

Alan Reitzfeld, who recently completed his four-year term as this Committee's Chair, completed his two-year term as Chair of the Aviation Law Committee of the International Bar Association ("IBA") in December 2020. Alan was recently appointed by the IBA to the officer position of Aviation Law Committee Immediate Past Chair for 2021.

Jennifer Ann Urban accepted an Adjunct Professor role at Eastern New Mexico University. Beginning in January 2021, she will be teaching the Aviation Law course for undergraduate students. In addition, she was recently appointed by the IBA as the Aviation Law Committee's Corporate Counsel Forum Liaison Officer for 2021-2022.

ARTICLES

FAA Announces New Drone Rules Requiring Remote Identification and Facilitating Operations at Night and Over People

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On December 28, 2020 the FAA announced long awaited rules furthering the integration of drones into the national airspace system. The new rules will require nearly all drones to be equipped with Remote Identification ("Remote ID") and will allow small drone operators to fly over people and at night under certain conditions, operations that are currently prohibited without a rule waiver.

The Remote ID requirement has long been sought by law enforcement and public safety officials. It will require that all drones subject to FAA registration be equipped to broadcast identification and location information (except in FAA-recognized "identification areas"). Drone manufacturers will have 18 months in which to begin manufacturing drones with Remote ID, and operators will have an additional year before having to comply with the rule.

The new rule on operations over people and at night applies to Part 107 operators and eliminates the need to obtain individual Part 107 waivers for such operations from the FAA. The new rule allows for operations over people (and motor vehicles) depending on the potential danger of injury posed to human beings by a particular class of drones. Night operations will be allowed by remote pilots who complete updated training and operating drones equipped with anti-collision lights. The FAA executive summary explaining the new rule can be found here: https://www.faa.gov/news/press_releases/news_story.cfm?newsId=25541

Both rules become effective 60 days after publication in the Federal Register.

[1] Michael Davies is of counsel at Dunning Rievman LLP.

A Claim Without A Crash: Aviation-Related Injuries On & Off the Ground


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When discussing aviation incidents and accidents, people often focus on crashes, but for every crash-related injury or fatality, numerous claims, injuries or alleged injuries occur in

[1] Dr. Adam Dershowitz is a managing engineer in Exponent's thermal practice where he specializes in aeronautical and astronautical engineering. He has expertise in aircraft and spacecraft systems and instrumentation, including unmanned systems (UAVs). Dr. Dershowitz consults on the interactions of complex systems, including human in the loop systems; airplane and helicopter icing; manned and unmanned space vehicles; cockpit displays; control of vehicles; decision making; safety critical software; software failures; software operation; IP matters; large databases and vehicle and structure fire cause and origin. He models and analyzes ground and flight vehicles, systems, and their accidents, and analyzes and presents high dimensionality and complex data.
Prior to joining Exponent, Dr. Dershowitz worked at Johnson Space Center for United Space Alliance. There, he worked in NASA's Mission Control Center on the motion control system of the International Space Station, designed and researched advanced technology solutions for Mission Control, and served as a member of the orbital debris analysis team for the Shuttle Columbia accident investigation. Dr. Dershowitz has significant teaching experience, both in the classroom and as a Certified Flight Instructor, in single and multiengine aircraft, and instruments.

Dr. Bruce Miller is a Managing engineer in Exponent's biomechanics practice and Dr. C. Dennis Moore is a Principal Engineer in Exponent's thermal practice.

seemingly minor or benign settings. While Exponent has extensive experience evaluating catastrophic accidents from multiple perspectives, we have also extended the application of multidisciplinary analyses to claims associated with much more common aviation and aviation-associated events. These include claims of injury from turbulence or landing, slips on stairs or jetways, falling objects from overhead bins, UAV ("Drone") operations, property damage and loss-of-use claims, breach of contract, and more. By leveraging our expertise in aeronautics, aircraft maintenance, and biomechanics, among other disciplines, we can evaluate both the causes of such events and the potential for injury to involved individuals.

In a recent webinar, we discussed several types of non-crash aviation investigations that we have conducted and addressed how the multidisciplinary analyses conducted provided a nuanced lens for evaluating and litigating claims in non-catastrophic aviation incidents. While far from comprehensive, these examples were chosen to demonstrate a range of claims, and how a multi-disciplinary approach is beneficial to help understand what occurred. Each of these case studies is summarized below.

Case study #1

A low-speed B-747 on-ground incident occurred at JFK International Airport, and we were retained to investigate the incident. The airplane landed at night, and then received and complied with taxi instructions from the control tower. There was ongoing construction at the airport, and a construction truck was parked in the object-free area of the opened taxiway. Security personnel saw the truck but did not report it. The pilots of the aircraft did not see the parked truck. The truck operator saw the airplane. He reported that he thought that the wing would pass over his truck and thus took no action. The number 4 engine contacted the truck, and damage occurred to the truck and the aircraft engine.

We used a multidisciplinary approach to analyze the incident. The team included personnel with expertise in human vision and perception, FAA regulations and guidance material on airport design and construction, and accident reconstruction. An inspection at night demonstrated the difficulty of seeing unlit objects at the scene, as well as how opposing experts' used computer simulation inappropriately. It was determined that the lack of training, compliance with regulations, and lack of construction safety planning were causative of the incident.

Case study #2

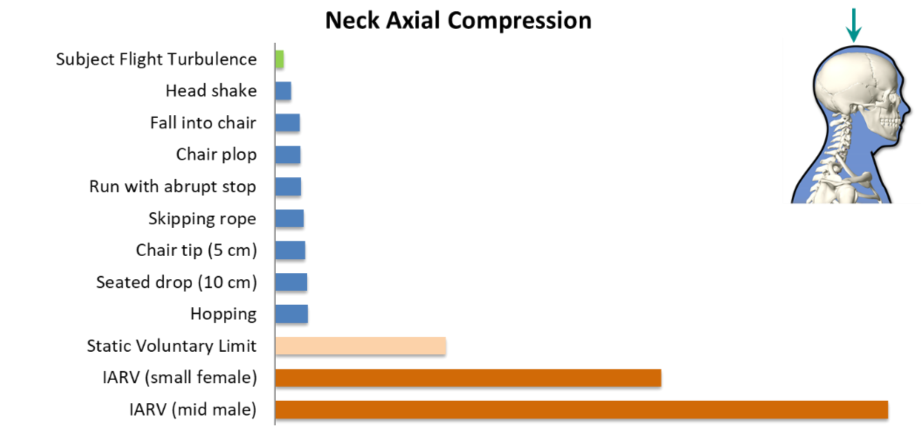
A "quick change" combi conversion of a Boeing B-737 to allow mixed passenger/cargo operations with a 20 minute changeover between passenger and cargo operations was experiencing in-service structural issues. A team was put together using personnel with expertise in FAA regulations, structural design, fatigue analysis, and aircraft maintenance. We analyzed the contractual design requirements and the engineering and fatigue analysis performed, and compared the in-service history of the aircraft with expected history from un-converted 737s, including maintenance requirements. Significant flaws in the design were identified.

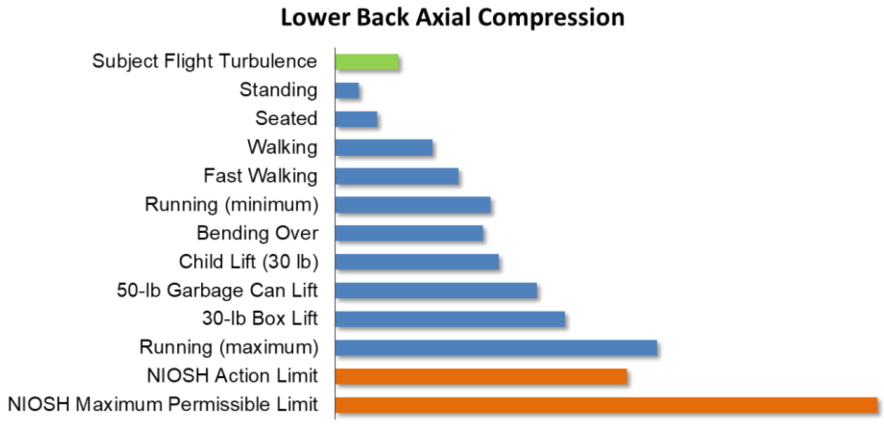
Case study #3

About 150 hours after an overhaul on an IO-550C engine installed on a Beech Baron, the owner/pilot experienced low oil pressure on the left engine during run up. Investigation by local maintenance personnel revealed that a piece of a bolt had lodged under the oil pressure relief valve, holding it open. We put together a team with expertise in metallurgy, FAA regulations, and aircraft maintenance. The investigation indicated that the overhaul shop had not properly torqued the crankshaft bolts, and thus they had begun to fail. The investigation also revealed that many of the aftermarket bearings installed by the overhaul shop, although eligible through FAA-PMA approval on other engines in the IO-550 and IO-520 series, were not FAA approved, and thus not eligible, for the IO-550C. This required that both engines be torn down and the bearings replaced, even though no failure had been observed on the right engine.

Case study #4

During a transatlantic flight from Trinidad and Tobago to New York, a B737-800 encountered turbulence, resulting in low-magnitude accelerations on the aircraft. Following the turbulence, a passenger complained of neck and back pain and claimed that the turbulence event was the source and should have been avoided by the pilot. We were retained to evaluate the overall aircraft dynamics as well as the passenger's injury complaints and injury potential as they related to the turbulence. A multidisciplinary team with expertise in the areas of flight dynamics, pilot operation, and injury biomechanics was utilized to analyze this incident.





Review of the aircraft's digital flight data recorder provided data for comparison to the flight envelope and standard flight loads and for use in assessing the biomechanical loads on the passenger's spine. Evaluation of the aircraft dynamics established that the turbulence encounter was comparable to in-flight accelerations and variations in altitude and attitude regularly encountered during commercial aircraft operation and did not constitute an upset or extreme turbulence event. Analysis of the passenger's injury complaints and the biomechanical loads during the incident found the lack of an acute mechanism for her complaints and determined that the loading during the turbulence would have been less than she would have sustained while boarding the aircraft, stowing her luggage, and taking her seat.

Conclusion

In conclusion, claims, injuries and injury complaints can arise from many types of aircraft operations or in many aviation-associated environments beyond the commonly discussed catastrophic crashes. A hybrid analysis involving different engineering disciplines, including an understanding of aviation, can lead to an understanding of these incidents, including how an incident occurred and the potential risks to exposed individuals. An understanding of potential aviation risks can lead to mitigation of potential hazards and prevention of future incidents and injuries.

This article is based on a webinar that we recently presented. The webinar, with additional detail, is available online at:

https://register.gotowebinar.com/recording/6486766071068483334

Drone Delivery Presents Opportunities to Restaurants During the COVID-19 Pandemic and Beyond

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The ongoing COVID-19 Pandemic and government orders limiting or restricting dine-in restaurant services have forced many restaurants to depend on delivery operations in order to remain economically viable. For restaurants seeking to expand delivery operations without significantly increasing labor costs or their dependency on third party delivery services, drone delivery may emerge as an attractive option. Drone delivery has the potential to revolutionize their business model both during and beyond the COVID-19 Pandemic.

In recent years and months, various restaurants have begun to develop their own drone delivery services and the ongoing COVID-19 Pandemic has significantly increased interest in drone delivery.[2] In 2016, Domino's began conducting experimental drone pizza deliveries in New Zealand using autonomous drones and announced an ambitious goal of ultimately making all of its pizza deliveries by drone.[3] UberEats revealed plans to begin making food deliveries by drone in October of 2019.[4] In August of 2020, a Mobile, Alabama based Buffalo Wild Wings franchisee partnered with Deuce Drone to demonstrate drone food delivery and announced plans to begin delivering orders by drone later in 2020.[5]

In order to deliver packages such as those containing food beyond their drone operators' lines of sight, restaurants must receive an Air Carrier Certificate from the Federal Aviation Administration (FAA) pursuant to Federal Aviation Regulations found at 14 CFR Part 135. In

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[2] Curtis Silver, "The Time for Delivery Drones to Rise Up is Now," Forbes (April 14, 2020) https://www.forbes.com/sites/curtissilver/2020/04/14/the-time-for-delivery-drones-to-rise-up-is-now/#51ebd8bb382a (All links in this newsletter last accessed on March 18, 2021).

[3] Stephen Feller, "Domino's Tests Drone Delivery of Pizza in New Zealand," UPI (November 17, 2016) https://www.upi.com/Business_News/2016/11/17/Dominos-tests-drone-delivery-of-pizza-in-New-Zealand/4271479363638/.

[4] Alex Davies, "Uber Eats Hopes Drones Can Lift it to Profitability," Wired (October 28, 2019) https://www.wired.com/story/uber-eats-drones-lift-profitability/.

[5] Tyler Fingert, "Drone Delivery Closer to Reality in Mobile After Demonstration; First Order to be Sent in October," Fox 10 News (August 13, 2020) https://www.fox10tv.com/news/mobile_county/drone-delivery-closer-to-reality-in-mobile-after-demonstration-first-order-to-be-sent-in/article_ee1f3208-ddb1-11ea-8f76-f7562a380915.html accessed.

order to receive such a certificate, the applicant must have a physical location and drone access; drone liability insurance; and have a President, 2/3 of the Board of Directors, and individuals controlling 75% or more of its interest who are U.S. citizens.[6] Moreover, restaurants' drone operators will be required to obtain remote pilot certificates and their drones must be registered with the FAA and marked with their assigned FAA registration numbers.[7]

The federal Drone Operator Safety Act, which was introduced by Sen. Sheldon Whitehouse (D-RI) and Rep. Jim Langevin (D-RI) and enacted as part of the bipartisan FAA Reauthorization Act of 2018, criminalizes drone operations in airport runway exclusion zones. Consequently, restaurants likely cannot offer drone delivery to locations near airports and restaurants located near airports likely cannot offer drone delivery.[8]

Restaurants seeking to offer drone delivery may be able to argue that any state or local laws, ordinances and regulations governing drone operation, noise, and safety are federally preempted and unenforceable. The U.S. District Court for the District of Massachusetts upheld the concept of preemption when it decided that a municipal ordinance requiring drone registration and prohibiting drone operation outside operators' lines of sight, flights below certain altitude over private property absent express permission of property owners, and flights over public property were federally preempted.[9] However, it is possible that municipal land use and zoning ordinances and regulations restricting and limiting drone take offs and landings in certain zones may be enforceable and not affected by federal preemption, since numerous courts have held that such ordinances and regulations prohibiting or limiting the size of airports, airstrips, or heliports in certain zones are enforceable and are not federally preempted.[10] While courts have yet to address this issue with regard to drones, it is possible that restaurants seeking to engage in drone delivery could be subject to municipal land use and zoning law. As a result, operators may even be required to obtain use variances for drone delivery operations if they are located in districts not zoned for aircraft takeoffs and landings and drone takeoffs and landings are not determined to be permissible accessory uses to restaurants.

Commercial drone operators, such as restaurants, that are not using drones for First Amendment protected activities such as newsgathering, must comply with the provisions of the FAA Reauthorization Act of 2018 governing the privacy practices of commercial drone operators. The law states that it is the sense of Congress that commercial drone operators should develop and implement publicly available privacy policies governing the collection, use,

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[6] 14 C.F.R. Part 135.
[7] 14 C.F.R. Part 107.
[8] 18 U.S.C. § 39B
[9] See, Singer v. City of Newton, 284 F.Supp.3d 125 (D. Mass. 2017).
[10] See, e.g. Hoagland v. Town of Clear Lake Indiana, 344 F. Supp.2d 1150 (N.D. Ind. 2004), aff'd 415 F.3d 693 (7th Cir. 2005), cert. denied, 547 U.S. 1004 (2006) ((citing Condor Corp. v. City of St. Paul, 912 F.2d 215, 219 (8th Cir. 1990); Broadbent v. Allison, 155 F.Supp.2d 520, 524 (W.D.N.C. 2001); City of Cleveland v. City of Brook Park, Ohio, 893 F.Supp. 742 (N.D. Oh. 1995); Faux-Burhans v. County Comm'rs of Frederic County, 674 F.Supp. 1172, 1173-1174 (D. Md. 1987), aff'd, 859 F.2d 149 (4th Cir. 1988); People ex. rel. Birkett v. City of Chicago, 329 Ill.App.3d 477 (Ill. Ct. App. 2nd Dist. 2002); Tanis v. Township of Hampton, 306 N.J. Super. 588 (N.J. 1997); In re Commercial Airfield, 170 Vt. 595 (Vt. 2000); Garden State Farms, Inc. v. Bay, 77 N.J. 439 (N.J. 1978)); Riggs v. Burson, 941 S.W.2d 44 (Tenn. 1997); Guillot v. Brooks, 651 So.2d 345 (La. Ct. App. 2nd Cir. 1995); Wright v. City of Winnebago, 73 Ill.App.3d 337 (Ill. Ct. App. 2nd Dist. 1979); Skydive Oregon v. Clackamas County, 857 P.2d 879, 882 (Or. App. 1993); Gustafson v. City of Lake Angelus, 76 F.3d 778, 787 (6th Cir. 1996).

retention, and deletion of data collected by its drones that protects and respects individual privacy consistent with federal, state, and local law.[11] Violations of such privacy policies constitute unfair trade practices subject to Federal Trade Commission (FTC) enforcement.[12] The FTC is currently taking the position that the Act "only does not require such persons to have privacy policies, though it states that the 'sense of Congress' is that such persons should have" such privacy policies. However, federal courts have yet to address whether the Act requires or simply recommends the adoption of such privacy policies and it remains to be seen whether the FTC will continue to take its current position.[13]

A restaurants' drone use could potentially be subject to the rapidly expanding patchwork of state information privacy and security laws since courts have yet to address whether such laws are federally preempted as applied to drones. However, courts have held that state information privacy statute are preempted as applied to airlines by the Airline Deregulation Act of 1978.[14]

On February 20, 2020, California Assemblyman Edwin Chau (D) introduced Assembly Bill 2787. The bill, which is currently pending before the California Assembly Privacy and Consumer Protection Committee would provide that drones used to deliver consumer products including food in California may only collect, use or retain audio, geolocation or visual information when reasonably necessary and proportionate to achieve the delivery purposes for which such information was collected or processed.[15] The legislation would also require that all such information be destroyed as soon as the delivery is completed unless federal law requires that it be retained.[16]

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[11] P.L. 115-254 § 357, § 375, § 378 (2018); https://www.ftc.gov/enforcement/statutes/faa-reauthorization-act-2018
[12] P.L. 115-254 § 375 (2018).
[13] https://www.ftc.gov/enforcement/statutes/faa-reauthorization-act-2018
[14] People ex. rel. Harris v. Delta Air Lines, Inc., 247 Cal.App.4th 844 (Cal. Ct. App. 1st Dist. 2016).
[15] California A.B. 2787 (2020), available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB2787
[16] Id.

ARTICLES

How the Apollo 13 Investigation Helped Make Moon Golf a Reality

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Chair, Subcommittee on
Commercial Space Flight

February 2021 saw the fiftieth anniversary of the Apollo 14 mission, the third landing of a crewed spacecraft on the surface of the Moon. When Apollo 14's lunar module touched down in the hilly Fra Mauro highlands on February 5, 1971, it must have been especially poignant for mission commander Alan Shepard.[2] Shepard, who had made history back in 1961 as the first American to fly in space, later found himself grounded by Ménière's disease and other ailments. Apollo 14 marked his return to spaceflight after almost ten years, at the age of forty-seven. When he finally climbed down the ladder and set his feet on the lunar regolith, Shepard radioed, "And it's been a long way, but we're here."[3]

Of course, the Apollo 14 mission accomplished more than simply giving America's first astronaut a chance to land on the Moon. The mission also deployed a variety of scientific experiments and collected surface samples that are still analyzed today. Despite its contributions to science and engineering, the mission may be best known for the moment when Shepard decided to have a little fun with some personal items he had brought on the flight: the head of a six-iron golf club, which he attached to a sample collection rod to form a makeshift club, and two golf balls. After adjusting his swing to account for his bulky space suit, Shepard struck a golf ball and sent it flying for what he described as "miles and miles and miles."[4]

Apollo 14, like the other missions to the Moon, was a collaborative effort involving hundreds of thousands of Americans working in the U.S. Government and contractors throughout the country. Unlike other missions, Apollo 14 also depended upon the work of an ad-hoc review board, which NASA formed less than ten months earlier to investigate an explosion during the Apollo 13 mission. The Apollo 13 anomaly was an unprecedented disaster that required extraordinary efforts from the flight crew led by mission commander Jim Lovell,[5] flight

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[1] U.S. Naval Academy Class of 2006. An associate in the Aerospace, Defense & Government Services industry group of Latham & Watkins, Mr. Murnane represents clients in the aerospace industry and other fields. He publishes and presents work on commercial spaceflight law in various aerospace fora. He was recently selected to author the chapter on legal issues in a forthcoming Springer Handbook on Space Resources. Any opinions contained herein are the author's own.

[2] U.S. Naval Academy Class of 1945.

[3] Eric M. Jones, "Down the Ladder for EVA-1," *Apollo 14 Lunar Surface Journal*, NASA (Apr. 2, 2017) available at www.hq.nasa.gov/alsj/a14/a14-prelim1.html.

[4] "Alan Shepard Hits A Golf Ball on the Moon," NASA available at www.youtube.com/watch?v=t_jYOubJmfM.

[5] U.S. Naval Academy Class of 1952.

controllers in Houston, and contractors across the country to save the spacecraft. Apollo 13 was "successful failure" to the extent that the crew was saved, but such a situation could not be allowed to recur. If the review board's investigation did not identify the causes of the Apollo 13 anomaly and enable NASA to ascertain that the problems had been corrected, Apollo 14 would not have been able to fly.

The importance that NASA placed on the Apollo 13 investigation was evident from its inception. Within hours if not minutes of the safe splashdown of the Apollo 13 command module in the Pacific Ocean, NASA Administrator Thomas Paine signed a memorandum establishing the Apollo 13 review board, with Edgar M. Cortright, Director of NASA's Langley Research Center, as chairman.[6] Within two business days, the review board's members had been assigned, including high-ranking officials from various NASA centers as well as Astronaut Neil Armstrong, who had achieved humanity's first landing on the Moon only nine months earlier.[7] The Aerospace Safety Advisory Panel, a federal advisory committee established by Congress in the wake of the launchpad fire that had killed the Apollo 1 crew, was assigned to oversee the review board's work before the board's members were even assigned.[8]

The review board convened on the evening of the same day its members were assigned at the Johnson Manned Spaceflight Center ("MSC") in Houston, Texas. MSC staff had already begun their own investigation into the Apollo 13 anomaly, and the staff provided data they had already collected to the review board, some of whose members were able to participate in a formal debriefing with the Apollo 13 astronauts, who had just returned to Houston from the Pacific. By the next day, the review board's members were already considering initial hypotheses of the explosion's cause along with the MSC staff.[9]

Over the next few days, the review board looked over data collected by MSC staff and relied on analysis from a number of subject matter experts. Although the Apollo 13 service module, where the explosion had occurred, was discarded in space prior to landing, board members reviewed inspection results from the command module, which had been hoisted out of the ocean and returned to its principal contractor, North American Rockwell in Downey, California. During this first week, the board was already focusing on the oxygen tanks in the service module, which was logical because the astronauts had observed evidence of an explosion in or around those tanks during the spaceflight.[10]

Over the next three weeks, the review board conducted a number of experiments to test its theories regarding the causes of the explosion in the service module. Given the largely unique nature of spaceflight operations, these experiments relied on the advanced facilities and resources available to NASA. MSC astronauts used simulation equipment in Houston to assist

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[6] Memorandum from Thomas O. Paine & George M. Low on Establishment of Apollo 13 Review Board to Edgar M. Cortright (Apr. 17, 1970).
[7] Memorandum from Thomas O Paine & George M. Low on Membership of Apollo 13 Review Board to Edgar M. Cortright (Apr. 21, 1970).
[8] Memorandum from Thomas O. Paine & George M. Low on Review of Procedures and Findings of Apollo 13 Review Board to Dr. Charles D. Harrington, Chairman, Aerospace Safety Advisory Panel (Apr. 20, 1970).
[9] Report of the Apollo 13 Review Board (NASA 1970) ("Review Board Report") 2-27 to 2-28. (N.B.: The Review Board Report is paginated in the format "Chapter #"-"Page #," such that "2-27" is the twenty-seventh page of the second chapter.)
[10] Review Board Report 2-29.

the board in its attempts to recreate the effects of the anomaly on the spacecraft. NASA's Ames Research Center in California conducted laboratory experiments to simulate the initiation and propagation of a fire within a cryogenic oxygen tank during spaceflight. The Langley Research Center in Virginia attempted to recreate the circumstances in which an explosion could eject a panel from the service module and send it flying off into space.[11]

By May 14, members of the review board's various specialty panels had drafted and circulated the first drafts of the report on the accident. The board would continue to meet and work on revisions and updates to the report for the next few weeks, but the crux of its work was already done. On June 15, less than two months after Apollo 13 astronauts Jim Lovell, Jack Swigert, and Fred Haise were recovered from their command module in the Pacific Ocean, the review board presented its findings to the NASA Administrator.[12]

The review board identified two serious issues in the manufacture and pre-launch preparations of the Apollo 13 service module and one of its oxygen tanks. The oxygen tank had been previously installed on an earlier service module, #106, which was ultimately used in the Apollo 10 mission that orbited the Moon in 1969.[13] However, prior to the Apollo 10 flight, North American Rockwell removed this particular oxygen tank from service module #106 in order to modify it in accordance with a mandated design change. The oxygen tank was thus replaced and held in reserve for later installation in Apollo 13's. However, an accident occurred during this replacement process. A bolt snapped while employees at North American Rockwell were hoisting the oxygen tank out of service module #106 with a crane, causing the oxygen tank to fall two inches and land back on its housing shelf. The review board found that there was a possibility that this incident had damaged the oxygen tank in such a way as to lead to the explosion during the later flight. However, the board determined the probability to be "rather low" that this drop of the tank caused the later explosion.[14]

Instead, the review board placed a higher probability for the cause of the explosion on a thermostatic switch that had been installed in the oxygen tank by its manufacturer, Beech Aircraft Corporation. The thermostatic switch was designed to protect equipment within the oxygen tank from overheating during "detanking," a process by which ground crews increased temperatures within oxygen tanks in order to empty them of their contents before refilling them. During this detanking process, it was essential that the interior of the oxygen tank not get too hot, otherwise various material within the oxygen tank, like the insulation around wires, could melt. Therefore, it was the function of the thermostatic switch to open the heater circuit and stop the heating process once the temperature exceeded eighty degrees Fahrenheit.

Unfortunately, the thermostatic switch installed in this particular oxygen tank was only rated to withstand a twenty-eight-volt power supply. This was a problem because the power supply used during the detanking process was sixty-five volts. Therefore, the review board concluded that when ground crews used sixty-five-volt power to detank the service module's oxygen prior to Apollo 13's flight, the overwhelmed thermostatic switch fused shut, failing to open the circuit

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[11] *Id.* 2-34 to 2-35.
[12] *Id.* 2-43.
[13] *Apollo 10*, NASA available at https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1969-043A.
[14] Review Board Report 4-19 to 4-21.

when the temperature exceeded eighty degrees, and thus allowing the insulation protecting the wires within the oxygen tank to suffer extreme heat that weakened its structural integrity.[15]

Weeks later, during the Apollo 13 flight, command module pilot Jack Swigert received a routine instruction from Mission Control to "stir" the cryogenic tanks in the service module. When Swigert activated a fan inside the oxygen tank, electrical current flowed through the wires powering the fan as it had many times before. This time, due to its weakened state, the insulation wrapped around one of the wires finally melted away, allowing electrical current to arc from the exposed wire to some other surface and ignite the pure oxygen within the tank. The fire rapidly grew, culminating in an explosion that blasted the tank open.[16]

The review board's identification of the probable cause of the Apollo 13 anomaly allowed NASA, North American Rockwell, and Beech Aircraft to address the problems with the Apollo program's service modules and provide the reassurance needed for the safe flight of Apollo 14. The June release of the report allowed NASA to announce on June 30 that the Apollo 14 mission, which had been scheduled to launch in either October or November 1970 prior to the Apollo 13 anomaly, would be only briefly delayed, and now be able to launch no earlier than January 31, 1971.[17]

That "no-earlier-than" date proved to be a conservative prediction. On that very day seven months later, Alan Shepard, Stuart Roosa, and Edgar Mitchell lifted off from Kennedy Space Center aboard a new and improved command and service module, with a six-iron head and two golf balls safely stowed aboard.

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[15] *Id.* 4-23.
[16] *Id.* 4-27 to 4-28, 4.37.
[17] NASA, New Release Log (1970) available at www.nasa.gov/centers/johnson/pdf/83122main_1970.pdf.

Laying Waste to the Sky: The Problem of Orbital Debris

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During the last 50 years, a catalogued piece of manmade orbital debris[2] has survived re-entry and hit the Earth' surface on an average of once each day.[3] One-a-day for 50 years -- does that mean Chicken Little[4] was right? Is the sky really falling? Are we doomed? Well, probably not. Since most of the planet is either ocean or sparsely inhabited land (such as tundra or desert), the falling debris poses little risk to us. There is, to my knowledge, only one recorded instance of a piece of space junk hitting a human being – Lottie Williams of Tulsa, Oklahoma was hit by a six-inch piece of a rocket body in 1997.[5] Fortunately, Ms. Williams was not seriously injured. There was an earlier incident in 1969 when a Japanese ship was hit by Soviet-made space debris and five Japanese seamen were injured[6], but it is not clear whether the men were directly hit or injured by collateral damage. Nevertheless, if it could happen to one person it could happen to any of us. So perhaps it's high time we did something about it. The rules to follow are those that we use in our own homes: don't make a mess, tell others if you do and clean-up after yourself.

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[2] NASA defined orbital debris as "all man-made objects in orbit about the Earth which no longer serve a useful purpose". See, NASA Orbital Debris Program Office, https://www.nasa.gov/news/debris_faq.html.

[3] National Aeronautics and Space Administration, "Orbital Debris Program Office Frequently Asked Questions #8" (n.d.), online: *ARES Orbital Debris Program Office* https://www.nasa.gov/news/debris_faq.html.

[4] Chicken Little, or Henny Penny, was a character from a children's fable who, after being hit on the head by an acorn, believed the sky was falling. See, Mari Ness, "The Sky is Falling! Maybe! 'Henny Penny' or 'Chicken Little'" (5 May 2016), online: *TOR.com* https://www.tor.com/2016/05/05/the-sky-is-falling-maybe-henny-penny-or-chicken-little/.

[5] Julie Bisbee, "Tulsa woman's a one hit wonder", *The Oklahoman* (21 February 2008), online: https://oklahoman.com/article/3207005/tulsa-womans-a-one-hit-wonder.

[6] Thomas J. Hamilton, "Soviet Space Debris Hits Japanese Ship, Injuring 5", *The New York Times* (July 5, 1969), online: https://timesmachine.nytimes.com/timesmachine/1969/07/05/78385523.pdf?pdf_redirect=true&ip=0.

The best way to understand the space junk problem is to reflect on two generally accepted propositions with respect to outer space: (i) "*Space is big. You just won't believe how vastly, hugely, mind-bogglingly big it is.*"[7] and (ii) "*The exploration and use of outer space . . . shall be the province of all mankind.*"[8] So on its face there shouldn't be any problem, right? I mean if space is that big (infinite, in fact), it should be able to hold a tremendous amount of space debris; and if it belongs to all people, then we should all be equally concerned about keeping it relatively free of dangerous items. Alas – it doesn't work that way. Here's why.

The Space We Want Is Not All That Big

Space may be vast, but the area most used, and most cluttered, is that immediately surrounding our planet. First, a few facts (and I apologize in advance for telling you what you probably already know). The international consensus is that space starts at 100 km (about 62 miles) above the Earth's surface (Karman Line).[9] Below about 250 km, the atmospheric drag (yes, there is some atmosphere at that altitude) causes a lot of debris to eventually fall to Earth. Fortunately, much of that burns up in the process. Most crewed space missions take place at about 400 km. And then there are the orbital levels of satellites – most of which are in low earth orbit (LEO) at about 2,000 km, such as the recently developed Starlink satellite constellations launched by Elon Musk's SpaceX that can include hundreds of small communication and internet satellites in a single launch.[10] There are also middle Earth orbits (MEO), the most common of which is 22,200 km and used for navigation satellites like the Global Positioning System of the U.S., Russia's Glonass and the E.U.'s Galileo. Finally there are geosynchronous orbits (GSO), the sweet spot being 35,786 km at the equator (to ensure that the satellite constantly hovers over a single location on the planet). LEO contains about 55% of all satellites and GSO is home to another 35%.[11] All of these satellites are moving in three-dimensional space, and the Earth's gravity causes those in the lowest orbits to move the fastest.[12]

So it can obviously get quite crowded at the lower orbits and there have been notable incidents that created large amounts of space debris. The problem with the destruction of an existing satellite in orbit, aside from eliminating a very expensive device and depriving its users of the service such satellite provided, is that it increases the amount of uncontrollable space

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[7] Douglas Adams, "*The Hitchhiker's Guide to the Galaxy*" (London: Pan Books, 1979).

[8] The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies, of 27 January 1967 (*610 U.N.T.S. 205)* (Outer Space Treaty).

[9] That consensus seems to be eroding. See, Fédération Aéronautique Internationale
"Statement About the Karman Lone" (November 30, 2018), online: *Fédération Aéronautique Internationale* https://www.fai.org/news/statement-about-karman-line.

[10] Jon Brodkin, "SpaceX and Oneweb broadband satellites raise fears about space debris" (October 4, 2017), online: *Ars Technica* https://arstechnica.com/information-technology/2017/10/spacex-and-oneweb-broadband-satellites-raise-fears-about-space-debris/.

[11] Thomas G. Roberts, "Popular Orbits 101", *Center for Strategic and International Studies, Aerospace Security* (October 26, 2020), online: https://aerospace.csis.org/aerospace101/popular-orbits-101/. The Union of Concerned Scientists determined that, as of July 2020, there are 2,787 operational satellites, 2,032 of which are in LEO and 560 in GEO. Union of Concerned Scientists, " UCS Satellite Database" (August 1, 2020), online: *Union of Concerned Scientists* https://www.ucsusa.org/resources/satellite-database.

[12] Dinesh Manandhar (Center for Spatial Information Science, University of Tokyo), "Introduction to Satellite Orbits" (January 26, 2018), online: *United Nations Office for Outer Space Affairs (UNOOSA)* https://www.unoosa.org/documents/pdf/icg/2018/ait-gnss/12_SatOrbits.pdf.

debris geometrically. Unintentional collisions are one way additional this debris is created. In 2009, a spent Russian satellite (Cosmos 2251) unintentionally collided with an Iridium communications satellite (Iridium 33)[13] creating approximately 1,800 pieces of debris of 10 cm or greater in size.[14] Another way debris has been created is the intentional destruction of a defunct satellite. A 1985 U.S. Star Wars anti-satellite test (using an F-15 to destroy a satellite) is an example of intentional creation of space debris.[15] The Chinese use of a non-operational weather satellite (the Fengyun-1C) to test an anti-satellite kinetic missile in 2007 is another. The Chinese test created approximately 35,000 pieces of debris larger than 1 cm.[16] And another example is the Indian anti-satellite test (Mission Shakti aka Project XSV-1) in 2019 which, although the intention apparently was to minimize space junk, caused a debris field that could last for months or years.[17] And all of that can lead to more collisions until a tipping point is reached beyond which it is too dangerous (or too expensive) to use the effected orbit or orbits.[18]

The Tragedy of The Commons Redux

Well okay, so the amount of room in desirable Earth orbits is not endless. What about the hortatory language in the Outer Space Treaty referred to above? Since space is "*the province of all mankind*", wouldn't all space faring nations have a vested interest in minimizing the amount of space junk floating about? Uh, nope, it doesn't appear so. Recall the concept of the tragedy of the commons that you may have run across in an undergraduate economics class. People use the shared resource in a manner that suits their own self-interest and that acts as a detriment to the common good.[19] That's what has been going on in Earth orbits. It is expensive to minimize space debris by, for instance, reserving enough fuel to move a satellite or rocket body to a graveyard orbit,[20] to deorbit it at the end of its useful life or to mitigate orbiting junk

[13] Becky Iannotta, "U.S. Satellite Destroyed in Space Collision" (February 11, 2009), online: *Space News* https://spacenews.com/u-s-satellite-destroyed-in-space-collision/.

[14] Nicholas Johnson, "The Collision of Iridium 33 and Cosmos 2251: The Shape of Things to Come" (October 16, 2009), online: *NASA Technical Reports Server (NTRS)* https://ntrs.nasa.gov/citations/20100002023.

[15] Raffi Khatchadourian, "The Elusive Peril of Space Junk", The New Yorker (September 21, 2020), online: https://www.newyorker.com/magazine/2020/09/28/the-elusive-peril-of-space-junk. Considering the ten most significant debris-generating events, none of them are related to U.S. ballistic missile defense tests. Steven A. Hildreth & Allison Arnold, "Threats to U.S. National Security Interests in Space: Orbital Debris Mitigation and Removal" (January 8, 2014), online: *Congressional Research Service* https://fas.org/sgp/crs/natsec/R43353.pdf at 5.

[16] Leonard David, "China's Anti-Satellite Test: Worrisome Debris Cloud Circles Earth" (February 2, 2007), online: *Space.com* https://www.space.com/3415-china-anti-satellite-test-worrisome-debris-cloud-circles-earth.html. In space, a bolt approximately 1 cm in size can have the explosive power of a hand grenade when it collides with another object. *Supra* note 15.

[17] Loren Grush, "More than 50 pieces of debris remain in space after India destroyed its own satellite in March" (August 8, 2019), online: *The Verge* https://www.theverge.com/2019/8/8/20754816/india-asat-test-mission-shakti-space-debris-tracking-air-force.

[18] This disastrous result is known as the Kessler Syndrome. This theory that cascading collisions would make an orbit unusable was postulated by NASA scientist Donald J. Kessler in 1978. See, Louis de Gouyon Matignon, "The Kessler Syndrome" (March 27, 2019), online: *Space Legal Issues* https://www.spacelegalissues.com/space-law-the-kessler-syndrome/.

[19] Margaret E. Banyan, "Tragedy of the commons" (May 14, 2020), online: *Britannica* https://www.britannica.com/science/tragedy-of-the-commons.

[20] NOAA, "Graveyard Orbits and the Satellite Afterlife" (October 31, 2016), online: *National Environmental Satellite Data and Information Service* https://www.nesdis.noaa.gov/content/graveyard-orbits-and-satellite-afterlife.

through some sort of mechanical active debris removal procedure. It's much cheaper (at least in the short run) to let it continue to float in space.

But that attitude may be changing both at the national and the international level, although arguably not at the pace as is necessary to prevent catastrophe. There is a tremendous economic incentive to de-clutter the LEO and GSO regions. Companies are beginning to recognize that the cost of launch insurance and in-orbit policies goes up as the chances of a payload being destroyed by space debris increases. Some insurance companies have even abandoned the market.[21] The United States generally adheres to the 25-year limit on the existence of a satellite in a useful LEO or GSO,[22] but the rest of the international community is all over the map.[23] Whether 25 years is a short enough period of time is, as you might imagine, open to debate with some calling for a five year limitation on time in non-operational orbit.[24] Interagency rivalry within the United States has stalled efforts within the last few years to mandate a shorter time limit.[25]

How to Clean Up Existing Space Debris

Space does not have to be pristine – or even broom clean. According to estimates of the Japan Aerospace Exploration Agency (JAXA), removing five large objects each year over the next 100 years, coupled with robust pre-launch debris minimization regulations, would probably be enough to reduce the current problem over a reasonable period of time (say 200 years or so).[26] And, although that might be a tall technological order right now, there are new mechanisms on the horizon that will make the goal obtainable. The use of mechanical or electromagnetic tethers, solar sails and satellite-deployed nets to decelerate debris (allowing it to re-enter the Earth's atmosphere and, hopefully, burn up) or move it to a graveyard orbit have all been proposed.[27] The first "garbage truck" mission, commissioned by the European Space Agency, is scheduled for 2025 when a consortium led by ClearSpace[28] will attempt to capture a dead

[21] Debra Werner, "Assure Space won't cover collision risk in low Earth orbit", (March 11, 2020), online: Space News https://spacenews.com/assure-space-leaves-leo/.
[22] Theresa Hitchens, "US Tightens Space Debris Standards; Keeps 25-Year Cap" (December 9, 2019), online: *Breaking Defense, Air Warfare, Space* https://breakingdefense.com/2019/12/us-tightens-space-debris-standards-keeps-25-year-cap/.
[23] UNOOSA, "Compendium – Space Debris Mitigation Standards Adopted by States and International Organizations" (February 25, 2019), online: *United Nations Office for Outer Space Affairs (UNOOSA)* https://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_25_Feb_2019p.pdf.
[24] Jeff Foust, "Orbital debris mitigation guidelines still useful, if complied with" (January 15, 2020), online: *Space News* https://spacenews.com/orbital-debris-mitigation-guidelines-still-useful-if-complied-with/.
[25] Theresa Hitchens, "New Space Debris Rules Stalled by Year-Long Interagency Spat" (September 24, 2019), online: *Breaking Defense, Air Warfare, Space* https://breakingdefense.com/2019/09/new-space-debris-rules-stalled-by-year-long-interagency-spat/.
[26] Tereza Pultarova, "Meet the Space Custodians: Debris Cleanup Plans Emerge" (April 26, 2017), online: *Space.com* https://www.space.com/36602-space-junk-cleanup-concepts.html.
[27] Elizabeth Howell, "Space Junk Clean Up: 7 Wild Ways to Destroy Orbital Debris" (March 3, 2014), online: *Space.com* https://www.space.com/24895-space-junk-wild-clean-up-concepts.html.
[28] ClearSpace SA, "Shaping Sustainability beyond Earth" (n.d.), online: *clearspace today* https://clearspace.today.

satellite with a robotic arm.[29] Active debris removal will come at a cost, but that has to be balanced against the risk of doing nothing.

A major impediment to orbital debris mitigation is deciding what is non-operational debris; one party acting alone cannot unilaterally decide to clean up Earth's orbits. Normal salvage rights and the law of finds do not translate easily into outer space. Much like the customary international maritime law exemption accorded to federal warships with respect to rights of salvage and the law of finds, Article VIII of the Outer Space Treaty grants control to a state party over any space object recorded on that state's registry (or relating to any such registered object).[30] National defense interests dictate avoiding tampering with space objects that have not been specifically declared to be abandoned by the state of registration. Even small debris is not fair game – a nation could assert that it is being used in connection with an experiment in tracking by defense elements. Private commercial concerns, wanting to protect proprietary scientific information, would be reluctant to authorize salvage operations of their objects. The possibility of noncooperative obstructionist states further complicates the clean-up issue.

A potential solution, at least with respect to minimizing future space debris, is to have a means of disposal integrated into each space object when launched. A large launching state (US, China, Russia, EU) could require private companies putting objects in orbit to incorporate a clean-up method into the space object itself. Such a measure should ensure clean-up within a reasonable amount of time (on the order of 2 to 5 years after useful life). As the frequency of objects increases and minimizing and mitigating techniques develop, clean-up technology would perhaps become less cumbersome and cheaper to employ. This is a solution that could be implemented unilaterally by a launching state or a group of like-minded launching states. An added benefit is that it avoids the complications that would arise if a regime of space debris minimalization and mitigation were attempted via an international convention (where the major space faring nations – China, Russia and the United States – are most certainly not like minded). As we know from experience, a treaty would take a long time to negotiate and implement. And absent an enforcement mechanism, it is likely that any such a treaty would be variably observed.

Conclusion

The United States is committed to stabilizing the LEO and GSO environment.[31] Putting the burden on private industry acting in their own self-interest could provide for a more rapid, efficient and cheap space debris mitigation technique. The United States, as a leader in the privatization of space exploration and utilization, should be the first to obligate the private sector to remedy the national defense and environmental catastrophe hovering above us in LEO and GSO orbits.

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[29] European Space Agency, "ESA commissions world's first space debris removal" (September 12, 2019), online: *European Space Agency – Safety and Security* https://www.esa.int/Safety_Security/Clean_Space/ESA_commissions_world_s_first_space_debris_removal.
[30] *Supra* note 8 at Article VIII.
[31] See Hildreth & Arnold *supra* note 15 at 10.

Flying in the Northeast: a Diverse and Beautiful Place

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Chair, General Aviation Subcommittee

I prefer life in the Northeast of the United States for many reasons. I often refer to the "texture" of our environment, a complex geographic layout on which so many versions of modern civilization are on display, from the magnificent architectural achievements of one of the world's few truly international cities, to rolling hills with farms, wide, sandy beaches and erosion-smoothed snowy mountains, and of course the center piece – the spectacular Hudson River and its surrounding valley.

For general aviation pilots, there are countless opportunities for a day trip for lunch and an interesting walking tour. They include Lake Placid to the North, Cape Cod and its islands to the East, Tangier Island to the south and Niagara Falls to the west, all around two hours away for the typical Cessna or Piper. And on the way, the number of airports below, and even the flat coastal terrain, provide the reassurance of alternate landing places "just in case".

Even if you do not have all-day available and can get away for only an hour, the opportunities are abundant. My Piper Cherokee Six (single engine, six-seat, low-wing aircraft) is based at Lincoln Park Airport in Morris County, New Jersey, in a typical NYC suburban community. Last May I flew 25 miles to the east, about a 12-15 minute flight, and flew a low approach into the shockingly quiet LaGuardia Airport. A few weeks ago, I flew the same distance and time to the west, to Aeroflex-Andover Airport in Andover, New Jersey. The photos below, will, I trust, illustrate what a diverse environment we live in, with so many beautiful places to enjoy, even as we battle the pandemic.

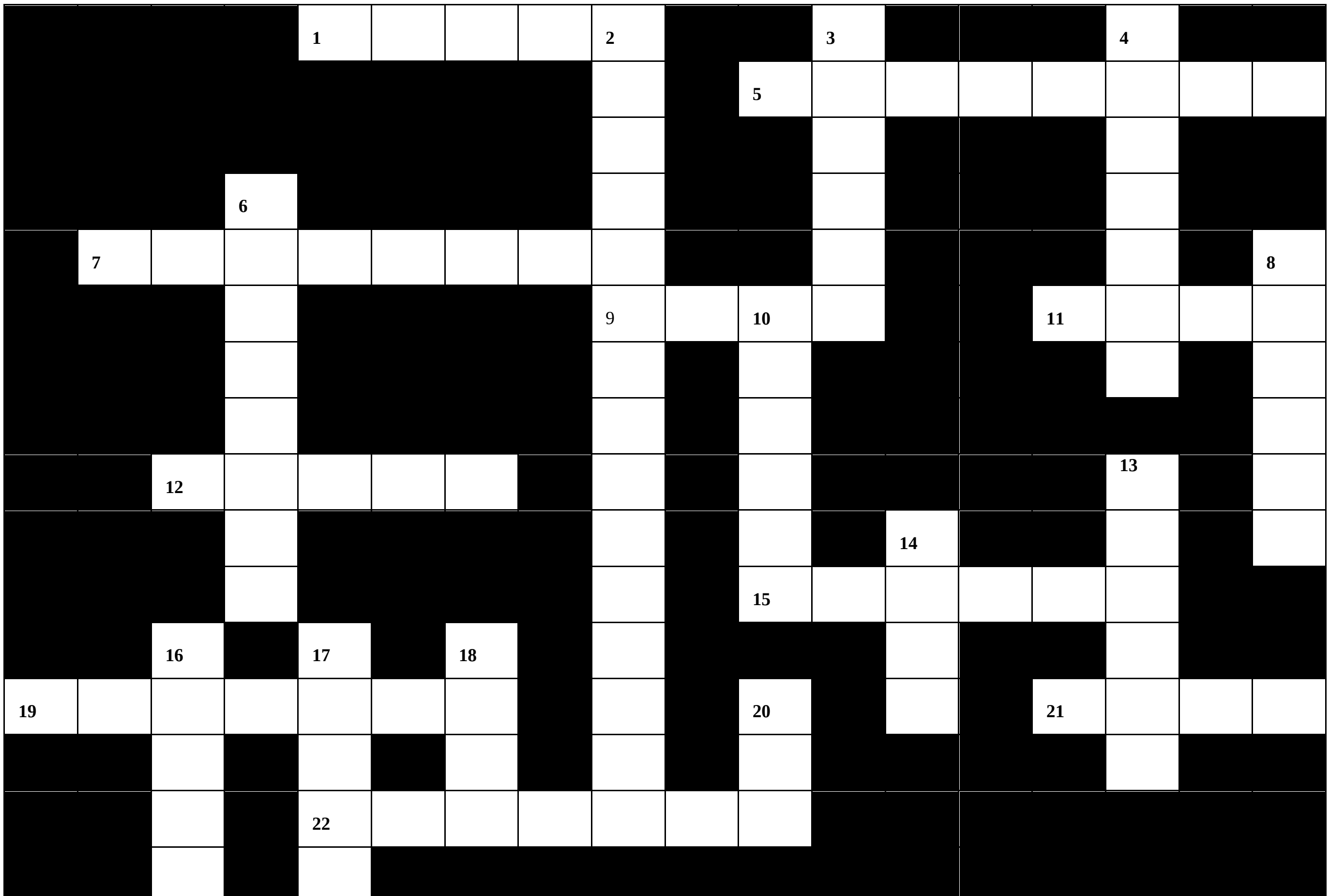
Stay safe.

[1] Albert J. Pucciarelli is a partner in the firm of McElroy, Deutsch, Mulvaney & Carpenter, LLP, in which he is chair of the firm's hotels and resorts and aviation practice groups. He was previously Executive Vice-President, General Counsel and Secretary of InterContinental Hotels until 1998. He is Chair of the New Jersey Bar Association Committee on Aviation Law and past-chair of the New York City Bar Association Aeronautics Law Committee (1999-2001). He is President of the Mid-Atlantic Pilots Association and the Ridgewood Arts Foundation and a Trustee of the New Jersey Aviation Hall of Fame and Museum. He is a commercial, instrument-rated pilot and aircraft owner.

FUN PAGES

Theory of Flight

By Alan D. Reitzfeld, Former Committee Chair



Across

1 More force or less force will change this.
5 Pressure of fluid decreases as this increases.
7 This decreases as #5 increases.
9 Another #3 force.
11 Unlike dating, it's ok to string this along.
12 The subject of this puzzle comes naturally to them.
15 Another #3 force.
19 #8 expanded on this person's analysis of motion years before.
21 Increase altitude.
22 #9 and #14 depend linearly on this characteristic of a fluid.

Down

2 A key fluid dynamics principle and a computer disk storage system bear his name.
3 One of the combination of four forces in aerodynamics.
4 An airplane wing, for example.
6 #5 is so important that it is repeated verbatim here.
8 Years before #2, he also addressed #9.
10 The general subject of this puzzle.
13 Subject of #8's three laws.
14 Another #3 force.
16 In a parade or when an object is less dense than the fluid it is in.
17 This type of flight does not need external thrust.
18 Direction of aircraft if lift and thrust are reduced.
20 Lifelong aspiration of aircraft.

The answer key is available for at least 30 days at:
https://drive.google.com/file/d/1O7_UXk3wZbMQmZepMEHbBv9buv-nMi3y/view?usp=sharing