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Have a safe flight

Aviation safety is the top community priority identified by the ASE Vision process and for the mission of the Federal Aviation Administration (FAA) that regulates US airports. Yet ways to enhance Aspen/Pitkin County Airport's (ASE's) safety have not yet been examined in depth. Safety is not even among the 14 topics mentioned as main responsibilities of the Airport Advisory Board[1]. However, Barry Vaughan's encouraging new initiative[2]—a new Safety Task Force he chairs under the Airport Advisory Board—is convening a dozen locally experienced pilots in public meetings to explore how to make our Airport safer.

There's a lot to do. Besides being rated (fairly or not) by *Travel+Leisure* as the worst US small airport to fly into[3], and highest in winter-break flight disruptions of the top 100 US airports[4], Aspen is said to have the most dangerous commercial airport in the country[5]. The National Transportation Safety Board (NTSB) has issued final reports investigating 41 Aspen aviation accidents and three further incidents occurring during the 33 years 1982–2014, with other investigations still underway. Of those 41 accidents, 13 caused a total of 44 deaths (though trending down)[6]. The worst single accident[7], in 2001, killed 18 people, nearly matching the 19 deaths in nearly a decade of Pitkin County auto accidents (2010–October 2019)[8]. A larger partial compilation found 50 Aspen aviation accidents in the past 55 years[9].

Then in late 2022, Mr. Vaughan's personal compilation expanded the database to the 58 years 1964–2022. His preliminary, unofficial, non-aviation-expert spreadsheet of the reports[10] found 124 NTSB-listed accidents or incidents (averaging 2.1 per year), 58 on and 66 off (but related to) Aspen Airport. The outcomes totaled 36 fatal flights, 120 deaths, 33 serious injuries, and 41 destroyed aircraft.

The senior County manager overseeing the Airport "said the airport is about as safe as it can possibly be. 'We have a very safe airport,' he said"[11]. He has no aviation background, and may have been referring only to the airport's physical assets. But of course the issue is how airport assets and users' knowledge and behavior interact with the surrounding terrain, winds, weather, special procedures, and other challenging conditions. The convenience of an airport just three miles from Aspen and six miles from Snowmass Village comes with confined terrain, tricky winds, erratic visibility, hence less-reliable service and potentially greater risk.

The County compiled[12] a list of 40 NTSB final reports of Aspen-related aviation accidents, but declined[13] to analyze them to extract common attributes and causes, so some local pilots did. Mr. Vaughan's analysis confirmed that all but two[14] of the incidents or accidents[15] in the County's initial list, and *all* the fatal accidents, *were not in commercial airliners but in General Aviation* (GA—nonmilitary, non-airline planes), and that *over half appear due to pilot error*[16]. His own larger analysis concurred. So why is Aspen GA so consistently and disturbingly accident-prone?

Deficient General Aviation pilot training

Aspen Airport's all-SkyWest commercial pilots' zero-fatality safety record over many decades reflects their high professional skills and their intensive, critically important Aspen-specific training. In contrast, GA pilots landing at Aspen in daylight[17] may have only general training and ordinary—highly variable—levels of skill. GA pilots may choose various forms of Aspen-specific training, real or virtual, but they are not required to have any, and Aspen Airport's Air Traffic Manager estimates that roughly nine in ten have none[18]. GA operators do come in various categories (charters, fractionals, corporate, private, etc.) with quite different training practices or requirements. Some undergo regular safety retraining and even pre-fly their Aspen approach on a simulator. Yet many GA pilots land at Aspen Airport only infrequently, some for the first time, and some with apparent insouciance born of limited awareness of its unique challenges.

Under current regulation, only the FAA could mandate Aspen-specific pilot training and require that filed flight plans into Aspen attach evidence of it. (Some European airports in mountainous terrain reportedly have such airport familiarization requirements, even including simulator training.) Aspen Airport's Director strongly supports this outcome, but the County has not asked the FAA to consider it, fearing industry lobbyists' veto[19]. But that seems no reason not to try, and Mr. Vaughan's Task Force will seek collaboration from GA trade groups in the hope of finding convergent interests. There is also an opportunity to establish a major privately funded GA safety training center in the ABC, more ambitious than current efforts. Aspen's uniquely comprehensive portfolio of aviation hazards could attract pilots from all over the country—a potential source of revenue, training flights in currently slack periods, and above all, a solid basis for improving aviation safety for Aspen and the whole industry.

So far, the ASE Vision process has only encouraged pilot information programs[20]. But if proper training by video, online tutorial, or simulation cannot be required (perhaps even as a license endorsement) as a condition of landing, perhaps the Airport might require a precision (in pilot-speak, ILS, MLS, or GPS) approach using Instrument Flight Rules (IFR). After all, inadequately trained pilots impose not just risks but costs on all Airport users and hence on Aspen's reputation and resort performance. Even small disruptions can have big consequences. Just this year, six times in six months, in a seemingly unprecedented cluster of pilot errors, Aspen Airport was shut down by private pilots' runway excursions or blockages. In consequence, a total of 32 inbound and 47 outbound commercial flights got cancelled[21], 15 diverted, and 29–36 delayed by over an hour[22], with uncounted but doubtless substantial inconvenience to those 123–130 flights' estimated ~6,000 passengers[23]—on the order of a thousand bad Aspen experiences per GA pilot error:

Date	Closure duration	Cancelled	Diverted	Delayed >1h
21 Feb 2022	8h57m	20 inbound, 22 outbound	7 inbound, to GJT	4 outbound delayed to next morning
24 Feb 2022	1h37m	5 inbound, 13 outbound	3 inbound, to GJT	8 inbound, 11 outbound
26 June 2022	1h44m	2 inbound, 3 outbound	1 inbound, to GJT	1 inbound, 1 outbound, both by nearly 5h
1501 12 July 2022	1h1m	0	0	3 outbound
1620 12 July 2022	0h27m			
15 Aug 2022	6h16m	5 inbound, 4 outbound Mon PM + 5 Tue AM	1 inbound to GJT + 1 each to origin city (IAH, SFO, ORD)	1 outbound delayed to Tue AM, + 7 more Tue outbounds (due to this incident or to other causes—no way to tell)

Even normal landings that a small fraction of GA pilots—2.6% of itinerants on the day of Pete McBride's classic one-day July photograph—choose to perform under Visual Flight Rules (VFR) often delay commercial flights. That's because IFR flights have priority, so controllers like to divert small VFR planes out of the IFR jets' sequence, then fit them opportunistically into later gaps; but airspace for holding patterns is extremely limited—circling over Aspen or Snowmass Village, causing noise complaints and perhaps increasing risk. Thus in practical effect, each VFR landing, by gumming up the flow, eliminates one IFR takeoff slot, causing cascading delays at peak periods[24]. FAA's prime objectives of safety and efficiency would be better met if Aspen could become, reasonably enforceably, an all-IFR airport. Conceivably this might be done by reclassifying Aspen's airspace as Class B, closed to planes without an IFR clearance, as is common around large metro airports. Local small-plane pilots may consider such a rule unnecessarily arduous. Or maybe there's some way to require IFR except for expert local pilots.

Capacity and congestion

Aspen's constrained airspace and terrain, and its fickle winds and weather, limit its maximum capacity to about 300 landings or takeoffs ("operations") per day in fine weather[25]. FAA rules require that this limited capacity be allocated first-come-first-served, with no preference between GA and commercial flights. Some pilots have ways to game that system, potentially creating an airspace conflict. The Airport's complex and exacting procedures permit a maximum rate of just 28–32 operations per hour in ideal conditions. That's because the required separation[26] between successive planes is 10–20 miles, *vs.* 2½–8 at a "normal" US airport. A 2018 study estimated that proposed ASE upgrades might raise good-weather capacity to ~40 operations per hour, but still sharply lower in bad weather[27].

The main cause of Aspen flight delays, besides the choice to land one way and take off in the opposite direction, is simply that demand on busy days exceeds capacity. Developing more ways to stretch capacity—most simply by better using the slack hours 0700–1000—could stretch capacity, cut delays, raise flexibility, and improve safety. The PACER program already reports real-time congestion so pilots can choose to avoid it, but this seems to have little effect because one of the selling points of GA travel is availability on demand, not on someone else's schedule.

FAA favors congestion-cutting, but unfortunately, found that a decade-old experimental aircraft landing reservation system didn't work well because Aspen has too many weather and other contingencies for booked slots to be reliably available, and because some pilots cheated[28]. However, in principle Aspen could ask FAA to allow congestion pricing, which FAA has long sought to advance, if the pricing applied equally to GA and commercial operations. Such a request appears not to have been made. Both slots *and airplane parking* might be priced—though wealthy owners or clients may respond to price far less than the very few private small-plane owners.

FAA's rates and charges policy explicitly allows "peak pricing systems" and doesn't consider them discriminatory[29]. Specifically, for example, airports may adopt a two-part landing fee (not to exceed allowable airfield costs) with both per-operation *and* weight-based components. The resulting higher fee per passenger for aircraft with fewer seats "may be justified by the effect of the fee on congestion and operating delays and the total number of passengers accommodated during congested hours[30]"—precisely the goal of the congestion pricing the County says it wants.

Tower, operations, and wildlife

The Safety Task Force could also advise the County on a modernized, relocated, and probably taller tower from which air traffic controllers can see, or monitor by modern remote cameras, the entire airport and its approaches. Aspen Airport is one of only a few in the country that controls on-airport operations from a single tower that also contains its approach radars. The tower's midfield location, suitable decades ago, has become far from optimal for modern operations.

Another obvious safety need is dramatically updated ground navigation equipment[31]. Aspen is one of the few US airports still reliant on Ground Based Navigation—obsolescent and hard to maintain. The best *airborne* precision landing systems are being vigorously deployed nationwide and internationally. Full deployment will take some years, but meanwhile, most—one expert estimates perhaps 80%—of GA planes already have an onboard system linking multiple ground sources (not just local), and often satellite (GPS) data, to the cockpit Flight Director screen and the autopilot for a safe automated approach. That airborne equipment is far more sophisticated and redundant than Aspen's public-use ground equipment, whose obsolescence constrains bad-weather operations by certain GA planes that mainly rely on it. Others simply use it as an en-route confirming cross-check.

The Task Force could consider how bad-weather landing decisions are made. Air traffic controllers only advise about airport conditions; they don't declare the Airport open or closed except in emergencies, though the County can close the Airport for maintenance or snow-plowing. Pilots always make the final choice about whether and how to land, considering controllers' advice if the tower is open at the time (0700–2000; at other times, Denver FAA controls Aspen's airspace). One pilot also notes that a pilot could effectively close an airport by reporting the braking action as "nil" to the tower so as to advise other inbound traffic; then pilots trying to land later may void their insurance coverage or operations specifications or both.

Surer exclusion of wildlife from the runway also needs attention. The Airport sits astride old elk movement and migration corridors[32] that may not have been properly planned for[33], so elk and deer abound, and substantial fence gaps have been observed. On 9 November 2022, Airport staff had to remove about 200 elk from Gate 8[34]. One elk could seriously damage a plane.

Head-on traffic

A fundamental safety issue is how Aspen's single runway is operated. At most of America's 5,000-odd public-use airports except the smallest, multiple runways let planes both land and take off into the wind, helping them fly better and more safely. (Tailwinds are destabilizing, so many jets aren't certified to take off or land in tailwinds over 10 knots.) Aspen has room for only one runway. Pilots can choose to land or take off in either direction[35], but about 99%[36] are said to land heading upvalley and take off heading downvalley (into prevailing winds to boost takeoff lift and help combat the runway's 2˚ upward slope). This head-to-head traffic is like driving on a one-lane road with traffic going both ways, without being able to swerve around obstacles. Only three US airports use such "Opposite Direction Operations." Aspen, with its uniquely constrained terrain, is the only US airport to use both directions *simultaneously*[37]—meticulously choreographed to prevent collisions in the air or on the ground.

This unique Aspen operational practice[38] can confuse pilots who don't know to look both ways before entering the runway (or crossing it midfield as proposed). It inevitably raises risk. It reduces capacity because planes must be farther apart. Safely operating both ways at once requires very strict FAA cutoff points, reliance on instruments, visual separation, and other special procedures that take a new Aspen tower controller about a year and a half to learn[39].

A little-used but potentially promising airspace decongestant

An important but underexamined option to help relieve the pressures and risks of Opposite Direction Operations would be to help more GA planes *with Aspen-knowledgeable pilots* (as they all should be!) *land toward downvalley* (on "Runway 33"). That's the same direction used for nearly all takeoffs, helping the two flows mesh. This approach from upvalley is now uncommon, takes care, but is not unduly difficult if understood and proficiently executed. Some GA pilots, especially locals, do it pretty often. On rare occasion, even some slower commercial airliners formerly did it, typically to avoid tailwinds, though current ones don't[40]. Richard R. Arnold, former ASE and Telluride Airport Director and flight teacher of a generation of Aspen pilots, has done it thousands of times in planes ranging from a Cessna trainer to a Learjet. He says it's the "safest and best" approach to land in Aspen. He likes it partly because it's almost always into a headwind, adding lift and, importantly, more deceleration than the 2˚ downhill runway slope defeats. He says the runway is long enough that he prefers this approach even on calm days. Another veteran pilot notes that the go-around from a Runway 33 landing, in case of inclement weather or last-minute runway congestion, is simpler than from the standard Runway 15 landing, where go-around is complex because of terrain constraints.

Local pilots' opinions differ, and so far, this option has been officially dismissed for reasons summarized by County Staff[41]:

> …the terrain environment in the Aspen area limits operations to/from the south [meaning the side toward the City of Aspen], especially during instrument conditions. The introduction of operations to/from the south would likely introduce new, and possibly, more egregious safety issues than those encountered in the current operational configuration. In addition, operations to/from the south would introduce impacts upon more urbanized areas (City of Aspen) that do not currently occur on a regular basis. Runway operations to/from the south can also introduce a degradation in aircraft performance due to the significant [2˚ downward] slope of the runway (increased takeoff roll and increased stopping distances). The final approach corridor from the south is also much more compressed than that from the north, decreasing the amount of space/time in which a pilot has to make close in corrections….[T]his type of operational change would allow planes to arrive or depart over the City of Aspen….It is highly doubtful the City of Aspen elected officials and the BoCC would consider opening up traffic in and out over the City of Aspen as part of regular operations at ASE.

All these concerns merit serious analysis by the new Safety Task Force, in collaboration with FAA experts. The context should also include ASE-specific GA pilot training, modernized ground avionics, and perhaps the potential to make ASE a true IFR airport. Ultraquiet future planes, and better understanding of how a well-designed approach pattern avoids town, could also displace the Fly Quiet initiative's effort since 2019 to discourage landings from upvalley as inherently and excessively noisy. Some of our most experienced pilots say those Runway 33 landings are inaudible from town if properly understood and executed, and that the corridor is not more compressed, so perhaps different experts are assuming different approach routes.

Importantly for both noise and safety, landing from upvalley *need not overfly downtown Aspen*, nor even the Hospital or High School, and the Airport's posted arrival procedures say not to[42]. There are at least two options for safely landing on Runway 33:

1. An IFR approach is FAA-approved, is taught for ASE operations by Flight Safety, and is adoptable at operators' discretion, requested by and tailored to their planes and pilots, as some big ASE operators have done. Descending to the WSW toward Highlands at the assigned altitude, roughly between Highlands base and the Rec Center, the plane heads due south and safely parallels the ridge running SSW from the base of Highlands, with at least a half-mile of horizontal clearance from the back of Aspen Mountain off (or below) the starboard wingtip. At a waypoint, the electronic guidance of the runway's centerline signals a slight left turn to continue the approach and land. There's plenty of time to do all landing preparations well before, not during, that turn onto the centerline. Alternatively, the pilot could simply descend the Highlands valley and turn left onto the centerline with no prior waypoint. Both variants of this first approach option can be used in any landable conditions, by any planes authorized to land at ASE, including the largest GA or commercial aircraft. Indeed, the Safety Task Force and FAA could well evaluate takeoffs and go-arounds on Runway 15 too, using a centerline departure route ("runway heading to assigned altitude") that climbs to clear obstructions. This would increase flexibility to land *and* take off consistently into the wind, as FAA and good airmanship encourage.
2. In the other, VFR, approach favored by Mr. Arnold (and still almost exclusively used in light-plane training operations), the plane flies straight upvalley over the ABC, curves right at (or at most a few hundred meters past) Buttermilk, and keeps curving right to meet the runway approach. Think of this path as a blunt fishhook with a long shank. The right turn is closer to the approach end of the runway than would be acceptable for an IFR approach, but has been executed in VFR conditions in jets as large as a Falcon 7X. The local pilots who favor this approach are generally in smaller and slower planes, but whenever applicable, it can reduce pressure on Opposite Direction Operations and required separations.

Both these approaches minimize ground noise—already modest because the airplane is descending on reduced engine power. Neither approach passes over the town, West End, Music Tent, Physics Center, Hospital, or High School. One can't even *see* the landing planes from town, let alone hear them. Fears of noise nuisance from Runway 33 approaches are thus apparently misplaced—or may assume overly expansive approach patterns common and habitual at flat lowland airports. Again, this is an issue of Aspen-specific familiarity and proficiency.

If operational suggestions by some private pilots familiar with these approaches prove widely applicable *for Aspen-proficient pilots*, and except during rare special events like the X Games, then landing from upvalley could become a far more common practice if desired. If approved in collaboration with FAA, that could reduce Opposite Direction Operations and make Aspen Airport both safer and more efficient—FAA's top priorities. As County Staff agree[43], with elimination of head-to-head traffic, "additional operations could occur, since the distance requirements would not be as tight"—effectively expanding Aspen's scarce airspace promptly and with no investment.

Questionable aircraft

Some unauthorized larger private airplanes, like older and noisier 737s just within the 95-foot wingspan limit but rated as exceeding the 100,000-pound weight limit[44], have occasionally landed at Aspen Airport[45], and at least one private 737 was alleged to visit "fairly regularly"[46]. It's unclear who decided, on what basis, that this type qualifies for our challenging Airport under standard safety contingencies[47]: the Aspen safety adequacy of a 737 is probably at best marginal, starting with its dubious accelerate/stop capability. Indeed, Richard R. Arnold questions the worst-case contingency performance even of some currently operating planes[48].

Emergency medical capacity

Such concerns call attention to our community's medical response capabilities, especially when passengers per plane are officially proposed to rise by up to 71%, and that's not a limit. Have we really thought through the medical and reputational risk of a potential 130-casualty catastrophic event, plus any victims on the ground? Aspen is blessed with a 5-star Level III Trauma Center hospital with casualty capacity[49] suited for a multi-car or small-plane accident. A gratifyingly improved mass-casualty plan is designed for up to 70 victims (like a CRJ700 or, roughly, a school bus). Airport training's "worst case" scenarios assume up to 150 casualties, but that "would exceed the capacity of [all] the Roaring Fork Valley's hospitals and require mass transportation to more distant facilities."[50] Mutual Aid may be infeasible if the Airport or highways or both are closed by accident or weather or both.

The implications for airplane size are obvious: smaller is better, bigger is worse. The trend toward smaller planes flying point-to-point routes could greatly reduce the risk of overwhelming emergency capacity. Bigger planes would enhance that risk.[51] And the proposed Lumberyard major housing development near the runway could increase it further, as we'll explore later.

Conclusions

Aspen's sterling reputation for commercial flight safety cannot afford even one accident. Its troubled reputation for noncommercial flight safety, with about one accident per year and some 120 people killed so far, needs prompt and major improvement. Comprehensive safety is about the whole system of the airport, its 200 square miles of airspace up to 21,000′, and the proficiency and training of inbound flight crews. The ASE Vision agenda scarcely began to address this priority in comprehensive, specific, and actionable terms, even though it's rightly at the top of everyone's declared list of concerns.

The Airport Advisory Board's long-overdue Safety Task Force has just launched with commendable intent and momentum, and we wish it every success. But piecemeal patches to this complex system won't suffice. The linked opportunities to address Aspen Airport's safety *and* other concerns require a highly integrated portfolio of simultaneous design, technological, business-model, governance, and perhaps regulatory improvements that forthcoming ads and essays in this series will explore. Together, that portfolio's elements can reveal important new opportunities.

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[1] Dan Bartholomew (Aspen Airport Director), brief to Airport Advisory Board, 18 Aug 2022, https://drive.google.com/file/d/1Jg4THrjD_dxmwOWatiHcBntTIdEYnYdc/view.
[2] Proposed 20 Oct 2022 with County foreknowledge, unanimously approved by the AAB 17 Nov 2022 and unanimously confirmed 6 Dec 2022 by the BoCC.
[3] https://www.travelandleisure.com/airlines-airports/best-small-airports-in-the-us, 7 Mar 2022, based on https://www.valuepenguin.com/airports-to-fly-into-study#Worst, 28 Feb 2022, showing 26.4% delay rate, 8.4% major delay rate, 26.21-minute average delay, 3.5% arrival cancellation rate, and top ($607) average airfare—scoring in the nation's bottom three on each metric examined. County Staff correctly pointed out to the Airport Advisory Board on 21 Jul 2022 that the article's causal logic is sketchy, but it's out there.
[4] Z. Wichter & D. Zhang, "USA TODAY analysis: Here are the 10 airports with the most flight cancellations around the holidays," *USA Today*, 15 Dec 2022, https://www.usatoday.com/story/travel/airline-news/2022/12/15/us-airports-most-flight-cancellations-delays/10888995002/.
[5] *E.g.* T. Gorman & S, Sarhaddi Nelson, https://www.latimes.com/archives/la-xpm-2001-mar-31-mn-45154-story.html (31 Mar 2001) and Bloomberg News, https://www.denverrpost.com/2017/03/20/aspen-telluride-airport-landings/ (20 Mar & 12 Apr 2017). FAA's Special Pilot in Command Qualification Airport List for commercial airlines (14 CFR Part 121) lists Aspen—not mentioning winds or weather—as having "*Mountainous terrain in immediate vicinity of airport, all quadrants; high climb gradient performance requirements; special procedures.*"
[6] ASE Vision *Technical Working Group Report*, 20 Dec 2019, pp 8–9, https://drncvpyikhjv3.cloudfront.net/sites/214/2019/12/24105603/TWG-Final-Report-and-Recomendation-12_20_19-with-added-Appendix1.pdf.
[7] The sobering NTSB report is at https://www.ntsb.gov/investigations/AccidentReports/Reports/AAB0203.pdf.
[8] Ref. 6.
[9] Amory Lovins, introduction to public forum, 22 Oct 2022; Mr. Vaughan's new 1964–2022 compilation finds far more. The introductory text is on pp 171–186 at https://civicclerk.blob.core.windows.net/stream/PITKINCOCO/4a5da1c89a.pdf?sv=2015-12-11&sr=b&sig=zXNqNGU24FM1e7C1PuFDyCnkKdL%2BJuFxBf1lJaoAFBA%3D&st=2022-11-27T16%3A41%3A56Z&se=2023-11-27T16%3A46%3A56Z&sp=r&rscc=no-cache&rsct=application%2Fpdf. The complete video, including discussion with Dick Arnold and Tom Keough, is on YouTube at https://youtu.be/F-MVGgaVk-k, and is also available at https://www.google.com/url?q=https://youtu.be/F-MVGgaVk-k&source=gmail-imap&ust=160451 8013000000&usg=AOvVaw2jfWamp2HJUSouYGdFbQTE.
[10] B. Vaughan, emails to A. Lovins, 10 and 14 Dec 2022. Mr. Vaughan is to be commended for undertaking this onerous public service, and for his generosity in sharing these preliminary results and kindly authorizing them to be shared further. His private analysis has not yet been checked by aviation experts, so some details may change, but the overall totals cited here look durable.
[11] https://www.aspendailynews.com/news/aspen-airport-operations-up-20-for-first-half-of-2021/article_c29e6c3e-ffcf-11eb-9f55-eb760153232b.html, 18 Aug 2021.
[12] Caroline Bonynge, ACE, ASC, C.M., Director of Operations, Safety & ARFF, Aspen/Pitkin County Airport, 2 Apr 2021 email "NTSB Accident Reporting" to Rich Engelhart, then Interim Airport Manager. The list is useful but appears to be incomplete and is now superseded.
[13] Most recently in County Staff's response to Amory Lovins's 19 Apr 2022 letter to the BoCC, p 6: "No reasonable benefit would be ascertained from the County performing its own accident study since all this information can be gleaned from the NTSB reports."
[14] Both involving the 100-seat BAe-146 airliner: in 1998, a hydraulic failure sent it beyond the runway with blown-out tires, narrowly missing another plane, coming to rest in three feet of snow, and slightly damaging the plane with no injuries to the 77 passengers plus crew; of note, it was sliding toward Buttermilk, whose parking lot is 0.3 miles from the end of the runway. Then in 2000, one engine's turbine disc failed during climb-out, but as designed, the plane landed safely using the other three engines. In addition, one CRJ700 no-injury accident, a 2017 engine fire after landing, is reported at https://www.aeroinside.com/9833/skywest-crj7-at-denver-on-jul-2nd-2017-engine-fire-on-landing, and the same site lists four ASE-related incidents for that aircraft type.
[15] The difference is that accidents involve death, serious injury, or substantial damage to the aircraft.
[16] Mr. Vaughan's personal interpretation of the accident reports (he's a pilot) implicated basic pilot error in 73 of the 120 mishaps, mountain flying conditions in 45, and mechanical failure in 24. Fourteen were "controlled flight into terrain"—flying a working aircraft into the ground under the pilot's control.
[17] Aspen Airport rules applying specifically to GA landings state this from a half-hour after sunset to airport closure for curfew at 2300 (https://www.aspenairport.com/operation/operating-procedures/curfew/; see also §517 at https://www.congress.gov/103/statute/STATUTE-108/STATUTE-108-Pg1569.pdf):
VFR Operations: Aircraft equipped as required under FAR 91.205 (D) for instrument flight and pilot is instrument rated; VFR pilot in command has completed at least one takeoff or landing in the preceding 12 months at ASE.
IFR Operations: Execute approach and departure procedures with air traffic control clearance.
[18] Keith Geirach, 18 Aug 2022 brief to Airport Advisory Board, https://drive.google.com/file/d/1Jg4THrjD_dxmwOWatiHcBntTIdEYnYdc/view, at 51:06.
[19] This sentence is based on Airport Director Dan Bartholomew's remarks in a 19 Oct 2022 discussion at https://drive.google.com/file/d/1I8-LR-uA6jvN0yRs-VERgB_m9FMGfuzj/view?usp=sharing.
[20] A tutorial is at https://code7700.com/kase.htm#gsc.tab=0. County Staff's response (Ref. 13) states at p 6: "The Airport does work with the FAA in support of their safety video series 'From the Flight Deck,' which addresses safety initiatives at certain unique airport facilities, including ASE. It is the responsibility of pilots and aircraft operators to become educated on best practices." Many pilots suggested another good start—an Aspen-specific instructional pamphlet that may now be available. The FBO could automatically send it to any pilot filing a flight plan to Aspen. A pamphlet is better than nothing, but inferior to videos and simulator training. The Airport's website at 1 Dec 2022 included useful but less-detailed information at https://www.aspenairport.com/operation/operating-procedures/high-altitude-safety/.
[21] For example, eight inbound and eight outbound flights were cancelled just in the 15 Aug 2022 incident described at https://www.aspendailynews.com/news/incident-that-closed-airport-monday-was-4th-time-this-year-private-jet-skipped-runway/article_681dbc48-21c4-11ed-bdc2-b71f1dc45445.html.
[22] Data very kindly provided by Airport Director Dan Bartholomew on request, emails to A. Lovins, 1 and 7 Dec 2022.
[23] That is, 123 to 130 flights × ~67 average seats × ~0.7 to 0.8 nominal load factor = 5,769 to 6,968 pax. Actual counts are unavailable.
[24] This paragraph and the next three are informed by the Geirach brief, Ref. 18.
[25] However, http://aspenairport.wpenginepowered.com/wp-content/uploads/2022/10/Capture-sept.jpg says 448/day capacity in ideal conditions.
[26] That's longitudinal separation along the arrival or departure path. Separations between planes on those separate paths may be much less, but they're also typically separated by different altitudes. Lateral separations under visual conditions may also appear close as seen from below.

[27] Lean Engineering, Ref. 47, at pp 119–120, though this improvement "could occur with or without the runway safety enhancements and…relocations" (p 126). Conversely (p 124), large jets in marginal conditions could inhibit even 16 ops/h nominal capacity.
[28] Geirach, *loc. cit.*, Ref. 18, at 1:07:30.
[29] US Department of Transportation, FAA, RIN 212-AF90, "Policy Regarding Airport Rates and Charges," *Fed. Register* **78**(175):55335 (10 Sep 2013), particularly §3.2: "A properly structured peak pricing system that allocates limited resources using price during periods of congestion will not be considered to be unjustly discriminatory. An airport proprietor may, consistent with the policies expressed in this policy statement, establish fees that enhance the efficient utilization of the airport." Also, §2.4.2(c) on p 55333 specifically allows noise-abatement and mitigation charges as part of "reasonable environmental costs" if they reflect a corresponding actual expenses to the airport.
[30] US Department of Transportation, FAA, RIN 212-AF90, "Policy Regarding Airport Rates and Charges," *Fed. Register* **78**(175):55330 (10 Sep 2013), particularly §2.1.4 at p 55333.
[31] Existing SkyWest commercial planes, which the Airport Director recently criticized as outdated in this regard (25 Oct 2002, https://www.aspendailynews.com/news/local-news-in-brief-oct-25/article_9e9d5e74-5412-11ed-87fe-a3251393f302.html), actually have a unique, FAA-approved electronic landing system, using proprietary software and data, that permits safe landings in worse conditions than all but the most sophisticated private jets can tolerate. This system is not mentioned in a 5 Jul 2022 article on potential satellite-based landing systems that have reduced delays at Sun Valley (www.aspentimes.com/news/theres-hope-for-reducing-delays-cancellations-of-airline-flights-at-aspen/).
[32] According to a local wildlife expert with decades of experience collaborating on wildlife issues with agency and university scientists and other experts—Tom Cardamone (personal communications, 10 Apr and 17 Dec 2022), whom the County hadn't asked.
[33] The FAA-approved 2012 *Wildlife Hazard Management Plan* (four parts, URLs at https://www.aspenairport.com/operation/planning/resource-documents/) reported in 1990–2011 no wildlife strike bigger than a fox. A search of all four parts for the word "elk" found none. The broader context of local wildlife issues is well described by S. Condon, "Effort underway to create safe passages for wildlife across Hwy 82," *Aspen Daily News*, 19 Dec 2022, https://www.aspendailynews.com/news/effort-underway-to-create-safe-passages-for-wildlife-across-highway-82/article_17848aca-7f55-11ed-8d05-b3b248132ab5.html.
[34] Tweeted by the Airport 9 Nov 2022 at https://twitter.com/FlyAspenAirport?status/1590478237444556912.
[35] Experienced local pilots in smaller jets or piston planes are more likely than itinerants to land from upvalley. Takeoffs over town require prior written approval, though it's unclear whether that rule is consistently enforced. Aspen's operational procedures are unique. A former SkyWest/ Aspen pilot explained in 2014 (https://www.boldmethod.com/blog/2014/01/aspen-approach/): "A special approach, the LOC DME to Runway 15, allows aircraft to land at Aspen with lower minimums—down to 8,780′ MSL (roughly 1,000′ AGL [half the requirement for non-precision instrument approaches]) and three miles of flight visibility. This procedure has a special missed approach procedure. If you can't land after crossing the missed approach point, you execute an emergency extraction procedure. The approach requires special training and isn't published in the standard package of approach procedures." However, an easier curved approach to Runway 15 (landing from downvalley), allowing just 537′ height above touchdown and 1¼-mile visibility, was FAA-approved in 2021 for modern private aircraft equipped with Honeywell avionics, including the Gulfstream G350/450/500/550/600 (the G600 is the largest that can now use ASE) and the Dassault Falcon 8X, all subject to specific pilot training, review, and instrument requirements: https://aerospace.honeywell.com/us/en/about-us/blogs/honeywell-receives-faa-approval-aspen-rnav-approach?id1.
[36] Ref. 18. However, p 33 of the 2018 Lean Engineering report cited in Ref. 47 says "Over 90 percent of landing aircraft use Runway 15 and 95% of departing aircraft use Runway 33," indicating that the Air Traffic Manager's 99% estimate *might* be higher than actual.
[37] Ref. 18.
[38] The Airport's Approach and Departure Procedures at https://www.aspenairport.com/operation/operating-procedures/approach-departure/ now specify: "Meteorological conditions permitting, use Runway 15 [from downvalley to upvalley] for all landings," and "Runway 15 takeoffs requires [*sic*] a waiver to be signed by Atlantic Aviation." More formally and somewhat differently, Pitkin County Code §10-12-040 begins: "There is established at the Airport a preferential Runway system for the taking off of all Aircraft. Subject to Runway closures, weather conditions, and emergencies, Aircraft shall take off to the northwest on Runway 33. Departures from Runway 15 are permitted only with written authorization of the Director of Aviation, and must be consistent with the Director of Aviation's criteria for approval of take-off on Runway 15 as published by the Director….There is established at the Airport a preferential Runway system for the landing of all Aircraft. Subject to Runway closures, weather conditions, and emergencies, Aircraft shall land on Runway 15."
[39] Ref. 18.
[40] The BAe 146 and Dash 8-Q400 were authorized and able to land from upvalley; the CRJ700 is capable of it but this is not current practice.
[41] Ref. 13, p 6.
[42] Ref. 38: "Meteorological conditions permitting, use Runway 15 for all landings. NOTE: Using Runway 33 [for landings] necessitates a high approach without overflying the town of Aspen."
[43] Ref. 13, p 7.
[44] With the 737's dual wheels. Tandem-wheeled planes can weigh up to 160,000 lb, but planes that comply with Aspen's 95′ wingspan limit and can perform adequately at Aspen's altitude are very unlikely to use tandem wheels.
[45] For example, B73S planes (i.e. 737-300 according to https://www.fly.faa.gov/edct/common/aircraft_types.txt) landing at 1046 on 4 Dec 2020 and at 1340 26 Dec 2020 were recorded by landing-fee collector Vector at 120,500 lb maximum landing weight and 143,500 lb maximum takeoff weight. It's unclear whether these are nominal specifications (which are 138,500 lb for the commercial 737-300), specific weights declared in the flight plan, or someone's estimate; conventionally, each type's maximum certificated landing weight is assumed, but private jets might weigh less depending on configuration details and, of course, type variants. Thus ASE's first 737 landing (J. Auslander, "'Whale' 737 makes first-ever landing as Aspen's airport as debate about larger plane continues," *Aspen Times*, 29 Dec 2018, https://skifederation.org/whale-737-makes-first-ever-landing-at-aspens-airport-as-debate-about-larger-plane-continues) was apparently the rather unusual shortened 737-500 with rated empty weight 70,510 lb, landing at under 90,000 lb and taking off at just under 80,000 lb (https://community.infiniteflight.com/t/kase-aircraft-size-restriction/312182/45?page=3). ASE's 100,000-lb weight limit is meant partly to protect the runway and taxiways from costly damage. (County Staff, in Ref. 13, says "We are unaware of any unauthorized aircrafts being given clearance to operate at ASE. We would encourage those facts being shared.") Wingspan is similarly determined by published specifications. In another example, the ERJ190 that landed 23 Mar 2021 has a maximum landing weight of 94,799/97,003 lb (LR/AR model) but a maximum takeoff weight of 110,893/114,199 lb (https://www.embraercommercialaviation.com/wp-content/uploads/2017/02/Embraer_spec_190_web.pdf) , so if it were desired to stay below the 100,000-lb limit at takeoff too, it would have had to load little fuel, unless its private interior configuration were considerably lighter than the commercial version and this difference were officially recognized.
[46] https://www.aspendailynews.com/opinion/semple-the-sounds-of-silence/article_962edb22-d899-11ec-b88f-27634eef7643.html/

[47] Such as engine loss at decision speed (i.e. accelerate/stop distance and second-segment climb gradient) and bad-weather go-around. The 737 family has not demonstrated the agility to maneuver out of trouble in these conditions at Aspen, where air is thin (especially in hot summer weather), weather and winds are erratic, and the clouds have rocks in them. Planes like the 737 whose engines are slung under their wings rather than mounted on their fuselage are especially awkward because failure of one engine causes yaw (sideways turning) that can make it hard to control the plane on its rapid and narrowly constrained climb-out to avoid terrain. At least one airline reportedly concurs (J. Auslander, "Aspen airport expansion will allow for 737-sized planes, but will they come?," *Aspen Times*, 12 Aug 2018, https://www.aspentimes.com/news/aspen-airport-expansion-will-allow-for-737-sized-planes-but-will-they-come/). A 2018 technical review of the 737-8 MAX for the County found at p 2 that "feasibility [of scheduled services] relies upon updating existing approach category (CAT) D operations. If no new approach procedures or SMS [Safety Management System] risk mitigations materialize to permit a CAT D aircraft to operate on CAT C approaches, then the 737-8 MAX may either be downgraded to charter feasibility or be considered non-feasible following the runway relocation [to meet ADG-III standards]." Lean Engineering, *Airspace Impact and Aircraft Feasibility Assessment Update*, 25 Aug 2018 report (filename suggests 26 Aug draft) to Aspen Pitkin County Airport https://aspenairport.wpenginepowered.com/wp-content/uploads/2020/09/ASE_Airspace-and-Aicraft-Feasibility-Draft_082618-1.pdf/ [*sic*]. The report also analyzed the 737-700, -800, and -7MAX, but apparently not the -300 already privately operating as noted. The 737-9MAX and -900 were found infeasible (p 4). (Of course, recent MAX modifications may change the analysis.) The weather assessment on pp 13–14 is also sobering, but the runway and wind analysis on pp 18–22 helps illuminate potential approaches from upvalley discussed above.

[48] At pp A12–A13 (4 Apr 2021) of https://civicclerk.blob.core.windows.net/stream/PITKINCOCO/8950407993.pdf?sv=2015-12-11&sr=b&sig=etIZVRYf3kPVKY1ZGuXdUDySUJUITys56CjU%2BOKcPOQ%3D&st=2021-12-21T15%3A53%3A22Z&se=2022-12-21T15%3A58%3A22Z&sp=r&rscc=no-cache&rsct=application%2Fpdf.

[49] Aspen Valley Hospital has 25 staffed total patient beds (including four now used or easily usable as ICU beds, with the rest potentially convertible). Its Emergency department has one trauma room and 16 monitor-wired regular beds. The four AVH ambulances can each hold one critical/red-status trauma patient with two EMTs and, in a pinch, up to one yellow and two green patients. Hospital resources already in routine use may be unavailable for casualties. Hospital staff and other medical professionals downvalley of the Airport may be unable to reach it. In a major emergency, some other hospital areas could be adapted to add surge capacity to meet the 70-casualty design basis. Airlift or road transfer to other hospitals may be too slow or impossible in the bad weather in which an accident is most likely to occur. A crashing plane could also take out Highway 82 and the frontage road—and even, as in one tested preparedness exercise, the Holy Cross Energy substation behind the ABC. Obviously any mass-casualty event would be extremely challenging—and worse if it's bigger.

[50] *The Final Report of the Airport Vision Committee: The Common Ground Recommendations*, p 7.

[51] An additional issue is that FAA's requirement that airlines' planes be able to evacuate passengers within 90 seconds, regardless of cabin capacity, is tested with only 60 able-bodied people, none of whom are elderly, children, or people with disabilities. Two US Senators have asked FAA to devise and adopt realistic standards: https://www.airlinerwatch.com/2022/12/two-us-senators-want-faa-to-rearrange.html, Dec 2022. Until potential new standards work through the fleet over decades, safe evacuation in a crash at Aspen cannot be assumed, so it would be prudent to assume more and graver casualties than if all passengers could swiftly evacuate.