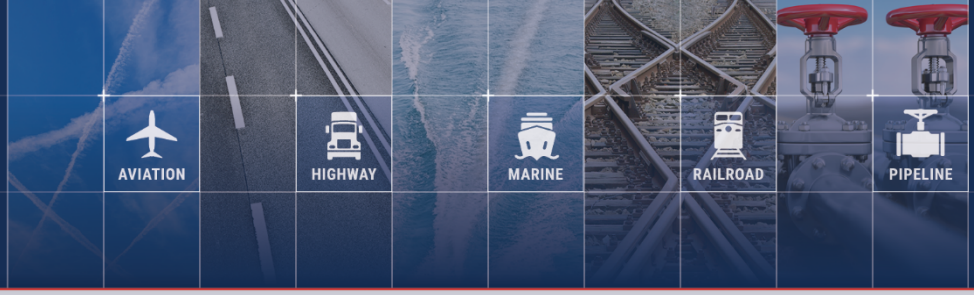

Aviation Investigation Final Report

Location:	Kahului, Hawaii	**Accident Number:**	DCA23LA096
Date & Time:	December 18, 2022, 10:07 Local	**Registration:**	N393HA
Aircraft:	Airbus A330-243	**Aircraft Damage:**	Minor
Defining Event:	Turbulence encounter	**Injuries:**	4 Serious, 20 Minor, 269 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

Before Hawaiian Airlines flight 35 departed, the captain called the flight dispatcher to discuss the flight release, at which time the dispatcher advised the captain of potential turbulence and potential embedded convective activity over the Hawaiian islands. While flying over the Hawaiian islands at flight level (FL) 400, the airplane, an Airbus A330, was in visual meteorological conditions and above a cloud layer between FL370 and FL380. A cloud that the flight crew described as a “plume” appeared vertically in front of the airplane. The flight crew called the lead flight attendant to advise her about the anticipated turbulence. Within about 1 to 3 seconds, the airplane encountered severe turbulence that resulted in multiple injuries in the cabin. Data from the airplane’s quick access recorder showed that the airplane experienced vertical accelerations greater than 2 Gs during the turbulence encounter. After the encounter, the airplane continued to the destination airport and landed there without further incident.

The National Weather Service (NWS) forecast products for the time and route of the accident flight indicated that a storm was approaching the Hawaiian islands that was expected to support an unstable atmosphere with abundant moisture and isolated thunderstorms. As a result of these conditions, the NWS issued a SIGMET (significant meteorological information) that was valid for an area of embedded thunderstorms to FL380 that included the turbulence encounter location. This SIGMET, which implied the potential for severe or greater turbulence, was provided to the flight crew. The NWS had also forecast moderate-to-severe clear air turbulence that was expected to develop behind the main area of precipitation. Thus, the conditions along the airplane’s flight route were favorable for convectively induced severe turbulence, and the flight crew was aware that thunderstorms and turbulence could occur along the flight route.

The flight crew noticed the plume-like cloud shortly before the airplane was to begin its descent into Honolulu. The captain then changed the weather radar display mode to determine the intensity and elevation of the weather formation directly in front of the airplane, but he and the first officer saw "nothing" displayed; weather radar has reduced sensitivity at higher altitudes. In addition, the *Hawaiian Airlines A330 Flight Crew Operating Manual*, *Quick Reference Handbook*, stated that weather radar does not detect weather that "has small droplets," such as clouds.

According to the cockpit voice recorder (CVR) transcript, the flight crew stated that the plume was "moving fast" and "building fast" but that the airplane should "clear most of it." The meteorological evidence for this investigation showed that the plume that the crew observed outside the airplane comprised cumulonimbus clouds with severe-to-extreme convectively induced turbulence. The operator's A330 flight crew operating manual/quick reference handbook also stated that "the flight crew should plan to fly above or around areas of severe turbulence." However, the crewmembers did not anticipate the likely severity of the rising plume, even though they had been provided with sufficient meteorological information (including information from the dispatcher and the air traffic controller) to make such a determination.

The CVR recorded the crewmembers stating, after the turbulence encounter, that they should have "gone around," indicating that sufficient time should have been available to deviate away from the plume. The operator's flight crew operating manual recommended that flight crews "consider storm cells above 35,000 ft as highly hazardous" and that a flight crew should not overfly a storm cell with its top at or above 25,000 ft because the airplane might encounter "stronger than expected" turbulence. Thus, the flight crew's decision to overfly the active storm cell was a factor in the severe turbulence encounter.

Once the flight crew notified the lead flight attendant about the expected turbulence encounter, the flight attendant attempted to convey this information to the other flight attendants via interphone. However, the turbulence occurred before she could complete the call. One flight attendant received serious injuries, and three flight attendants received minor injuries due to the turbulence encounter. The seatbelt sign had been turned on before the turbulence event, but the captain did not make an announcement over the public address system about the anticipated turbulence. The lack of a verbal warning directly from the flight deck might have contributed to some of the flight attendant and passenger injuries.

When the turbulence encounter ended, the cabin crewmembers who were able and medically trained passengers assisted those with injuries. Cabin crewmembers and an off-duty company pilot secured loose interior panels for landing. The flight attendants made a list of passengers with serious injuries, and the lead flight attendant informed the flight crew that more than a dozen passengers were injured and that the airplane would need to be met by medical personnel upon landing. The flight attendants turned on the call lights in the cabin for those passenger seats so that the passengers could be readily identified for attention by emergency

services upon landing. Thus, the in-flight response to the turbulence encounter was timely and effective.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The flight crew's decision to fly over an observed storm cell instead of deviating around it despite sufficient meteorological information indicating the potential for severe convective activity.

Findings

Personnel issues	Decision making/judgment - Flight crew
Environmental issues	Convective turbulence - Contributed to outcome

Factual Information

History of Flight

Enroute-cruise	Turbulence encounter (Defining event)

On December 18, 2022, about 1007 Hawaii standard time, Hawaiian Airlines flight 35, an Airbus A330-200, N393HA, was operating at FL400 about 65 nautical miles north-northeast of Kahului, Hawaii, when the airplane encountered severe turbulence. Of the 2 flight crewmembers, 8 flight attendants, and 283 passengers (including 2 off-duty Hawaiian Airlines pilots in the cockpit jumpseats and 3 lap-held children) aboard the airplane, 4 occupants (1 flight attendant and 3 passengers) sustained serious injuries, and 20 occupants (3 flight attendants and 17 passengers) sustained minor injuries. The airplane sustained minor damage. The regularly scheduled domestic passenger flight was operating under the provisions of Title 14 *Code of Federal Regulations* Part 121 from Phoenix Sky Harbor International Airport (PHX), Phoenix, Arizona, to Daniel K. Inouye International Airport (HNL), Honolulu, Hawaii.

The captain was the pilot monitoring, and the first officer was the pilot flying. The captain stated that the airplane was in visual meteorological conditions at FL400 and was above a cloud layer between FL370 and FL380. The captain stated that flight conditions were smooth with clear skies above the cloud layer and that the onboard weather radar displayed no returns.

According to the CVR, at 0955:57, air traffic control (ATC) advised the flight crew of a nearby airplane to go around weather due to reported turbulence that was ahead. Another flight crew (Hawaiian Airlines flight 45) reported continuous moderate chop.

At 0958:22, a flight attendant aboard the accident airplane made a passenger announcement that the airplane would be landing in 45 minutes and that passengers who wished to use the lavatory should do so at that time. At 1000:43, ATC advised the flight crew that “moderate to extreme precipitation and turbulence” and “light to moderate chop” would be occurring for the next 40 miles. About 31 seconds later, ATC advised the flight crew of another Hawaiian Airlines airplane (flight 11) that cloud tops were at FL410 with “light chop and moderate turbulence.”

During a postaccident interview, the captain stated that a cloud that looked like a “plume” appeared vertically in front of the airplane. The captain also stated that he set the weather radar to “elevation mode” (which allows the radar antennas to be tilted at different angles to scan the atmosphere), but the flight crew saw “nothing” displayed on the weather radar screens. At 1007:07, a flight crewmember stated, “it’s moving fast” and that the airplane should “clear most of it.” About 15 second later, the flight crew called the lead flight attendant

to let her know to expect a “bumpy” ride shortly. At 1007:31, the flight crew noted, “it’s building fast.”

At 1007:43, the CVR recorded sounds, including rattling, that were consistent with a turbulence encounter. Sounds associated with autopilot disconnection and engine indicating and crew alerting system (EICAS) chimes were also recorded. The crew reacted to the turbulence with surprise, confirmed pilot control of the airplane, and reengaged the autopilot. Also at 1007:43 and then at 1007:59, an altitude alert sounded for about 1.5 seconds.

Data from the airplane’s quick access recorder showed that, at 1007:42 (1 second before indications of a turbulence encounter were recorded on the CVR), the airplane’s altitude increased by 68 ft (40,020 to 40,088 ft), and its vertical acceleration was 0.69 G. At 1007:43, the airplane’s altitude further increased by 248 ft (40,088 to 40,336 ft), and the airplane’s vertical acceleration was 1.27 G. The quick access recorder data also showed that, at 1007:44 (when the autopilot disconnected), the airplane’s vertical acceleration was 2.18 G. One second later, the master caution and master warning became active. At 1007:46, the vertical acceleration had decreased to -0.98 G.

At 1008:12, a flight attendant made an announcement for passengers to be seated and fasten their seatbelts. Between 1008:14 and 1009:11, the CVR recorded additional EICAS chimes. During that timeframe (at 1008:54), the lead flight attendant notified the flight crew that medical assistance would be needed upon landing.

At 1010:06, the CVR recorded the flight crewmembers stating that they should have “gone around it.” The flight crew also communicated with a flight attendant, who confirmed injuries in the cabin that needed medical attention. The flight attendant also stated that the cabin interior “doesn’t look good.”

At 1010:41, the flight crewmembers discussed the event, stating that they thought that the airplane would have cleared the cloud formation but that it “came up real fast.” One crewmember questioned, “did it just pop up?”. At 1013:43, the flight crew made a passenger announcement about the turbulence encounter. Less than 1 minute later, the flight crew contacted Hawaiian Airlines dispatch to inform the operator about the turbulence encounter. The crew stated that the airplane “hit 40 degrees of bank” and that passengers had been injured. The crew requested medical assistance for those with injuries and estimated that the airplane would be arriving at HNL at 1045. Shortly afterward, the flight crew notified ATC that the airplane had started its descent, and the CVR recorded the flight crew performing descent checks.

At 1018:14, the flight crew informed ATC that the airplane encountered “severe turbulence” at FL400 and requested expedited handling to HNL. In response, ATC declared an emergency for the flight. At 1019:08, a flight attendant provided details to the crew about some passenger injuries and stated that, in the aft half of the cabin, the ceiling was damaged and oxygen masks had dropped. At 1020:52, the flight crew informed company dispatch about three confirmed

injuries and stated that the airplane was “coming in as fast as [it] can.” Dispatch notified the crew that emergency medical services were alerted and ready. At 1024:17, the captain made a passenger announcement, indicating that he would keep the seatbelt sign illuminated after landing to allow emergency personnel to access those who were injured.

The CVR showed that, at 1025:44, the flight crew began to discuss what else they could have done regarding the event, but this conversation was mostly unintelligible because of an overlapping unrelated radio transmission. At 1026:35, the crew noted that the cloud formation was not depicted in red (high reflectivity) on the weather radar display and that the formation had “caught them completely off guard.” About 2 minutes later, a flight attendant informed the flight crew that about 10 people were injured, and the flight crew then contacted company dispatch with the updated number of airplane occupants who would need medical attention.

As the airplane was descending to 10,000 ft, ATC told the crew to expect the instrument landing system approach to runway 4R. Afterward, the crew performed the in-range checklist. At 1033:55, the flight crew discussed the airplane’s earlier attitude, indicating that “we went at least 40 degrees…maybe more” and that the airplane “kicked off everything.” The crewmembers then stated that they had just practiced a similar upset event in the simulator.

Between 1035:31 and 1036:52, ATC instructed the flight crew to turn onto a left heading of 220° and cleared the airplane to an altitude of 6,000 ft. At 1039:15, ATC cleared the airplane to 1,500 ft, and another discussion about the turbulence encounter ensued, with the flight crew stating that the plume “came out of nowhere” and that “nothing” was displayed on their weather radar screens. ATC continued to vector the airplane toward HNL and cleared the airplane for the approach.

The flight was then handed off to the HNL tower, and the crew contacted the tower at 1043:21. The tower controller cleared the airplane to land on runway 4R, and the crew performed the before landing checklist. The CVR recorded sounds consistent with touchdown at 1046:26. About 30 seconds later, the flight attendants made an announcement for passengers to remain seated to allow medical personnel to board. (This announcement was repeated at 1051:50 and 1053:18.)

At 1048:44, the flight crew discussed the turbulence encounter again, and one of the crewmembers stated that it reminded him of a “volcanic explosion” and that the upset was “the most unusual attitude” he had experienced. This crewmember was thankful that the seatbelt sign was on at the time of the encounter. At 1058:57, the captain reminded the passengers to remain seated.

At 1100:03, the flight crew ran the parking checklist. At 1100:20, one of the flight crewmembers visually confirmed that the cabin had structural damage. At 1100:59, the flight crew resumed discussing the turbulence encounter, stating that the clouds were “kinda flat” but that, once the airplane was closer to the clouds, “it built super fast.” The crew also noted that, even though the airplane “dumped everything,” including the autopilot and authothrottle,

all electrical systems stayed on. At 1102:39, the flight crew discussed that about 12 people were injured. The CVR recording ended at 1103:50.

Pilot Information

Certificate:	Airline transport	**Age:**	51,Male
Airplane Rating(s):	Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	September 21, 2022
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	September 11, 2022
Flight Time:	12291 hours (Total, all aircraft), 5887 hours (Total, this make and model), 9224 hours (Pilot In Command, all aircraft)		

Co-pilot Information

Certificate:	Airline transport	**Age:**	Male
Airplane Rating(s):	Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	October 12, 2022
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	December 18, 2022
Flight Time:	8214 hours (Total, all aircraft), 1031 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus	**Registration:**	N393HA
Model/Series:	A330-243	**Aircraft Category:**	Airplane
Year of Manufacture:	2013	**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	1422
Landing Gear Type:	Retractable - Tricycle	**Seats:**	293
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	ROLLS-ROYC
ELT:		**Engine Model/Series:**	RR772B-60
Registered Owner:	HAWAIIAN AIRLINES INC	**Rated Power:**	71100 Lbs thrust
Operator:	HAWAIIAN AIRLINES INC	**Operating Certificate(s) Held:**	Flag carrier (121)

The airplane was configured with 2 pilot seats, 2 cockpit observer seats, 11 flight attendant seats, and 278 passenger seats. Three of the 283 passengers on the accident flight were lap-held children, and two off-duty Hawaiian Airlines pilots were in the cockpit observer seats.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Phoenix, AZ (KPHX)	**Type of Flight Plan Filed:**	IFR
Destination:	Honolulu, HI (KHNO)	**Type of Clearance:**	IFR
Departure Time:	07:00 Local	**Type of Airspace:**	

The weather document attached to the dispatch release included the departure, destination, and alternate airport meteorological aerodrome reports, terminal aerodrome forecasts, and notices to air missions. The document also included the SIGMETs and AIRMETs that were current when the flight was released at 0141 (0441 mountain standard time).

According to the release flight dispatcher, the captain of the accident flight had contacted flight dispatch at 0233 (0533 mountain standard time) and was briefed on the flight plan and the forecast weather conditions. The dispatcher discussed potential turbulence and an area of isolated embedded cumulonimbus clouds over the region near HNL. The dispatcher advised the captain about additional fuel (in case the airplane would need to enter a holding pattern) and the weather expected in the HNL area.

Before the flight departed, the flight crew was provided with updated weather information at 0311 (0611 mountain standard time), including a SIGMET for thunderstorms. At 0401 (0701 mountain standard time), the crew was issued a SIGMET for embedded thunderstorms over the area. The crew was also alerted to the presence of thunderstorms at HNL at 0414 (0714 mountain standard time). A report sent through the aircraft communication addressing and reporting system indicated that another Hawaiian Airlines flight at FL400 encountered smooth conditions over the area.

The relief flight dispatcher provided the flight crew, at 0745 (1045 mountain standard time), with a SIGMET update regarding embedded thunderstorms with tops to FL380 that was moving to the northeast with no change expected. (This SIGMET is described in more detail later in this section.) The flight crew acknowledged this information. The flight dispatcher on duty at the time of the accident stated that, at 1010, the flight crew reported a turbulence encounter while the airplane was at FL400.

The closest National Weather Service (NWS) reporting station was Kahului Airport (OGG), Kahului, Hawaii, which was located on the island of Maui and was 120 miles southwest of the accident site. The airport had a federally installed and maintained automated surface observing system that was augmented by certified observers during normal operating hours. At 0954 (13 minutes before the turbulence encounter), the following conditions were reported: wind variable at 3 knots, visibility 10 miles in light rain, a few clouds at 1,500 ft above ground level (agl), ceiling broken at 2,500 ft, overcast at 6,000 ft, temperature 22°C, dew point temperature 21°C, and altimeter 29.83 inches of mercury.

The NWS Ocean Pacific Center's Pacific surface analysis chart for 0800 on the day of the accident depicted a low-pressure system associated with an occluded frontal system to the north-northwest of the Hawaiian islands. This system was associated with storm force conditions (sustained surface wind or gusts between 48 and 63 knots) and was projected to move to the southeast and intensify during the 24 hours that followed.

This storm system, which was identified as a Kona storm, was expected to affect Hawaii with a strong westerly wind. (A Kona storm brings heavy rain and strong wind to Hawaii from the

southwest or south-southwest.) Another dissipating frontal system was located east of this system with a trough extending southward, which was associated with gale force conditions (sustained surface wind or gusts between 34 and 47 knots).

The NWS 24-hour Pacific High-Level Significant Weather Prognostic Charts that were valid for 0800 and 1400 depicted the expected conditions between FL240 and FL630. The chart for 1400 showed a large area of potential moderate turbulence over the accident site between FL240 and FL420 and an area of isolated embedded cumulonimbus clouds with tops to FL390 over the area. Both charts were included in the weather package provided to the flight crew.

The NWS Aviation Weather Center's meteorological aerodrome report website showed that the observations for OGG indicated general marginal VFR to IFR conditions from 0400 to 1200 with light-to-heavy rain and broken-to-overcast cloud cover. The observations also reported that thunderstorms were occurring at OGG about 1200.

The National Oceanic and Atmospheric Administration's Geostationary Operational Environmental Satellite-17 image for 1006 showed that the turbulence location was near overshooting tops of embedded cumulonimbus clouds and thunder. The Geostationary Operational Environmental Satellite-18 imagery for 1000 between FL400 and FL410 depicted a greater than 50% probability of moderate or greater turbulence over the area of the turbulence encounter site.

The closest NWS Weather Surveillance Radar-1988 Doppler (WSR-88D) was located at Kamuela, Hawaii, about 138 miles south-southwest of the turbulence encounter location. The WSR-88D composite reflectivity images at 1005 and 1010 depicted echoes of 40 to 45 dBZ under the flight track surrounding the period in which the turbulence encounter occurred.

The NWS Honolulu Weather Forecast Office issued SIGMET Victor 0356, which was valid through 0745. SIGMET Victor 2 was issued at 0744 and was current through 1145. The SIGMET advised of embedded thunderstorms with tops to FL380 that was moving northeastward at 5 knots. The NWS Honolulu Weather Forecast Office also issued, at 1000, an Area Forecast Discussion about short-term weather conditions within that region. The product indicated the potential for moderate-to-severe clear air turbulence behind the main area of showers.

Of the 21 pilot reports received between 0800 and 1400 for the area within 120 miles of the turbulence encounter, the only report that described severe turbulence was from the accident flight crew. There were seven reports of turbulence ranging from light to moderate and three reports of encounters with heavy rain.

Wreckage and Impact Information

Crew Injuries:	1 Serious, 3 Minor, 6 None	**Aircraft Damage:**	Minor
Passenger Injuries:	3 Serious, 17 Minor, 263 None	**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	4 Serious, 20 Minor, 269 None	**Latitude, Longitude:**	20.8893,-156.4729(est)

As a result of the encounter with turbulence, damage occurred throughout the cabin area. A passenger service unit in row 39 fell from the overhead compartment. Ceiling panels were missing near rows 36 to 41. (A figure showing the airplane's internal configuration can be found in the Survival Factors Group Chair's factual report in the docket for this accident.) An overhead light in the rear galley area cracked. The flight attendant handset near door L4 broke into multiple pieces. Other damage occurred to overhead bin components, light panels, and exit signs.

Survival Aspects

The eight flight attendants working the flight received their last recurrent training between May and October 2022.

According to flight attendant and passenger statements, about 45 minutes before landing, the flight crew announced that the airplane would start its descent into HNL in about 10 minutes, and the seatbelt sign was illuminated. The flight attendants were finishing cabin service, securing carts, and collecting required state agricultural forms. About this time, the flight crew called the lead flight attendant to alert her about turbulence during the descent. As the flight attendant initiated a call to the rest of the cabin crew, the turbulence encounter occurred.

Passengers described feeling a "hard jolt" followed by a "free fall" sensation. Unsecured items, such as phones, jackets, and water bottles, began "floating" around the passengers. After about 3 seconds, "two hard hits" occurred. Flight attendants and passengers who were not restrained were thrown upward, impacting the ceiling or baggage compartments above them, and then downward onto the floor.

A passenger who had left her seat to go to the lavatory reported that she felt the airplane shake; she then "flew" face first into lavatory ceiling and was "thrown abruptly" onto the floor.

Once the airplane had stabilized, she crawled back to her seat (31C) and was helped into it by the passengers seated next to her. Flight attendant 4 stated that she hit the ceiling twice. She secured herself in her seat at the L4 door, but, because the handset there had been damaged by the turbulence, she unbuckled herself, crawled to the flight attendant seat by the R4 door, and used that handset to call for help. Flight attendant 5 reported that she ended up on the floor after "violent shaking" and was helped into her seat at the R4 door. Both flight attendants were tended to by passengers with medical training. The other flight attendants began working their way through the cabin to pick up items and check on passengers and crew. Off-duty Hawaiian Airlines crewmembers also assisted injured passengers.

An off-duty Hawaiian Airlines pilot worked with the flight attendants to secure loose cabin panels before landing. The flight attendants made a list of passengers with serious injuries and turned on the call lights above their seats so that those passengers could be identified for attention by emergency medical services upon landing. The lead flight attendant informed the flight crew that more than a dozen passengers were injured and that the airplane would need to be met by medical personnel upon landing.

Once the cabin was secured, all the flight attendants and medically trained passengers returned to their seats and put on their restraints for landing. Once the airplane landed and arrived at the gate, the passengers were instructed to remain seated so that emergency personnel could board the airplane to take the more seriously injured passengers and flight attendant 5 off the airplane first. Afterward, the remaining passengers disembarked the airplane through the L2 door (in the forward cabin just behind the first-class seats) and walked to the gate area, where other injured passengers were being triaged.

According to information that Hawaiian Airlines provided, about 25 occupants were transported via ambulances, buses, and personal vehicles to local hospitals. A lap-held child was one of the occupants transported by a personal vehicle to a hospital; the child received a minor injury and was later released. Other passengers reportedly sought medical treatment after returning to their residences.

Organizational and Management Information

The Hawaiian Airlines A330 Flight Crew Operating Manual, Quick Reference Handbook, described severe turbulence as follows:

Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in airspeed…. Occupants are forced violently against their seat belts and loose objects will move around the aircraft.

The manual also provides the following related procedures:

When possible, the flight crew should plan to fly above or around areas of severe turbulence….

Before the aircraft enters an area where turbulence is expected:

- All loose equipment must be secured in the cockpit and in the cabin

- The flight crew must set the SEAT BELTS sign to ON

Keep the autopilot ON

When thrust changes are excessive: Disconnect Autothrust

For approach: Use Autothrust for managed speed

Regarding weather radar, the manual stated that "*the purpose of the weather radar is to help the flight crew detect and avoid storm cells (e.g. cumulonimbus* [clouds])." The manual also stated the following:

Weather detection is based on the reflectivity of water droplets. The weather echo appears on the ND [navigational display] *with a color scale that goes from red (high reflectivity) to green (low reflectivity).*

The intensity of the weather echo is associated with the droplet size, composition and quantity (e.g. the reflectivity of a water particle is five times more than an ice particle of the same size). The flight crew must be aware that the weather radar does not detect weather that has small droplets (e.g. clouds or fog), or that does not have droplets (e.g. clear air turbulence).

The *Hawaiian Airlines A330 Flight Crew Operating Manual* contained general recommendations for flight crews to apply when a "significant" storm cell is detected. The recommendations included the following:

The flight crew should consider storm cells above 35,000 ft as highly hazardous.

If the top of the storm cell is at or above 25 000 ft, the flight crew should not overfly, because the aircraft may encounter turbulence stronger than expected.

The flight crew should not attempt to enter a storm cell, or overfly its top by less than 5,000 ft, because the aircraft may encounter severe turbulence.

Additional Information

The Federal Aviation Administration (FAA) defined turbulence as "air movement that normally cannot be seen and often occurs unexpectedly." The FAA stated that turbulence could be created "by many different conditions, including atmospheric pressure, jet streams, air around mountains, [and] cold or warm weather fronts or thunderstorms" and that turbulence "can even occur when the sky appears to be clear." The FAA also stated that turbulence can be dangerous and provided guidelines to keep passengers safe. These guidelines included keeping seatbelts buckled at all times and listening to pilots and flight attendants.

FAA Advisory Circular (AC) 120-88A, "Preventing Injuries Caused by Turbulence," dated January 19, 2006, provided information and practices to prevent injuries caused by turbulence. The AC noted that flight attendant injuries "occur at a disproportionately high rate compared to other crewmembers and other cabin occupants because [flight attendants] spend more time in the passenger cabin unseated and, therefore, unbelted." The AC stated that effective flight attendant training should be designed to prevent or mitigate flight attendant injuries during turbulence and emphasize the importance of flight attendant safety during turbulence.

The AC also provided guidance on injury avoidance actions according to turbulence onset categories. The category "imminent turbulence or turbulence occurring" was defined as "sudden, unexpected, or imminent turbulence requiring immediate action to protect cabin crew and passengers." The avoidance actions were the following:

> *(1) Captain turns on seatbelt sign and makes a PA* [passenger address] *announcement, "F/As* [flight attendants] *and passengers be seated immediately. Passengers please remain seated until this area of turbulence has passed and I have cleared you to move about the cabin."*
>
> *(2) Cabin crew take first available seat and secure themselves.*
>
> *(3) No compliance checks are performed and items are secured only if they present no delay in securing a person in a seat.*
>
> *(4) When conditions improve, captain makes PA announcement advising the cabin crew that they may resume their duties and whether or not the passengers may move about the cabin.*

The National Transportation Safety Board (NTSB) adopted a Safety Research Report, "*Preventing Turbulence-Related Injuries in Air Carrier Operations Conducted Under Title 14 Code of Federal Regulations Part 121*" on August 10, 2021 that examined the prevalence and risk factors of turbulence-related accidents in Part 121 air carrier

operations. As a result of the research, the NTSB issued multiple safety recommendations to address the following safety issues:

> *Insufficient submission and dissemination of turbulence observations.*
> *A lack of shared awareness of turbulence risks.*
> *The need for mitigation of common turbulence-related injury circumstances.*
> *The need for updated turbulence guidance.*

The FAA's *Aviation Weather Handbook*, FAA-H-8083-28, which was issued on November 25, 2022, states the following about clear air turbulence (CAT):

> *CAT is defined as sudden severe turbulence occurring in cloudless regions that causes violent buffeting of aircraft. CAT is a higher altitude turbulence (normally above 15,000 ft) particularly between the core of a jet stream and the surrounding air. This includes turbulence in cirrus clouds, within and in the vicinity of standing lenticular clouds and, in some cases, in clear air in the vicinity of thunderstorms. Generally, though, CAT definitions exclude turbulence caused by thunderstorms, low-altitude temperature inversions, thermals, strong surface winds, or local terrain features.*
>
> *CAT is a recognized problem that affects all aircraft operations. CAT is especially troublesome because it is often encountered unexpectedly and frequently without visual clues to warn pilots of the hazard.*

Administrative Information

Investigator In Charge (IIC):	Lovell, John
Additional Participating Persons:	Todd Gentry; FAA AVP-100 Bennet Walsh; Hawaiian Airlines; Honolulu, HI John Crabbe; ALPA
Original Publish Date:	December 12, 2024
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=106472