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Wheel-well Stowaways Risk Lethal Levels of Hypoxia and Hypothermia

Successful stowaway flights spur others to try this form of illegal transportation. But a U.S. Federal Aviation Administration report indicates that few survive the high-altitude phase of flight, and those who do are often unconscious during descent and risk falling to their death when the landing gear is lowered.

FSF Editorial Staff

Hours after the Avianca Boeing 747 landed, U.S. Customs Service investigators routinely searching the aircraft found the body of a 19-year-old Colombian man who had hidden in a wheel well and had apparently frozen to death en route from El Dorado Airport, Bogota, Colombia, to John F. Kennedy International Airport (JFK), New York, New York, U.S.[1] The fatality was one of 13 wheel-well stowaway flights documented in a report by the U.S. Federal Aviation Administration (FAA) Civil Aeromedical Institute (CAMI) and through additional research by Flight Safety Foundation (FSF).

The report, *Survival at High Altitudes: Wheel-Well Passengers*, concluded that, in addition to documented cases of wheel-well stowaways, it is "also likely that various unsuccessful attempts were never documented (or known) because the bodies fell into an ocean or into a remote land area." The report noted that some successful stowaway flights may be unknown because accomplices at the destination airport may have helped a stowaway survivor to escape. Like the 19-year-old Colombian, stowaways are often inspired by others who have successfully traveled in the wheel wells of aircraft, the report said.

To document the occurrence of wheel-well stowaway flights, the authors of the CAMI report searched the database of *The New York Times*, which yielded 10 reported wheel-well stowaway flights between 1947 and 1993. An FSF review of nine U.S. newspapers from 1993 through March 1997 and telephone interviews with airline personnel revealed three additional wheel-well stowaway flights.[2] Of the 13 stowaway flights reported, eight resulted in death. Stowaways were relatively young, ranging in age from 13 to 35 (Table 1, page 2).

In reviewing the known stowaway flights, CAMI researchers found that to gain access to the aircraft the typical stowaway hid "near the point where the departing aircraft waited at the runway for takeoff clearance. While the aircraft was stationary, the [stowaway] mounted, undetected, a main landing gear and climbed into a wing recess area adjacent to where the gear would retract" (photo, page 3).

"Certain aircraft contain sufficient space in the landing gear area for a small adult to crawl into the space and hide relatively securely," the report said. "The [Douglas] DC-8 has space above and forward of the right main landing-gear strut (about [1.2 meters by 1.1 meters by 0.9 meters (four feet by 3.5 feet by three feet)]) to accommodate one or even two small adults" (photo, page 4). A stowaway is unable to use the space above

Table 1
Wheel-well Stowaway Flights

Date	Stowaway Passenger, Age	From	To	Aircraft	Maximum Altitude and Outcome
March 22, 1997	Male, adolescent	Nairobi, Kenya	London, England	B-747	Crushed in nosewheel well. Fatal.
Oct. 14, 1996	Male, adolescent	New Delhi, India	London, England	B-747	10,675 meters (35,000 feet). Survived in nosewheel well.
Aug. 4, 1993	Male, 19	Bogota, Colombia	New York, New York, U.S.	B-747	Fatal.
June 4, 1993	Male, 13	Bogota, Colombia	Miami, Florida, U.S.	DC-8	10,675 meters (35,000 feet). Covered in frost. Survived.
Nov. 14, 1986	Male, 35	Panama City, Panama	Miami, Florida, U.S.	B-707	11,895 meters (39,000 feet). Survived.
March 23, 1975	Unknown, adolescent	Bogota, Colombia	Miami, Florida, U.S.	B-707	Fell from aircraft. Fatal.
April 14, 1972	Male, 18	San Diego, California, U.S.	New York, New York, U.S.	B-707	10,675 meters (35,000 feet). Left-wing wheel well. Frozen. Fatal.
Feb. 24, 1970	Male, 14	Sydney, Australia	Tokyo, Japan	B-707	Fell 60 meters (200 feet) on takeoff from Sydney. Fatal.
June 21, 1970	Male, 13	Lyons, France	Abidjan, Saudi Arabia	DC-8	Fell at Abidjan when landing gear lowered. Fatal.
July 26, 1969	Male, 17 No details on second stowaway.	Havana, Cuba	Madrid, Spain	DC-8	8,845 meters (29,000 feet). First stowaway survived. Second fell to death.
April 19, 1966	Unknown, 20–21	Paris, France	Morocco	Caravelle	Right-wing. Frozen. Fatal.
Sept. 28, 1966	Male, 17	Bogota, Colombia	Mexico City, Mexico	Jet airliner	10,370 meters (34,000 feet). Survived.
Aug. 5, 1947	Male, 30	Lisbon, Portugal	Natal, Brazil	Piston-powered airliner	Survived in wheel well.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute/Flight Safety Foundation

the left landing gear strut in the DC-8 because hydraulic reservoirs and other items occupy the area.

After takeoff, a stowaway is afforded a degree of security by metal covers that close over the wheel-well opening. But a stowaway faces two life-threatening conditions during flight: hypoxia and hypothermia.

Hypoxia occurs when there is an inadequate supply of oxygen to the tissues.[3] Hypothermia is a decrease in the core body temperature to a level at which normal muscular and cerebral functions are impaired.[4] Severe levels of hypoxia or hypothermia can render a person unconscious and, if prolonged, lead to death. Table 2 (page 4) outlines some of the environmental characteristics to which a stowaway is exposed, including reduced atmospheric pressure, partial pressure of oxygen (PPO_2) and low temperatures associated with high altitudes.

The relative amount of oxygen in the air (21 percent) does not vary appreciably at altitudes up to 21,350 meters (70,000 feet). At sea level, atmospheric pressure is 760 mm Hg (millimeters of mercury), and PPO_2 is 160 mm Hg (or, simply, 760 times 0.21). As altitude increases, the pressure of the atmosphere falls, as does the partial pressure of its components such as oxygen.

The way in which the body obtains oxygen and eliminates carbon dioxide (CO_2) is influenced by the decrease in PPO_2. Thin-walled sacs in the lungs, called alveoli, diffuse oxygen into the blood. As the oxygen-laden blood circulates through the arteries, tissues that have a lower PPO_2 absorb the oxygen. Water vapor in the lungs maintains a constant pressure of 47 mm Hg. But the amount of CO_2 and the water-vapor volume in the lungs become larger as the total pressure in the lungs decreases.

The increased volume of water vapor and CO_2 proportionately reduces the body's ability to absorb oxygen from the air. At very high altitudes (13,725 meters [45,000 feet] or higher), even the use of 100 percent oxygen will not sustain consciousness because of the increased volume of water vapor

Stowaways have gained access to airliners by climbing the landing gear and entering the wheel-well recess. Arrow indicates technician demonstrating stowaway location. (Photo: U.S. Federal Aviation Administration Civil Aeromedical Institute)

and CO_2 in the lungs.[5] Above 10,065 meters (33,000 feet), to breathe normally, the air to the lungs must be pressurized by some mechanical means.[6]

As the aircraft climbs, a few heat sources inside the wheel-well compartment may, for a short time, help delay the onset of hypothermia in the stowaway. These sources include friction heat generated within the tires during takeoff, warm hydraulic fluid in the lines and other ambient heat in the stowaway area. "These heat sources are progressively diminished as flight at altitude proceeds," the report said.

Physiological effects for the stowaway are minimal at altitudes to 2,440 meters (8,000 feet). A slight increase in breathing rate begins at this point, as the oxygen level in the blood flowing to cells decreases from 97 percent (at sea level) to about 92 percent. Although the stowaway is unlikely to notice, sensitivity to light has already decreased.[3]

Passing through 4,575 meters (15,000 feet), a stowaway's reaction time has decreased by as much as 50 percent.[6]

As the aircraft climbs to 5,490 meters (18,000 feet), the stowaway's rate of breathing increases by about 65 percent to compensate for the lack of oxygen. By this point, he or she experiences several neuromuscular, visual and cognitive symptoms of hypoxia. These include weakness, light-headedness, confusion, further degradation in color vision and peripheral vision, the onset of fine tremors, slurring of speech, euphoria and lethargy.[3,6]

As the aircraft nears 6,710 meters (22,000 feet), the stowaway (if unacclimated to living at high altitudes) will be able barely to maintain consciousness because the amount of oxygen in the blood flowing to the cells has decreased from 97 percent to 50 percent. The blood oxygen level that occurs at this altitude will lead to unconsciousness in six minutes or less.[6] The report added, "At all cruising jet altitudes, the PPO_2 is below that required to support brain consciousness."

The report found that the onset of hypothermia among stowaways often was accelerated because they were only lightly clothed in temperatures as low as -63 degrees C (-81.4 degrees F). For example, the stowaway in the 1986 incident listed in Table 1 survived the 2.5-hour flight at a maximum altitude of 11,895 meters (39,000 feet) in jeans, a T-shirt, baseball cap, athletic shoes and earmuffs.[7]

Although it is not possible to calculate the actual temperatures endured by the stowaways, they can be estimated, in degrees C, by doubling "the first two numbers of altitude, subtract[ing] 15 and chang[ing] the sign," the report said.

One or two young adults can fit into the space above and forward of the right — but not the left — main landing-gear strut of the Douglas DC-8. (Photo: U.S. Federal Aviation Administration Civil Aeromedical Institute)

When mild hypothermia sets in, the individual begins to shiver, as the body attempts to maximize surface heat production. As hypothermia enters a moderate stage (where a person's core temperature decreases from 35.5 degrees C to 34 degrees C [96 degrees F to 93 degrees F]) violent shivers begin, and conditions similar to hypoxia, such as slurred speech and irrational behavior, occur. When an individual is in a state of severe hypothermia, shivering occurs in violent waves. This action eventually ceases because shivering is not sufficient to counteract the temperature drop of the body's core after it falls to a level between 33 degrees C and 30 degrees C (92 degrees F and 86 degrees F). When shivering ceases, the battle to maintain the proper internal body temperature has been lost, and the stowaway will need medical assistance to recover. Muscle rigidity develops, the pupils dilate and the pulse rate decreases.[5] "Body temperature in hypothermia can fall to levels of 27 degrees C [81 degrees F] or lower," the report said.

The report noted that to survive severe hypoxia in the unpressurized wheel well of a cruising airliner, physiologic control mechanisms place the body into a state similar to

Table 2
Wheel-well Environmental Characteristics, by Altitude

Altitude meters	Altitude feet	Atmospheric Pressure (millimeters of mercury)	Partial Pressure of Oxygen (millimeters of mercury)	Temperature C°	Temperature F°
12,200	40,000	141	30	-65	-85
9,150	30,000	226	47	-45	-49
6,100	20,000	349	73	-25	-13
3,050	10,000	523	110	-5	23
0	0	760	160	15	59

Source: U.S. Federal Aviation Administration Civil Aeromedical institute hibernation. In this condition, the thermoregulatory center of the brain (nerve cells in the preoptic anterior hypothalamus) is inactivated, and the body temperature is determined by the external environment. During this hibernation-like state the body's oxygen requirement greatly diminishes. As the body curls into a fetal position to conserve heat, the heart rate may be as low as two beats per minute and breathing rate as low as once per 30 seconds.[4]

In addition to hypoxia and hypothermia, stowaways risk developing decompression sickness (DCS) and nitrogen gas embolism (the sudden obstruction of a blood vessel) at altitudes above 6,100 meters (20,000 feet), the report said. DCS is caused by the expansion of free gases in certain body cavities (e.g., abdominal region and sinuses), causing great pain in those areas. Nitrogen gas bubbles forming in blood and tissue fluids can cause neurological problems, intense pain in muscles and joints and other symptoms.[7]

The report suggested that youthful, thin individuals are less likely to develop DCS during unpressurized, high-altitude flight than are heavy-set and older individuals.[8,9] Variables such as age, body composition and other physiological complexities make it impossible to determine when DCS will occur in an individual. Generally, there is a lack of DCS symptoms from sea level to 3,965 meters (13,000 feet). Incidence of DCS rapidly increases between 6,100 meters and 7,625 meters (20,000 feet and 25,000 feet), and the incidence level varies from 80 percent to 100 percent at altitudes above 9,150 meters (30,000 feet).[10]

The report noted: "As a wheel-well stowaway is carried to lower altitudes, a gradual rewarming occurs, along with reoxygenation. If the individual is so fortunate as to avoid brain damage or death from the hypoxia, hypothermia, cardiac arrest or failure on rewarming, or severe neurovascular DCS complications, some progressive recovery of consciousness occurs ... . Survival is jeopardized if the recovering stowaway begins moving … and falls out when the landing gear is lowered."

Although researchers understand the physiological effects of hypoxia, hypothermia and DCS individually, the combination of all three elements, and factors that contribute to an individual's survival under such conditions, has yet to be studied.[11]

Some pilots who have been involved in these wheel-well passenger incidents commented that the gear had not properly retracted, requiring the gear to be cycled several times. In at least one instance, upon landing, a lone wheel-well passenger indicated that he had been accompanied by another stowaway at the beginning of the flight.[11] That suggests the possibility that a stowaway can be killed in the process of landing-gear retraction, perhaps damaging the landing gear.

Although it is not known to have occurred, these stowaway flights suggest that a criminal could place a bomb in a wheel well.

Pilots should be vigilant during taxi operations that require several stops along the ramp and while holding for takeoff at the departure runway to prevent stowaways from attempting to board wheel-well areas, the report said.♦

Editorial note: This article was adapted from *Survival at High Altitudes: Wheel-Well Passengers*, by Stephen J.H. Véronneau, Stanley R. Mohler, Anthony L. Pennybaker, Bruce C. Wilcox and Farhad Sahiar. Report no. DOT/FAA/AM-96/25, dated October 1996, includes tables, figures and a list of key references.

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