The Mystery:
Why does the forward lower lobe cargo door rupture/open in flight?

There is a time for conjecture, speculation and just plain guessing. Now is that time. The investigation is open and active into TWA 800. Based upon the available evidence, observed events, experience, education, and some common sense, here are some possible explanations for why the forward cargo door of the Boeing 747 ruptures/opens in flight:

Principle: Balloon expands. Balloon pops. Why.
Fuselage undergoes internal pressure. Door pops. Why.
Boundary layer will reduce the actual speed of the air across the door to a very low amount. Further away from the door the airspeed builds up. The sucking force of the jet engine is negligible. The main force to open door comes from within. The internal pressure against the large forward cargo door is very, very high. The door will have to be open some distance before the slipstream can tear it open, up, and away.
All that is needed for the door to be pulled out and torn up and away is a lip of the door to protrude into airstream. A slight bulge on a worn door will stick door edge out into 300 KCAS slipstream and allow the air to pull door out and tear it away. What can cause the door edge to stick out? How much is needed? Assuming 300 KCAS of force over the door, high internal pressure to keep passengers comfortable, the edge of the door does not have to stick out very far before being pushed from within, and blown from the front. Let us assume two inches sticking out from the bottom of the sill is the amount than once reached the forces of wind take over and tear eight foot by nine foot door away. What would cause bottom of door to extend out two inches?

The midspan latches have no locking sectors at all so the modification does not apply to them at all. Is it not strange that the risk of latch cams becoming unlatched, and they have several times, is so great as to warrant locking sectors yet the two side midspan latches have none? And each of them holds in more door sill than the lower latches. That is an astonishing discovery: no locking sectors on all Boeing 747 forward cargo door latches which have rupture evidence at that midspan latch as shown on UAL 811 recovered door.

The absence of locking sectors for the midspan latches and the AD to strengthen the eight locking sectors for the lower eight latch cams explains much.

It probably solves how the forward cargo door of AI 182 and TWA 800 ruptured at aft midspan latch while the bottom latches remained latched in place: that is the locking sectors did their job on those two doors and prevented the eight lower latch cams from being driven into the unlatched position when chafed wires shorted and turned door motor on. Unfortunately the midspan latches had no such protection and were driven into the unlatched position enough for the internal pressure to rupture at that now weakened area leaving similar shattered door pieces and bottom latches still attached to lower sill for AI 182 and TWA 800.

For UAL 811 and Pan Am 103, the soft, pre-AD, locking sectors were overridden by door motor and all ten latches were driven into the unlatched position allowing the door to open completely and slam upward, breaking in two and tearing away, leaving the identical pattern of torn away fuselage skin and door broken in half longitudinally at midspan latches for each door.

Four aircraft, four door motors to unlocked position, two locking sectors held and two didn't; two partial openings/ruptures and two total openings as reflected in the reconstructions and photographs of wreckage. AI 182 and TWA 800 had locking sectors hold so ruptures. PA 103 and UAL 811 had locking sectors overridden so entire door opened and came off.

1. Pneumatic: If the air keeps on coming into the balloon and less air escapes the balloon expands until pressure inside balloon exceeds strength to contain pressure. Balloon pops at weakest spot on surface.
a. If air keeps coming into Boeing 747 fuselage with less air escaping, the fuselage will pop at weakest spot, a large door. Or if there is a small opening in fuselage, air may escape or air may enter from 300 KCAS airstream until door bulges out. If a hole appears in a seal of the cargo compartment, or a hole appears from corrosion, the 300 KCAS airstream might enter compartment and highly pressurize to cause door to bulge out the necessary small amount to allow a larger hole to allow more airstream to enter and the cycle continues rapidly until door is open enough for wind to tear it away. All the steel latches in the world are not strong enough to withstand 300 KCAS against a large surface door.
b. If the fuselage is balanced in pressure and the aircraft starts to climb that balance is disrupted and the system attempts to compensate. If the compensation is not smooth, or it is jerky, a surge of high pressure air may momentarily bulge out the door the required amount for it to be torn away. The puff off high pressure air may only last for a seconds before the pressurization system corrects its balance but that may be long enough to open a worn door with gouged latch cams and lock sectors. So, if there is a malfunction in pressure regulating devices of 747 then too much air may enter and may bulge worn door out enough to be torn away.

c. If older fuselage flexes enough the worn seal on a worn door may leak allowing air to enter cargo compartment pressurizing it and pushing out on door which opens more allowing more air in to pressurize compartment which pushes out on door...
d If pilot applies power to all engines, increased air requirements result in increased sucking power of jet intakes which may allow cargo door to bulge toward engine number 3, just a few yards away. Very unlikely because of 300 knot slipstream which negates any suction of the jet engine on the door.
e. The midspan latches may be a weak area. One latch holds eight feet of vertical side of door in tight. The door may fracture/rupture at midspan and open. The bottom latches may remain latched. Fuselage distortion and twisting may put unusual stresses on door frame.
f. Engine cowling comes loose. Possible sequence: EPR/EGT indication of surge as loose cowling on number three comes off, shown as radar blip, bleed air from three affected, more heat/air goes into forward cargo compartment, overpressure blows out weakest area, around or through cargo door. Nose then comes off sequence follows as evidence shows. All suspect planes have JT9D. Cowlings have come off many times before. Cowling would explain radar blip too early in sequence for door. Cowling reflects light. Engine bleed air comes from three and others and goes into forward cargo compartment. Ducts fail. Blow out around/of door would explain latches being latched yet door goes.

2. Electrical:
a. Door actuator motor gets signal to open and turns cams which are normally stopped by lock sectors, but worn lock sectors allow cams to turn just a few degrees which allow door to slightly open.
b. Frayed wires in door motor bundle rub against metal fuselage and short connection and turn motor on for a few seconds.
c. Motor gets signal to turn on from adjacent powerful transmitters in main equipment compartment.
d. Exhaust Pressure Ratio related problem:
800 had EPR changed before fatal flight
103 had EPR blip on #3 just before crash.
182 had EPR gripe not fixed for fatal flight.
811 could have had EPR gripe but all non cargo door gripes omitted from report.

3. Mechanical:
a. The cam sectors are not completely over center and therefore can be forced open by internal force.
b. The manual locking handle jams and looks locked but isn't.
c. The locking sectors get bent and do not fully engage cam sectors.
d. Something unseen is jammed between door and frame preventing full closure.

e. Loader rams door sill and bends it out of rig preventing flush closure.

4. Combination of factors:
a. Worn latches, not tight.
b. Worn lock sectors, not tight.
c. Not closed fully, not tight.
d. Pressure regulating system not smooth.
e. Door out of rig slightly, not tight.
f. Electrical short in door open system.
g. Must be going 296 KCAS or higher.
e. Older fuselage twisting and flexing.
f. Small hole from corrosion or worn seal allowing high speed air in with no way out.
g. Door motor gets signal to open.

Miscellaneous:
a. It is never closed fully and pops open when pressure differential is high enough.
b. It was backdriven manually damaging cams allowing door to spring open.
c. It was back driven electrically damaging lock sectors.
d. Fuselage flexing normal or by turbulence allowed door to spring open.
e. Electrical short within door opening system turning on door actuator motor.
f. Loose heavy cargo shifts into door.
g. Internal explosive force against door.
h. Locking pins shearing and releasing door to open.
i. Intentionally/unintentionally opened by crew inflight.
j. Electrical power surge from communication radio antenna or power supply.
k. Frayed electrical wires to door control system shorting on fuselage.
l. Passenger using electronic device triggering door open signal.
m. At certain airspeed the wind has enough force to pry open poorly sealed door.
n. When door closed it squeezed against something that prevented full closure allowing later opening.
o. A ship or aircraft was pointing laser tracking device on aircraft and it penetrated door and ignited something which blew out door.
p. Surface to air missile hits door and opens it.
q More to come...open for suggestions, can't fix it without knowing the problem, can't stop the effect of crashing without knowing the cause of door rupture/opening.

United Airlines Flight 811:
Contributing Factors:

First AAR had wrong cause for door opening, improper latching. Once door was found, a switch was found to be defective changing probable cause to electrical short.
Frayed wires in door motor control bundle.

Air India Flight 182:
Contributing Factors:

Airspeed crept up to above recommended speed, 296 knots instead of 290 knots because of fifth engine in pod.

Pan Am Flight 103:
Contributing Factors:

Older airplane, night door closing

Trans World Airlines Flight 800:
Contributing Factors:

Extremely old airplane, night door closing, running late.

Design considerations for a forward cargo door on a Boeing 747

The first rule in designing and building a pressurized hull is: Don't cut holes in it. If one must cut holes in the hull for essential reasons make sure the holes are small well sealed. And then if the hole fails to seal, make sure the hull does not come apart.
Those principles were violated in aircraft and submarines to the dismay of the families of the victims of inadvertent door openings in pressurized hulls.
The nuclear submarine Thresher was sunk because a small hole in the hull had a valve installed backwards so the water kept on coming in and sunk the boat and killed everyone on board.
UAL Flight 811 had a cargo door open inflight and nine passengers were sucked out to their deaths from their seats above the cargo door.
The design errors on doors for Boeing 747 are as follows.
1. The hole is too large. It is large to accommodate passengers' spare clothes and other non-essential items. A small hole will depressurize slowly and not allow huge amounts of fast moving air into the hull.
2. The hole has a complicated door system for locking and unlocking which is prone to misuse. In fact two Airworthiness Directives have been issued against that specific door, the forward lower lobe cargo door.
3. a. The door is hinged on top and opens upwards. The tradition of passengers entering by a front hinged door and baggage loaded into a top hinged door goes back to stagecoaches, buggies, cars, trains, and buses. And when those cargo doors opened the penalty was bashed baggage and damaged doors. At speeds above 200 knots such an error has catastrophic results. The door opens and the airstream pushes the door up and tears it off it upper hinges taking away as large part of fuselage skin, exposing the nose of the aircraft to huge amounts of powerful fast moving air. Top hinged doors on fast moving pressurized hulls is a fatal design error. They also exist to ease the loading of the non-essential items by the baggage handlers.
b. Doors hinged on the front are slightly better but the door will still flap around and eventually break off leaving a large hole. The air pressure will attempt to keep the door closed. A front hinged door, when it opens in flight, will at least give the crew time to slow the airplane down to reduce flutter and possibly allow safe return to land.
Cargo doors, and passenger doors, and engine doors, and access doors will all be left open or open by themselves sooner or later. The effect should be mild and easily corrected. The consequences for that small oversight should not be total destruction and death.

Doors

1. Big Airplane Doors that open when they shouldn't.
Forward lower cargo door in Boeing 747 resulting in nose tearing off and rest of airplane disintegrating into fireball. Cause of door opening unknown.
2. Medium airplane canopy that opened when it shouldn't.
RA-5C Vigilante reconnaissance carrier jet on final approach and rear canopy popped up and was lost at sea. Aircraft recovered safely. Thousands of dollars lost, plane grounded until replacement, cause unknown.
3. Small airplane doors that open when they shouldn't.
Right hand side passenger door on Beech Baron. On takeoff door popped open. Experienced passenger held door tight to keep it from flapping. Pilot returned and landed. Door closed and airplane resumed flight. Two months later same plane took off with different pilot, immediately went into steep climb, stalled, crashed, two killed, pilot and inexperienced passenger. Cause unknown.
4. Spacecraft door that opened when it shouldn't.
Gus Grissom on a Mercury spacecraft after landing in water and hatch popped and craft sank. Valuable scientific data lost. Cause unknown.
5. Car door open when it shouldn't.
Rear hatchback on 1984 Honda Civic opened. Car stopped and hatchback closed. No damage. Cause was driver error in not slamming hatch shut.
6. Submarine valve open when it shouldn't.
USS Thresher valve installed backwards, water entered and couldn't be stopped. Ship sank, all aboard killed. Cause installation error.
7. House door open when it shouldn't.
After evening out occupants returned home to find front door unlocked and open. Cause negligence of home owners leaving in a rush and door open.
8. Motorcycle saddlebag open when it shouldn't.
Kawasaki Concours sport tourer motorcycle right side saddlebag had top two clasps only partially closed. Error noticed in mirrors, stopped, closed clasps on saddlebag and resumed ride. No damage, cause was rider negligence.
9. Ferry door that opened when it shouldn't.
An Estonian ferry between Tallin and Helsinki had front cargo door open, sank ferry, high loss of life. Cause was pilot going too fast in heavy seas. Wreck to be encased in concrete on seabed.
10. Car door that closed when it shouldn't.
1949, car door slammed on finger disfiguring tip for life. Extreme pain. Cause miscoordination between person slamming door and person with fingers in the way.
11. Spacecraft door that wouldn't open when it should.
Apollo 1 capsule caught on fire on ground and crew could not escape because hatch would not

open. Three killed.
12. House door that shut when it shouldn't.
Hot day and doors open to let in air and breeze came up. Air flow started closing door which accelerated and slammed shut with loud bang waking baby.
13. Door stayed shut and wouldn't open when they should.
Cocacabana nightclub fire, exits blocked, many died. Doors sealed shut to prevent unauthorized entry.

Comment: The distinct crash similarities of aircraft type, radar returns, wreckage plot, sudden short loud sound, abrupt power cut, fodded engines, inflight damage, missing bodies, torn off noses, and start place of damage qualify three aircraft into one class from which the deduction may be made that one unifying cause had the same effects. Another accident with the same similarities except for a torn off nose and less wreckage may also be included in that class. The unifying cause for all four accidents is the inadvertent rupture/opening of the forward cargo door inflight. 27 Mar 97 3 May 97 14 Sep 97 2 Nov 97

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