National Aeronautics and Space Administration

SYSTEM FAILURE CASE STUDIES

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Got Any Ideas?

When the 155 passengers and crew members aboard U.S. Airways Flight 1549 left New York City on a cold day in January 2009, no one anticipated the drama that was about to unfold. Takeoff proceeded normally, but when the aircraft climbed to 3,200 feet, a flock of migratory geese crossed its flight path. Each of the Airbus A320's turbofan engines ingested a goose and subsequently suffered damage that disabled its thrust-producing capability. Unable to return to the airport and left without other landing options, the flight crew valiantly ditched the plane in the Hudson River. Seconds after the aircraft skidded onto the frigid water, passengers evacuated onto the wings and waited for rescue (Figure 1). Within minutes, commuter ferries and Coast Guard vessels arrived at the scene where they rescued the airplane occupants: shivering, shaken, but alive.

Figure 1: Passengers and crew members of U.S. Airways Flight 1549 stand on the aircraft wings and slide/rafts as they wait to be rescued.

Background

Engine Structure and Testing

The FAA National Wildlife Strike Database shows that bird strikes have caused 229 deaths in civil and military aviation between 1998 and 2009. Because bird strikes can result in catastrophic engine damage, the FAA requires aircraft engines to undergo bird ingestion tests before becoming certificated. To receive certification, the Airbus A320's two turbofan engines were required to have a 2½ pound bird volleyed into the engine core followed by four 1½ pound birds volleyed toward other areas of the fan disk. To pass the tests, the engines were required to remain operational at 75% power for more than five minutes after the bird ingestion. In 1996, the engines that would later be used on U.S. Airways Flight 1549 were certificated for bird ingestion according to these standards. In 2007, the FAA adopted new regulations regarding bird strikes, and the new rules increased the size of the birds used in the core tests to 5½ pounds. However, engines certificated prior to 2007 were not obliged to meet the new requirements.

Aircraft Controls

The Airbus A320 is not equipped with a conventional control yoke. Instead, pilots use a sidestick to fly the aircraft. Sidestick inputs are analyzed by an electronic interface called a fly-by-wire system designed to prevent the aircraft from executing maneuvers outside of its performance limits. It does this by attenuating pilot commands and activating hydraulic flight control surfaces through electrical signals. As long as the system is set to "Normal Law," the flight computer keeps the aircraft within a safe flight envelope with respect to roll, pitch, yaw, and speed. Normal Law includes "alpha-protection" (α-prot), which prevents the aircraft from stalling.

The airspeed display in the A320 cockpit is depicted in Figure 2. Green Dot speed represents the speed at which the aircraft must travel to obtain the best lift over drag ratio, allowing the maximum range for a glided flight. V_{LS} is the lowest selectable

Pilots Ditch Passenger Jet in Hudson River; All Occupants Survive.

Proximate Causes:

- **Bird strikes critically damage core in both engines**
- **Pilot approaches landing below optimum gliding airspeed**
- **Low airspeed increases descent rate, damages fuselage**
- **Water-rated aircraft remains afloat long enough for rescue**

Underlying Issues:

- **In-Flight Engine Diagnostics**
- **Emergency Event Checklist Design**
- **Simulation Training**