

## 3. Conclusions

### 3.1 Findings

1. The flight crew was properly certificated and qualified and had received the training and off-duty time prescribed by Federal regulations. No evidence indicated any preexisting medical or behavioral conditions that might have adversely affected the flight crew's performance during the accident flight.
2. The airplane was certificated, equipped, and dispatched in accordance with Federal regulations and approved TWA procedures.
3. At the time of the accident, there were light winds and scattered clouds in the area, but there were no significant meteorological conditions that might have disrupted the flight.
4. The in-flight breakup of TWA flight 800 was not initiated by a preexisting condition resulting in a structural failure and decompression.
5. The in-flight breakup of TWA flight 800 was not initiated by a bomb or a missile strike.
6. The fuel/air vapor in the ullage of TWA flight 800's center wing fuel tank was flammable at the time of the accident.
7. A fuel/air explosion in the center wing fuel tank of TWA flight 800 would have been capable of generating sufficient internal pressure to break apart the tank.
8. The witness observations of a streak of light were not related to a missile, and the streak of light reported by most of these witnesses was burning fuel from the accident airplane in crippled flight during some portion of the postexplosion preimpact breakup sequence. The witnesses' observations of one or more fireballs were of the airplane's burning wreckage falling toward the ocean.
9. The TWA flight 800 in-flight breakup was initiated by a fuel/air explosion in the center wing fuel tank.
10. Boeing's design practice that permits parts less than 3 inches long in any direction to be electrically unbonded may not provide adequate protection against potential ignition hazards created by static electricity generated by lightning or other high-energy discharges.

11. It is very unlikely that the flammable fuel/air vapor in the center wing fuel tank (CWT) on TWA flight 800 was ignited by a lightning or meteor strike; a missile fragment; a small explosive charge placed on the CWT; auto ignition or hot surface ignition, resulting from elevated temperatures produced by sources external to the CWT; a fire migrating to the CWT from another fuel tank via the vent (stringer) system; an uncontained engine failure or a turbine burst in the air conditioning packs beneath the CWT; a malfunctioning CWT jettison/override pump; a malfunctioning CWT scavenge pump; or static electricity.
12. Electromagnetic interference from radio frequency sources external to TWA flight 800 did not produce enough energy to ignite the fuel/air vapor in the center wing fuel tank.
13. Electromagnetic interference from personal electronic devices played no role in igniting the fuel/air vapor in TWA flight 800's center wing fuel tank.
14. It is unlikely that electromagnetic interference from aircraft system wiring played a role in igniting the fuel/air vapor in TWA flight 800's center wing fuel tank.
15. Existing standards for wire separation may not provide adequate protection against damage from short circuits.
16. A short circuit producing excess voltage that was transferred to the center wing tank (CWT) fuel quantity indication system wiring is the most likely source of ignition energy for the TWA flight 800 CWT explosion.
17. Silver-sulfide deposits on fuel quantity indication system components inside fuel tanks pose a risk for ignition of flammable fuel/air vapor.
18. The ignition energy for the center wing fuel tank (CWT) explosion most likely entered the CWT through the fuel quantity indication system (FQIS) wiring, and, although it is possible that the release of ignition energy inside the CWT was facilitated by the existence of silver-sulfide deposits on an FQIS component, neither the energy release mechanism nor the location of the ignition inside the CWT could be determined from the available evidence.
19. Failure modes and effects analyses and fault tree analyses should not be relied upon as the sole means of demonstrating that an airplane's fuel tank system is not likely to experience a catastrophic failure.
20. A fuel tank design and certification philosophy that relies solely on the elimination of all ignition sources, while accepting the existence of fuel tank flammability, is fundamentally flawed because experience has demonstrated that all possible ignition sources cannot be predicted and reliably eliminated.
21. Operating transport-category airplanes with flammable fuel/air mixtures in fuel tanks presents an avoidable risk of an explosion.

22. The placement of heat-generating equipment under a fuel tank containing Jet A fuel can unnecessarily increase the amount of time that the airplane is operating with a flammable fuel/air mixture unless measures are in place to either (1) prevent the heat from entering the center wing fuel tank (CWT) or (2) eliminate the flammable vapor inside the CWT.
23. The condition of the wiring system in the accident airplane was not atypical for an airplane of its age, and the airplane was maintained in accordance with prevailing accepted industry practices.
24. Until recently, insufficient attention has been paid to the condition of aircraft electrical wiring, resulting in potential safety hazards.
25. The issues defined in the Federal Aviation Administration's Aging Transport Non-Structural Systems Plan are important safety issues that must be fully addressed through appropriate changes, including rulemaking.

### 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system.

Contributing factors to the accident were the design and certification concept that fuel tank explosions could be prevented solely by precluding all ignition sources and the design and certification of the Boeing 747 with heat sources located beneath the CWT with no means to reduce the heat transferred into the CWT or to render the fuel vapor in the tank nonflammable.