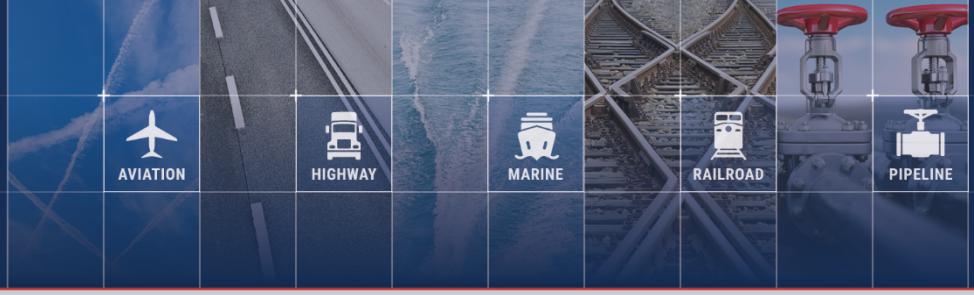

Aviation Investigation Factual Report

Location:	CHICAGO, Illinois	**Incident Number:**	CHI96IA200
Date & Time:	June 14, 1996, 01:18 Local	**Registration:**	N906UP
Aircraft:	Boeing 727-30C	**Aircraft Damage:**	None
Defining Event:		**Injuries:**	3 None
Flight Conducted Under:	Part 91: General aviation - Positioning		

Factual Information

HISTORY OF FLIGHT

On June 14, 1996, at 0118 central daylight time (cdt), a Boeing 727-30C, N906UP, operated as United Parcel Service (UPS) flight 9601, experienced a total loss of power on all three engines, and a subsequent loss of electrical generating power, during an en route descent in preparation for landing at Greater Rockford Airport, Rockford, Illinois. The crew declared an emergency and diverted to Chicago, Illinois. A landing was made at Chicago O'Hare International Airport with all engines operating and electrical generating power restored. Night visual meteorological conditions prevailed at the time of the incident. The positioning flight was being conducted under 14 CFR Part 91. An IFR flight plan was on file. No injuries were reported by the three flight crew members, and no damage to the airplane occurred. The flight originated at Louisville, Kentucky, at 0017 cdt.

The flight crew stated that the airplane lost engine power after beginning a descent from 22,000 feet mean sea level (MSL). The power was not restored to the engines until the airplane was on the approach to runway 32R (10,000' x 150') at the O'Hare airport, and approximately 1,000 feet above the ground. Emergency electrical power was available to the crew throughout the descent. The crew reported normal indications throughout the flight until beginning the descent for landing. The flight engineer said that prior to the descent, he had configured the fuel system to crossfeed between the fuel tanks, so as to reduce a slightly higher fuel quantity indication in the right wing tank, and level the fuel amounts in all three tanks. The crew stated that the fuel boost pumps in the center tank were turned off before the crossfeed valve was opened for the number two engine fuel lines. The crew indicated that the crossfeed valves to the other two fuel manifolds may have been activated shortly after. The first indication of a malfunction was the simultaneous failure of all three of the generators.

A Systems Group was formed on June 14, 1996. The group conducted an examination of the airplane at the UPS base at Chicago O'Hare Airport. The group concluded their field examination on June 27, 1996. A copy of the Systems Group Chairman's Report is attached as an addendum to this report.

AIRCRAFT INFORMATION

The airplane was a Boeing 727-30C, N906UP, serial number 19314, owned and operated by United Parcel Service. The airplane had been modified under Supplemental Type Certificate (STC) Number SA8472SW, issued on November 25, 1992, for installation of three Rolls Royce Model TAY 651-54 engines, and Dee Howard Company TR6510 thrust reversers, by Dee Howard Company of San Antonio, Texas. A copy of the STC Number SA8472SW, the type certificate data sheet, and the Federal Aviation Administration (FAA) STC issue paper are

attached as addendums to this report.

The airplane was referred to by UPS as a Boeing 727-100QF.

FLIGHT RECORDERS

The Digital Flight Data Recorder (DFDR), was removed from the incident airplane and sent to the NTSB's Vehicle Performance Laboratory for readout and evaluation. A successful DFDR readout was performed. The report of that readout is attached as an addendum to this report.

The DFDR data indicated that prior to the recorded power loss, N906UP was at 20,000 feet MSL, in a slight descent, heading 315 degrees, and with N1 values on all three engines steady at 36 percent. This was the last recorded data before the power loss occurred on the DFDR. The next recorded event of the DFDR was with the aircraft at 1,600 feet MSL, pitch 3 to 5 degrees nose up, and all engines showing an N1 of near zero (0) percent. Approximately 45 seconds after the recorder power was restored, the number 2 and 3 engines rapidly spooled up (over an elapsed time of 5 seconds) to an N1 of 93 percent. The number 1 engine followed 20 seconds later. The DFDR recorded a landing at the O'Hare Airport approximately 50 seconds later.

The recorded data received from the DFDR was verified for accuracy by examining previous performance of the airplane also recorded on the medium. This was done in order to determine if the data received by the recorder was consistent with takeoff, cruise, and normal landing characteristics of the aircraft. The data was found to be consistent with the normal operation of the aircraft.

There was no usable data on the Cockpit Voice Recorder (CVR).

TESTS AND RESEARCH

Subsequent to the incident, the airplane was subjected to a detailed inspection. There was no apparent damage to the airplane, its systems, or associated controls. At the inception of the investigation, the engine controls and switches were found in the normal shutdown positions. The aircraft pneumatic systems were examined for failures or malfunctions. During ground tests, the pneumatic systems functioned normally. The engine instruments were examined for failures or malfunctions. The instruments operated normally during the ground tests. Examination of the engine controls did not reveal any miss- rigging, malfunctions, or failures. The flight instrumentation system showed no apparent damage. The flight controls were examined for rigging, deflection, and malfunctions. They operated normally during ground tests with no malfunctions noted.

The electrical system's examination revealed no apparent damage. During ground tests, the three engine driven generators and the Auxiliary Power Unit operated normally. Examination of the circuit breaker panels revealed no evidence of malfunction. The hydraulic system was

examined for evidence of malfunction or failure; none was found. The powerplants were examined for evidence of fire, failures, leaks, or other malfunctions. No evidence was found that would indicate any malfunctions.

The airplane had been converted by a Supplemental Type Certificate (STC) to remove the original powerplants and install Rolls Royce Tay 651-54 engines and Rolls-Royce supplied engine accessories. The original fuel tanks, lines, valves, manifolds, boost pumps, and filters remained.

The airplane fuel system consists of three tanks; a left, right, and center fuel tank. In normal operations each tank feeds a respective engine; i.e., right tank to right engine, etc. Each tank contains multiple fuel boost pumps, a single fueling port for all tanks, a fuel dump valve, a crossfeed valve, associated lines, check valves, and quantity indicating system components. There are two fuel shutoff valves for each powerplant in the fuel system; one airframe mounted engine shutoff valve, and one high pressure fuel shutoff valve on its associated engine.

The fuel system crossfeed valves and plumbing allow fuel to be selected from any tank to feed any of the three powerplants through a crossfeed manifold. Fuel cannot be transferred from tank to tank. According to the holder of the STC, modifications did not alter any of the original fuel system components.

The fuel tanks were inspected for blockage, debris, and other abnormalities. The individual fuel lines, fuel boost pumps, fuel manifold valves, and check valves were pressure tested, inspected, then operationally tested, with no anomalies found. Each of the individual boost pumps were isolated from their respective systems and tested with normal indications.

Ten uninstrumented flight tests were conducted on the incident airplane and two other UPS B-727 airplanes with the Rolls Royce Tay 651-54 engine conversion, between June 28, 1996 and July 10, 1996. Parameters for the flight tests were established so as to protect one engine from flameout when attempting to duplicate the scenario as best recalled by the flight crew on the morning of June 14, 1996. In all but the first flight, the crews were able to duplicate multiple engine flameouts at different altitudes, and with the airplane's fuel system set in various configurations. In the first flight, the airplane was not configured properly to duplicate the engine flameout scenario. An eleventh uninstrumented flight test was conducted on July 14, 1996, with a UPS B-727, which had not undergone the Rolls-Royce Tay 651-54 engine conversion. Using the same test parameters established for the previous 10 flight tests, the flight crew was unable to produce any flameouts in the three Pratt and Whitney JT8D-7 engines.

The flight tests reproduced the scenario of what occurred en route to Chicago, Illinois, on June 14, 1996. First, the number one engine was protected by closing the number one crossfeed valve and keeping the number one engine at cruise power. Next, the number two engine boost pumps were turned off, and the number two crossfeed valves were closed. The number three

boost pumps were confirmed "on" and the number three crossfeed valve was opened. Power on the number two engine was reduced to idle and allowed to stabilize for 3 to 5 minutes. Next, the number three engine's power was retarded to idle. The number two crossfeed valve was then opened. The result was consistently the near simultaneous flameouts of number two and three engines. This test sequence usually produced the same results at varying altitudes between 8,000 and 39,000 feet MSL.

On August 1, 1996, it was determined by the FAA, the Dee Howard Company, UPS, and Rolls Royce, that a series of tests, to include on-ground engine and fuel system rig tests, and instrumented flight tests, would be conducted to determine the cause of the engine flameouts, and to develop a hardware modification to the airplane's fuel system/engines, to prevent multiple engine flameouts in various fuel system configurations.

Between August 1, 1996, and May 7, 1997, numerous rig tests and instrumented flight tests were conducted to determine the cause of the multiple engine flameouts. The results of these tests consistently revealed that when the B-727 fuel system is configured with one engine operating in suction feed, air and vapor evolve from the fuel in the engine and airplane fuel systems. The air and vapor accumulate at fuel system high points and at the inlets to the engine's high pressure and low pressure pumps (the areas of lowest pressure). When boosted fuel is restored to the system, either by turning the tank boost pumps to "on" or by opening a crossfeed valve, there is rapid filling and recompression of these air and vapor areas. This results in a high flow velocity as the fuel flow rate moves toward the high end of the boost pump output capacity. The fuel is then decelerated to "engine demand flow rate" as it reaches the engine high-pressure fuel pump. This change in the velocity of the fuel flow causes a "pressure spike" which is first observed at the inlet to the engine high-pressure fuel pump. The formation of the pressure spike is accompanied by a rapid drop in engine high- pressure fuel pump output and fuel burner line pressures leading to a collapse in engine combustor discharge pressure and engine flameout. The formed pressure spike travels from the first engine back through the airplane's fuel system into the other exposed engines causing these engines to flameout in a similar manner. The elapsed time at which the pressure spike travels back through the fuel system to the other engines is just under one second. A copy of the Flameout Mechanism Report produced by the Dee Howard Company is an attachment to this factual report.

ADDITIONAL INFORMATION

Subsequent to the incident and initial testing, the Federal Aviation Administration (FAA) and the Dee Howard Company reviewed the UPS-Boeing 727 Airplane Flight Manual Supplement. Revisions to the Limitations Section and to several operating procedures were recommended. UPS incorporated these revisions as changes to the checklists and Aircraft Operating Manual (AOM) procedures. Crews are instructed to maintain positive fuel pressure to all engines at all times, and are given alternate procedures to prevent flameouts in the case of a loss of fuel pressure to the engines. Copies of the revised documents are attached as an addendum to this report.

An Operations Group was formed during the investigation on June 17, 1996. Interviews of the flight crew members, examination training records, examination of ATC tapes, and examination of aircraft maintenance records were conducted in Chicago, Illinois, through June 20, 1996. A copy of the Operations Group Chairman's Report is attached as an addendum to this report.

A technical review meeting made up of the parties to the investigation was convened at the Dee Howard Company, San Antonio, Texas, on November 13, 1998. The meeting was chaired by the NTSB. In attendance were three representatives from United Parcel Service, two representatives from Rolls Royce, six representatives from the Dee Howard Company, and three representatives from the FAA Southwest Region Airplane Certification Office. Summaries of the rig and flight tests were presented, as were two hardware solutions to the triple-engine flameout mechanism; in-line suppressors, and pressure relief valves. At the time of the meeting, two vendors had been identified to produce the hardware for flight testing, to begin in January 1999. A flight test and certification schedule is attached as an addendum to this report.

Parties to the investigation were the FAA Flight Standards District Office, Schiller Park, Illinois; the FAA Southwest Region Airplane Certification Office, Ft. Worth, Texas; United Parcel Service, Louisville, Kentucky; the Boeing Aircraft Company, Seattle, Washington; Rolls Royce of London, England; Dee Howard Company, San Antonio, Texas; and the Independent Pilots Association, Louisville, Kentucky.

Pilot Information

Certificate:	Airline transport; Flight engineer; Flight instructor	**Age:**	34,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Glider	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Instrument airplane	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	January 30, 1996
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	10121 hours (Total, all aircraft), 105 hours (Total, this make and model), 5842 hours (Pilot In Command, all aircraft), 106 hours (Last 90 days, all aircraft), 28 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Boeing	**Registration:**	N906UP
Model/Series:	727-30C 727-30C	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	19314
Landing Gear Type:	Retractable - Tricycle	**Seats:**	4
Date/Type of Last Inspection:	June 13, 1996 Continuous airworthiness	**Certified Max Gross Wt.:**	142000 lbs
Time Since Last Inspection:	1 Hrs	**Engines:**	3 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	Rolls-Royce
ELT:	Not installed	**Engine Model/Series:**	TAY 651-54
Registered Owner:	UNITED PARCEL SERVICE CO	**Rated Power:**	15400 Lbs thrust
Operator:		**Operating Certificate(s) Held:**	Air cargo
Operator Does Business As:	UPS	**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night/dark
Observation Facility, Elevation:	KOR ,666 ft msl	**Distance from Accident Site:**	
Observation Time:	00:56 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Scattered / 5500 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	270°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29 inches Hg	**Temperature/Dew Point:**	23°C / 21°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	LOUISVILLE (SDF)	**Type of Flight Plan Filed:**	IFR
Destination:	ROCKFORD (RFD)	**Type of Clearance:**	IFR
Departure Time:	00:17 Local	**Type of Airspace:**	Class B

Airport Information

Airport:	CHICAGO O'HARE INTL. ORD	**Runway Surface Type:**	Concrete
Airport Elevation:	666 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	32R	**IFR Approach:**	ILS;Visual
Runway Length/Width:	10003 ft / 150 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	3 None	**Aircraft Damage:**	None
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 None	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	Bowling, David
Additional Participating Persons:	
Report Date:	October 22, 1999
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=10123