NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

April 26, 2004

Captain's Vertical Speed Indicator Simulation Study
DCA02MA054

A.   **ACCIDENT**

Location:	Tallahassee, Florida
Date:	July 26, 2002
Time:	0540 Eastern daylight time (EDT)
Aircraft:	FedEx Flight 1478, a Boeing 727-232, N497FE

B.   **SYSTEMS GROUP**

Chairman:	Tom Jacky
	National Transportation Safety Board
	Washington, DC

C.   **SUMMARY**

On July 26, 2002, at 0545 eastern daylight time, a FedEx B-727, N497FE, crashed on final approach to Tallahassee Regional Airport, Florida. The airplane was operating as Flight 1478 from Memphis, Tennessee, to Tallahassee. The airplane crashed short of runway 9, and was subsequently destroyed by impact and post-crash fire.

The annunciation of the captain's vertical speed indicator was simulated for the final approximately 4 minutes of the accident flight, from a pressure altitude of 2,000 feet to the end of recorded data. The purpose was to determine the indicated vertical speed at the 500' above ground level callout by the ground proximity warning system (GPWS). The flight data recorder (FDR) pressure altitude data was provided to the TCAS/VSI manufacturer. The manufacturer used the data to derive vertical speed data and use the data to simulate the annunciated vertical speed information. The simulation was recorded onto a CD ROM and presented to the systems group chairman.

The simulation revealed that, at the time of the GPWS 500' above ground level (AGL) callout, the indicated vertical speed was a descent of approximately 1,050 feet per minute.

D.   **DETAILS OF INVESTIGATION**

   1.   Description of Vertical Speed Indicator

The captain's vertical speed indicator (VSI) was a combined instrument, a Thales Avionics traffic alert and collision avoidance system/vertical speed indicator (TCAS/VSI) model number 457400PB1900, serial number 10,548. The post-crash fire destroyed the instrument, including the liquid crystal display (LCD) instrument face. The first officer's VSI was also a Thales Avionics TCAS/VSI, model number 457400PB1900, serial number unknown due to post-crash fire.

The VSI/TCAS indicator uses pin programming to accept various vertical speed sources (pneumatic, analog or digital), depending on the airplane-wiring configuration. For the accident airplane the captain's TCAS/VSI received information from the airplane's central air data computer (CADC) via an ARINC 429 Low Speed source. The first officer's VSI/TCAS used the airplane's static pressure source.

The pin programmed software for the captain's TCAS/VSI enabled the instrument to identify, accept and process Aeronautical Radio, Inc. (ARINC) 429 label 212 encoded vertical speed (11-bit binary encoding). The data is received at an update rate corresponding to ARINC 429, between 31.3 and 62.5 milliseconds. The TCAS/VSI uses a first order filter and a 4 second time constant to reduce data noise inherent with vertical speed data. The first officer's TCAS/VSI uses pin-programmed software to use a 5 second time constant for indication.

Once processed by the TCAS/VSI, vertical speed data is annunciated on the LCD display. The vertical speed value to be displayed is converted into an angular value for the pointer symbol (a needle). The display features a circular scale that is divided into arc-segments for positive and negative vertical speed values, with a display range from 6,000 to -6,000 feet per minute (fpm). The positive and negative vertical speed scales are divided in 4 linear sectors – from 0-1,000 fpm, 1,000-2,000 fpm, 2,000-4,000 fpm, and 4,000-6,000 fpm.

2.   Simulation of VSI/TCAS Annunciation For Accident Sequence

Pressure altitude, recorded by the FDR at a rate of once per second (1 Hz), was used for the simulation. The FDR pressure altitude time history was provided to the manufacturer in an electronic file format (in seconds from beginning of FDR transcription, and pressure altitude in feet). The pressure altitude was provided in units of feet mean sea level (MSL).

The TCAS/VSI instrument manufacturer conditioned the pressure altitude data to prepare for the simulation. The pressure altitude data were processed as follows:

1)   Interpolated to an update rate of 16 Hz.
2)   Interpolated data were differentiated into vertical speed data.
3)   Convert to vertical speed ARINC 429 low speed message label 212 data.
4)   Transmit ARINC formatted data to the VSI indicator in real time.

5)   Record the resultant displayed vertical speed values on a timed referenced digital video file.

The video simulation consisted of a computer screen with seconds until end of data, pressure altitude in MSL feet, and raw, unfiltered vertical speed with a 4-point running average. A VSI is presented next to the computer that shows the annunciated vertical speed via the needle movement.

The simulation was provided to the systems group via Microsoft Windows Media compatible video file on a CD ROM.
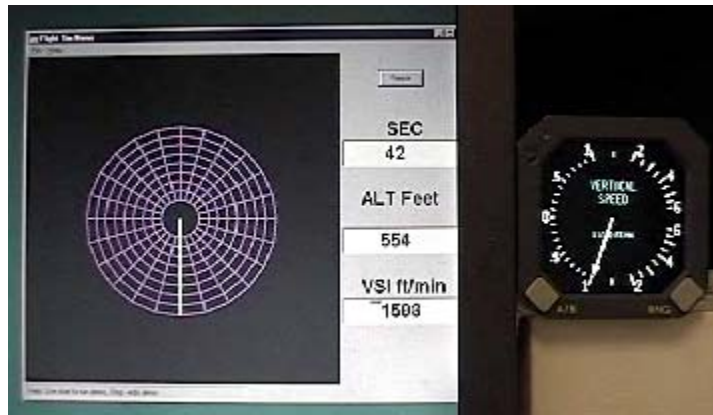

Figure 1. Picture of simulation at 500 ft AGL (554 ft MSL).

The 500' AGL callout by the GPWS was noted on the CVR transcript at 536:47.8 Local Time, with an FDR-recorded altitude of 554 feet MSL. According to the simulation, at the time of the 500' AGL callout, the following values were noted:

Captain's indicated vertical speed: ~1,050 fpm
FDR Altitude: 554 ft MSL
Smoothed, averaged, instantaneous vertical speed: 1503 fpm
Seconds until end of simulation: 42 seconds

For reference see Figure 1.

The simulation was unable to replicate any filtering or time-constant delays of the ADC.

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Attachment – Simulation of Vertical Speed Indicator during FedEx Flight 1478 Final Approach