ATTACHMENT 8

Report prepared for this investigation by Dr. Scott Meyer
(4 pages)

**DEPARTMENT OF THE NAVY**
**NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY**
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IN REPLY REFER TO:

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Subj: REVIEW OF ACCIDENT DCA-94-076

1. I have conducted aerospace medical research for the past fourteen years at the National Aeronautics and Space Administration, Houston, TX, and the Naval Aerospace Medical Research Laboratory, Pensacola, FL. My work has focused on the cardiopulmonary and musculoskeletal aspects of aviation physiology. Currently, I am the principal investigator on a Congressionally-funded project to evaluate muscular strength and anthropometric requirements for naval aviation. Previously, I headed a project that examined the components of pulmonary ventilation involved with breathing during air combat maneuvers under high $+G_z$ forces and the performance of anti-G straining maneuvers with naval jet pilots.

2. I have reviewed the crash of USAir Flight 427 on 8 September 1994 near Pittsburgh, PA (accident DCA-94-076). Based on the circumstances leading up to the accident, the transcript of the pilots' comments preceding the crash, the visual reconstruction of the accident, and the digital audio recording from the Cockpit Voice Recorder (CVR) of the last thirty minutes of the flight, my observations on the pilots' breathing and muscular exertion are provided.

3. The mechanics of breathing, or ventilation, are usually regulated by neural and hormonal factors for the purposes of oxygen and carbon dioxide exchange, the control of blood acidity, and oral communication. In normal, healthy individuals at rest, inhalation is an active muscular movement while exhalation is a passive response. The rapidity and depth of breathing affect the amount of oxygen and carbon dioxide exchanged between the atmosphere and the body. During exercise of increasing intensity, breathing rate increases first followed by increased depth of breathing.

4. The sounds of breathing (through the mouth) of the Pilot-in-command (PIC) are audible periodically throughout the tape. At several points during the first twenty-seven minutes of the tape,

the breathing rate of the PIC was measured at thirty breaths per minutes, which is higher than normal for an asymptomatic adult male of normal weight with no history of pulmonary problems. The depth of breathing appeared to be normal at those times. Normal sighs and yawns were heard at various times during the routine portion of the tape. After the onset of the emergency period, the rate of breathing of the PIC increased and, at one point, was close to sixty breaths per minute, or hyperventilation. However, the depth of the rapid breathing did not increase noticeably. There was an initial, large exhalation with the utterance "Jheez" in response to the first sudden, unusual movement of the aircraft at the start of the emergency sequence. That was followed shortly by a deep, rapid inhalation before the word "Whoa" was heard from the PIC, almost as if he was startled by the continued departure of the aircraft from normal flight. The breathing response of the PIC after the onset of the emergency appears to have been a normal sympathetic nervous system response that would include increased heart rate, breathing rate, body temperature, and blood pressure, all commonly observed in emergency situations. During the emergency period, his breathing was not strained or impaired by the occurrence of events.

5. The breathing of the First Officer (F/O) was inaudible throughout the routine portion of the tape. The emergency period starts with the F/O having just remarked that he had located the aircraft traffic. Immediately following his statement and coincidental with the initial, unusual movement of the aircraft was the remark "Zuh". This appears to be an attempt to continue speaking that was abruptly halted with the abnormal departure (pitch, roll, or yaw) of the aircraft. He may have been responding to the situation by seizing the controls to correct the movement and reflexively stopped speaking to concentrate on his duties. After the onset of the emergency, two rapid grunting exhalations were heard. The first grunting sound was soft indicating some submaximal muscular exertion. The second grunting sound was louder and more forceful representative of the use of increased, but probably submaximal, muscular force. The grunts suggest that the F/O was straining possibly in an attempt to manipulate the controls of the aircraft to override the autopilot. Following the second sound, no further grunting was apparent, but deep, rapid breathing was audible from the F/O. Again, these breath sounds would not be out of the ordinary in the given situation. It is apparent that the F/O was conscious and cognizant of the situation. It seems that he was at the controls and focused on correcting the situation.

6. The muscles of the arms, shoulders, back, chest, abdomen, and legs have been associated with routine movements of aircraft controls. However, the physical act of manipulating the controls of modern aircraft under normal conditions does not usually require excessive muscular force. Tests and standards for muscular strength are not currently included in the pilot selection process in either civilian or military aviation. Nevertheless, during emergency situations, increased muscular

force may be needed to manipulate the controls of an aircraft. Generally, during increased muscular exertion, it is common for the individual performing the movement to apply a considerable exhalatory force against a closed or partially closed glottis in the throat. When the breath is finally exhaled, it is forceful and quick and usually accompanied by a grunting sound. The forceful movements of weight lifting and other short duration, high intensity physical activities are routinely accompanied by grunting. When the arms are used for pushing, pulling, or turning a wheel in an upright sitting position, the mechanics of the movements require the body to be stabilized to exert maximal force. This is usually accomplished by securing the torso to a chair or bench and bracing the body with the legs. Likewise, when legs are employed to exert a pushing movement, the upper body is usually braced. When these movements are made suddenly in response to an unexpected event, the body's mechanical reaction is usually reflexive.

7. It is difficult to determine with certainty from the tape whether the PIC exerted increased muscular force on the controls during the emergency period. There was no audible grunting or straining indicative of muscular exertion heard. There was no indication of muscular strain during any of the verbal communications from the PIC heard on the tape. His initial comments were calm and controlled. His nonverbal breathing was unobstructed. That is not to say that the PIC was not on the controls, but only that he did not appear to be exerting increased muscular force during that time. The physical fitness of the PIC at the time of the accident is not known. He had been fully cleared to resume his duties as Captain following back surgery six months before the accident. My experience with exercise rehabilitation for post surgical patients with back injuries is limited. However, it would not be out of the ordinary for such an individual to be protective of the surgical repair and reluctant to exert excessive muscular force with the upper body. In an emergency situation that required quick reflexive actions, most likely there would not be a conscious effort to minimize muscular exertion. There is no evidence that the PIC was trying to forcibly manipulate the controls of the aircraft at any time during the emergency period.

8. Similar to the PIC, the F/O did not appear to be straining during any of the initial routine portion of the tape. Unlike the PIC, there were few words spoken during the first part of the emergency period. The two grunting sounds of the F/O heard after the onset of the emergency are indicative of muscular exertion or physical straining. It is impossible from the grunting sounds alone to determine the muscles involved in the exertion. The muscular straining could have been an effort to control the ailerons, elevators, or rudder, requiring involvement of the arms, legs, or both. The physical size of the F/O (6'3", 210 pounds) would not have handicapped his efforts to exert maximal force on the rudder pedals but may have cramped his ability to exert aileron control with the column in the full aft or full

forward positions. It is normally difficult to generate large muscular forces in the movement of turning the yoke left or right with the arms fully flexed or extended because of an ineffectual mechanical advantage due to the position of the arms, the angles of the arm and shoulder joints, and the muscles used. More force can be exerted pushing or pulling with the arms and pushing with the legs. Apparently, the F/O was physically involved with trying to fly the aircraft, but it is difficult to determine whether he was working with his hands on the yoke or his legs on the rudder, or both. At the point during the emergency period when the autopilot disengaged, there was audible evidence that the F/O was physically straining before the autopilot disengaged. However, there was no audible evidence that the F/O was physically straining after the autopilot disengaged. This was also the case with the PIC. Both crewmen were reported to be in good condition prior to the flight. There were no signs from the normal communications throughout the tape that either crew member was physically incapacitated or hampered in the performance of his duties by persistent physical problems.

9. Both the breathing and physical responses of the PIC and F/O appear to be within normal limitations given the events of the emergency situation and not contributing factors to this accident. Both crewmen were apparently conscious and fully aware of the emergency nature of the situation. Neither seemed impaired or incapacitated from the sounds heard on the tape.

10. Thank you for the opportunity to participate in the NTSB review of this accident.

Scott Meyer