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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: A-96-1 through -5

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

In the summer of 1995, the National Transportation Safety Board was asked to conduct a special investigation into the ongoing computer and related equipment outages experienced by the Federal Aviation Administration (FAA) en route air traffic control (ATC) system. The special investigation focused on the problems that received notoriety at the five air route traffic control centers (ARTCCs) with the oldest display computer systems (the IBM 9020Es). A team of investigators conducted interviews and research at these five ARTCCs (Washington, Fort Worth, Cleveland, New York, and Chicago Centers).

The special investigation report presented a basic overview of the ATC system and ARTCC computer systems, and discussed the maintenance and repair of aging display computers and the problem of outages involving these and other systems. The report also discussed a few ongoing FAA modernization programs to address these issues.

The Safety Board has completed its report[1] of this special investigation and has concluded that the U.S. ATC system is very safe and that the public should not be unduly alarmed by recent press accounts of specific ARTCC equipment malfunctions. Nonetheless, these malfunctions have had a detrimental effect on the efficiency of air traffic movement. The outages involving the aging IBM 9020E equipment have become more frequent, and the effects of these outages are being exacerbated by extended restoration time because of the lack of qualified technicians and working spare parts. Also, some of the IBM 9020E computer systems are increasingly likely to be operated with compromised redundancy, which increases technician workload and the risk of outages. However, the report also concluded that the FAA's plans to upgrade the computer systems will be beneficial.

[1] National Transportation Safety Board. 1996. Air traffic control equipment outages. Special Investigation Report NTSB/SIR-96/01. Washington, D.C.

Technician Availability and Training

The five facilities visited by Safety Board investigators rely on IBM 9020E display computers to process and store data for display on controller plan view displays (PVDs). The IBM 9020E requires very highly trained and experienced FAA technicians to maintain and repair it. Because the system has aged and the number of 9020E certified technicians has declined, the ability to diagnose, maintain, and repair the equipment has deteriorated.

As an example, at the Fort Worth ARTCC, only four technicians are specifically assigned to the 9020E unit. Although six AF managers from other departments are available to support the four technicians (together known as a "tiger team") in an emergency, only four are available for routine maintenance--clearly insufficient to provide around-the-clock coverage. Technicians note that because of advancement and retirement, 9020E expertise at Fort Worth has declined sharply in the last 2 years. They also note that two of the four 9020E technicians are eligible to retire. According to the facility manager, one of them, who has 30 years of experience, "holds 50 to 60 percent" of the center's 9020E knowledge. This technician is expected to retire in about a year. Further, a 1994 FAA study of potential airways facilities (AF) technician retirements through 1998, based on retirement eligibility alone, projects a steady downward decline of personnel in all facilities.

Because of dwindling expertise in the field, AF technicians are increasingly likely to call on the FAA Technical Center in Atlantic City, New Jersey, for assistance. If needed, a 9020E expert at the Technical Center is available to travel to provide troubleshooting and repair guidance. One of these experts told Safety Board investigators that he had typically made four or five such emergency trips for 9020E repairs each year; however, as of late September, he had made 12 such emergency site visits in 1995. He attributes this increased need for Technical Center engineering support directly to the retirement of several key technicians.

In May 1995, the FAA completed a supportability review of its ability to continue maintaining and repairing its display computers. The report concluded that the number of qualified technicians varies among the ARTCCs, and the authors noted that this situation is "...growing more critical." The study team wrote that some facilities are operating with only one or two technicians per shift, and that some shifts are not covered at all. Saying that the staffing situation is not likely to change, the authors noted that, "Training, vacations, sick leave are not coverable, much less the requirements of typically round-the-clock shift operations."

Until recently, there has been no formal training on the IBM 9020E system since the last class was offered in 1990. Any informal training has been limited and conducted entirely on the job. The FAA conducted an abbreviated 9020E training course during October 1995. The newly trained technicians should be able to perform basic

maintenance and repair tasks, freeing the more experienced technicians to perform more challenging troubleshooting and repairs. The Safety Board believes that such abbreviated courses could help to relieve the technician staffing problem. However, even though the number of technicians may be increased because of these courses, the overall experience level of the technician force will not.

Many FAA managers told the Safety Board that it is very difficult to convince a technician who is eligible to retire to remain with the FAA when, because his or her numbers are dwindling through normal attrition, he will be "on call" virtually all the time. Several also said that they had restrictive overtime budgets that limit their ability to assign technicians as needed. Many highly trained, in a way irreplaceable, technicians said that they felt guilty whenever they went out of electronic pager range, even when they were officially off duty. Some said that they would remain with the FAA until the newer computer systems were up and running, but many others said that any adverse changes to the current civil service retirement system would cause them to retire immediately. The Safety Board urges the FAA to explore a variety of innovative personnel strategies to keep the maintenance and repair capability within the ARTCCs at an acceptable level. Such strategies might include overtime pay, monetary and time-towards-retirement credit, and rehiring retired technicians as reemployed annuitants.

Equipment Maintenance

The ability to maintain the aging IBM 9020E equipment was described as a very big problem by FAA managers, AF technicians, and air traffic controllers. Many repairs require extensive troubleshooting and replacement of individual components on circuit boards. Many AF technicians and managers are concerned not only about parts and repairs, but also about the age of the wiring bundles, which require increasing care when any maintenance is done. About 5 years ago, AF staff at the Forth Worth Center conducted a risk assessment of the 9020E because of increasing concerns about spare parts and system maintenance in general. The repair procedures that resulted from this risk assessment established specific 9020E repair procedures specially adapted for the age of the components. These procedures were designed to pose the least risk to the system. When these procedures were described to the Safety Board, they had only been distributed to the FAA Technical Center. Technicians at other centers were unaware of them. Although FAA managers have the capability to implement and revise mandatory procedures in response to technician suggestions, no method exists for sharing useful suggestions of a nonmandatory nature. The Safety Board concludes that the conduct of the risk assessment by the Fort Worth AF staff is commendable and believes that useful suggestions and repair techniques should be evaluated by FAA management and shared with technicians at other facilities, as appropriate.

DARC Training for Controllers

Each ARTCC is equipped with a computer system that uses three main computers to drive controller workstations. Two of the computers (the Host computer and the

display computer) comprise the primary system, which is used during normal operations, and the third is the backup (DARC). These computers are used to combine radar and flight plan data to present each controller with a dynamic display of relevant aircraft targets. In the event of a primary system outage, controllers use the DARC system. During such an outage, if the Host is available, DARC delivers correlated radar and flight plan information to controller PVDs relying on the Host to process the flight plan information. This mode of operation is referred to as "DARC/Host," and is similar to operation under the primary system; however, some features are not available to controllers.

Five features that are not available during DARC/Host operation include: (1) conflict alert, a computer warning that safe aircraft separation has been compromised; (2) en route minimum safe altitude warning, a computer warning that an aircraft is operating below a preset minimum altitude; (3) mode-C intruder alert, a computer warning that an untracked aircraft is operating in the airspace; (4) distance reference indicator, a moving 5-mile ring around aircraft targets that is used as a separation aide; and (5) route display, a feature that displays a lighted line along an aircraft's planned route of flight. Further, controllers must coordinate all handoffs to controllers at other facilities manually. If the Host should become unavailable, the backup system is used in "DARC/Standalone" mode. In this mode, in addition to the loss of the above five features and the automated handoff feature, no processed flight plan data are available, so operation is very different from that under the primary system. The loss of features and increased workload do not alter a controller's responsibilities regarding aircraft separation or terrain clearance.

Controllers said that only those who regularly work midnight shifts get effective, hands-on, DARC/Standalone experience. This access to DARC/Standalone occurs during planned outages that are usually scheduled for primary system maintenance. The controllers stated that the first call in the radar room during an unplanned daytime transition to DARC/Standalone operation is, "Help! Who has worked a mid [midnight shift] lately?" This suggests that although formal procedures for transition from normal operation to DARC/Host operation are not difficult, nor even very necessary, the procedures for transition from normal operations to DARC/Standalone, and vice versa, are not well established, or are not well understood.

A Safety Board investigator observed a planned outage that required DARC/Standalone operation during a midnight shift at Washington Center. Before the outage, the supervisor circulated among all controllers and told them to expect a planned outage at 0030. Shortly thereafter, computer bells at each position in the control room signaled the start of the outage, and controllers selected DARC at their consoles. An inter-facility automated handoff that had been initiated before the outage was completed successfully. This seemed to surprise one controller who had not realized that automated handoffs initiated under primary system could be completed successfully under DARC/Standalone. During the outage, one controller showed two other controllers that the range/bearing feature is available during DARC/Standalone operation. The two controllers had believed that this feature was unavailable. When asked, the controller

demonstrating the use of the feature said that he had discovered it accidentally. The controllers demonstrated some additional DARC features to each other during the initial period of the outage.

The Safety Board is concerned about the lack of knowledge about DARC/Standalone operations that appears to exist within the controller workforce. Training methodology on DARC/Standalone varies somewhat between ARTCCs, but can be characterized as classroom work and initial one-time on-the-job training certification. Scheduled proficiency training occurs in some centers, but does not include DARC simulator training. Although unplanned DARC/Standalone operation is infrequent, it is a serious condition that controllers must be prepared to handle.

Effective on June 1, 1995, a General Notice to all ARTCCs (GENOT RWA 5/66) required that all developmental controllers receive 1 hour of instruction on DARC. Generally, the managers of the facilities visited by Safety Board investigators satisfied this requirement by requiring developmental controllers to work a midnight shift during a planned outage, much like the outage described above. The Safety Board believes that on-the-job training is a useful, but currently insufficient, way to train controllers on DARC operations.

Many controllers and training managers expressed a strong need for DARC training simulators. They noted that existing ARTCC dynamic simulation (DYSIM) laboratories, which are used to simulate primary system operation, cannot be used to simulate DARC, and that other training methods were only partially satisfactory. The Safety Board believes that no teaching method is as effective as full simulation. Safety Board investigators asked representatives from the FAA's Air Traffic Automation Software Policy and Planning Division if there were any plans to provide facilities with DARC simulation capability for training purposes. These representatives said that full DARC simulation (including transition procedures) is possible using equipment and software already in place at all ARTCC facilities, but it is not currently being used.

To simulate DARC, the Host's dual processors can be "split" to allow two configurations to exist at once: a live configuration and a training configuration. During split-Host operation, one of the Host processors is used to drive some PVDs in a live system, and the other processor drives the remaining PVDs in a simulated system. Full dynamic configuration of training scenarios is possible. This system was developed for use in the Denver ARTCC to train controllers on operations involving the new Denver airport. As designed, the split-Host configuration allowed the Denver facility to use the Host to conduct controller training without affecting live operation. Split-Host operation can be implemented at all ARTCC facilities immediately. Split-Host operation will eventually be required at all facilities as part of FAA modernization efforts.

Given the success of split-Host operation as a training tool at the Denver ARTCC, and the notably high reliability of the Host, the split-Host operation could serve as an appropriate simulation tool for controller DARC training. Therefore, the Safety Board

believes that the FAA should create a simulator-based training program using the simulation capabilities of split-Host operation during off-peak periods. The training program should include simulated transitions to and from DARC operating under both DARC/Host and DARC/Standalone modes. All controllers should be required to complete this new training program.

The FAA periodically updates the software that drives DARC. The upgrade scheduled for deployment on or about June 1997 will include the conflict alert, en route minimum safe altitude warning, mode C intruder alert, and route display features. These features will be available in DARC/Host mode. The Safety Board concludes that adding these features will enhance the safety of operations conducted under DARC/Host and strongly believes that the FAA should make every effort to deliver these features as planned. Because FAA managers expressed concern that resource limitations or competition from other agency programs could jeopardize these enhancements, the Safety Board will continue to monitor the progress of this project.

Impact of Communications Outages

Controllers complained more frequently about communications problems than computer outages. The communications problems most frequently cited were not related to the automated radar displays, but to air-to-ground frequency degradations or failures. Many controllers and air traffic managers said that they were more concerned about radio frequency outages than computer outages because controllers can only issue control instructions to pilots with whom they are in radio contact.

Radio frequency failures occur for many reasons. For example, a remote communications outlet may be struck by lightning, the telephone line connecting a remote outlet with an ATC facility may be cut, or interference may be introduced into a channel for a variety of reasons, such as noise from dirty connectors. AF technicians at one facility told investigators that a local telephone company once sent test tones into a live circuit being used by a controller to communicate with aircraft, rendering the frequency associated with this circuit useless. Managers told investigators that the available frequency spectrum is becoming very crowded, which has prompted a reduction in ATC radio transmitter power. They are concerned that frequency congestion could worsen if the available spectrum is further reduced, such as by auctioning portions of the spectrum to the private sector. The Safety Board shares this concern and plans to examine this issue further.

At Washington Center, one controller said that an aircraft in his sector lost power in an engine, began descending through lower altitudes under his control, and declared an emergency. The controller did not hear the mayday call, which was relayed to him by other aircraft under his control. The disabled aircraft apparently selected the emergency radio frequency (Guard) during the emergency, but the controller did not have emergency frequency transmit/receive capability at his position. A controller at another position monitoring Guard called the controller to ensure that he was aware of the emergency.

Apparently the pilot of the disabled airplane restarted his engine at about 8,000 feet and continued flying, but the controller was never able to communicate with him. The controller said that the emergency frequency was available at only a limited number of controller positions at Washington Center.

At New York Center, controllers stated that communications "dead spots" are well known within some sectors. Controllers are unable to communicate with aircraft in these locations, so they routinely compensate by not issuing clearances to aircraft passing through known dead spots. AF staff noted that frequencies were generally free of dead spots when they were assigned, but holes have appeared in radio coverage because buildings and other obstructions such as cellular telephone towers and cranes have been erected. The reduction in transmitter power, which was intended to minimize signal bleedthrough, may have also further diminished radio coverage. Some controllers routinely use the backup emergency communications (BUEC) system for enhanced coverage in known dead spots (especially low altitude feeder routes).

In the past, AF was able to restore lost frequencies relatively quickly. However, it is no longer able to provide the same level of service because some centers have resorted to unstaffed technician shifts because of technician shortages. At one location, the goal is to begin repairs within 24 hours of a failure. At some centers, radio frequency allocation specialists said that it might take as long as 6 months or more to correct a bleedthrough problem, such as that created by another ATC facility. AF staff also noted that when frequencies fail, it often takes a long time to get a replacement frequency released for the facility to use. Further, because off-duty technicians are not officially subject to recall and are not compensated for any on-call time, it can be difficult to locate an off-duty technician in a timely manner when a frequency (or any other equipment) failure occurs during an open shift. If the technician has consumed alcohol on his or her own time, for instance, he or she may not be legally able to report to work to make needed repairs.

AF technicians and controllers stated that because of such communications shortcomings, controllers are very dependent on the BUEC system. They also stated that controller positions have been added that have no access to BUEC. Recently, controllers have lost primary frequencies, and switched to BUEC only to find it already in use by another remote communications site. The Safety Board is concerned that the overreliance on the BUEC system reveals deficiencies in the primary communications system, such as dead spots and interference. The Board is also concerned that some of these deficiencies will not be rectified by the FAA's ongoing communications modernization program, the voice switching and control system (VSCS). Therefore, the Safety Board believes that the FAA should identify and rectify safety deficiencies, such as failures, interference problems, and inadequate radio coverage, that are not currently being addressed in VSCS. Further, because air-to-ground communications are a vital link in the ATC system, all controllers should have immediate access to a backup communications system. Therefore, the Safety Board believes that the FAA should provide controllers access to the BUEC system at every controller console.

Therefore, as a result of this special investigation, the National Transportation Safety recommends that the Federal Aviation Administration:

Explore innovative personnel strategies, such as overtime pay, monetary and time-towards-retirement credit incentives, and rehiring retired technicians as reemployed annuitants, to keep the maintenance and repair capability within air route traffic control centers at an acceptable level. (Class II, Priority Action) (A-96-1)

Create a program to evaluate suggestions and repair techniques proposed by technicians in the field and to share these innovations with technicians at other facilities, as appropriate. (Class II, Priority Action) (A-96-2)

Create a simulator-based training program using the simulation capabilities of split-Host operation during off-peak periods. The training program should include simulated transitions to and from the direct access radar channel (DARC) operating under both the DARC/Host and DARC/Standalone modes. All controllers should be required to complete this new training program. (Class II, Priority Action) (A-96-3)

Provide air traffic controllers access to the backup emergency communications system at every controller console. (Class II, Priority Action) (A-96-4)

Identify and rectify safety deficiencies, such as frequency failures, interference problems, and inadequate radio coverage, that are not currently being addressed in the FAA's voice switching and control system program. (Class II, Priority Action) (A-96-5)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT and GOGLIA concurred in these recommendations.

By: Jim Hall
Chairman