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Resources, Community, and
Economic Development Division

B-280745

August 14, 1998

The Honorable Vince Snowbarger
House of Representatives

Subject: Air Traffic Control: Information Concerning Equipment Outages at Two Kansas City Area Facilities

Dear Mr. Snowbarger:

The Federal Aviation Administration's (FAA) air traffic control (ATC) mission is to ensure the safe, orderly, and expeditious flow of air traffic in our nation's airspace. To accomplish this mission, FAA employs a vast network of ATC computer hardware, software, and communications equipment to prevent collisions between aircraft and obstructions and facilitate the efficient movement of aircraft through the air traffic system. The equipment that FAA uses to direct aircraft in the Kansas City area has experienced numerous outages during the past 7 months.[1] Among this equipment was the primary surveillance radar that enables air traffic controllers to monitor aircraft and weather within a 50-mile radius of the airport as well as the information system that merges data from the 16 radars serving the en route center, which controls planes in transit at high altitudes.

Concerned about the reliability of the equipment at the two Kansas City area ATC facilities and FAA's ability to safely direct air traffic in this area, you asked us to respond to the following questions: (1) What impact did the equipment's outages have on the safety of the ATC system and on airline operations? (2) What procedures help ensure aviation safety during equipment outages? (3) To what extent has equipment at the Kansas City facilities met FAA's availability requirements? (4) How do the outage rates of equipment at those facilities compare to the rates at other facilities? (5) What actions is FAA taking to address equipment outages?

[1]ATC equipment can be out of service for both scheduled maintenance and failure to perform. This review covers those instances when the equipment failed to perform, which we refer to as "outages."

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In summary, we found that the 18 outages at the two Kansas City facilities, which occurred from December 1997 through June 1998, were caused by various factors, such as defective equipment, human error, and weather. The outages did not result in any reports of violations to FAA's safety standards; however, they delayed flights, causing airlines to incur additional costs and inconveniencing passengers. As for the equipment at those two facilities, the percentage of time that it was operating satisfactorily (available) compared favorably to the national average. With respect to outage rates, the equipment at the en route center experienced fewer outages than the national average, while the equipment at the tower/terminal facility had more outages. As a result of these outages, FAA has taken several actions, including replacing defective equipment, reconfiguring the en route center's power system to reduce the potential for a catastrophic equipment failure, and conducting a special inspection of the equipment at the tower/terminal facility.

OVERVIEW OF THE AIR TRAFFIC CONTROL SYSTEM

Automated information processing and display, communications, navigation, surveillance, and weather equipment permit air traffic controllers to view key information, such as aircraft locations, aircraft flight plans, and prevailing weather conditions, and to communicate with pilots. This equipment resides at, or is associated with, several ATC facilities, including air traffic control towers, terminal radar approach control facilities (terminal facilities), and air route traffic control centers (en route centers).[2] These three types of ATC facilities provide the following functions:

- Airport towers control the flow of aircraft (i.e., before landing, on the ground, and after take-off) within 5 nautical miles of the airport and up to 3,000 feet above the airport. Air traffic controllers use a combination of information technology and visual surveillance to direct departures and approaches, maintain safe distances between aircraft, as well as communicate instructions and weather-related information to pilots.

- Terminal facilities sequence and separate aircraft as they approach and leave busy airports, beginning about 5 nautical miles to about 50 nautical miles from the airport and up to 10,000 feet above the ground. Often a terminal

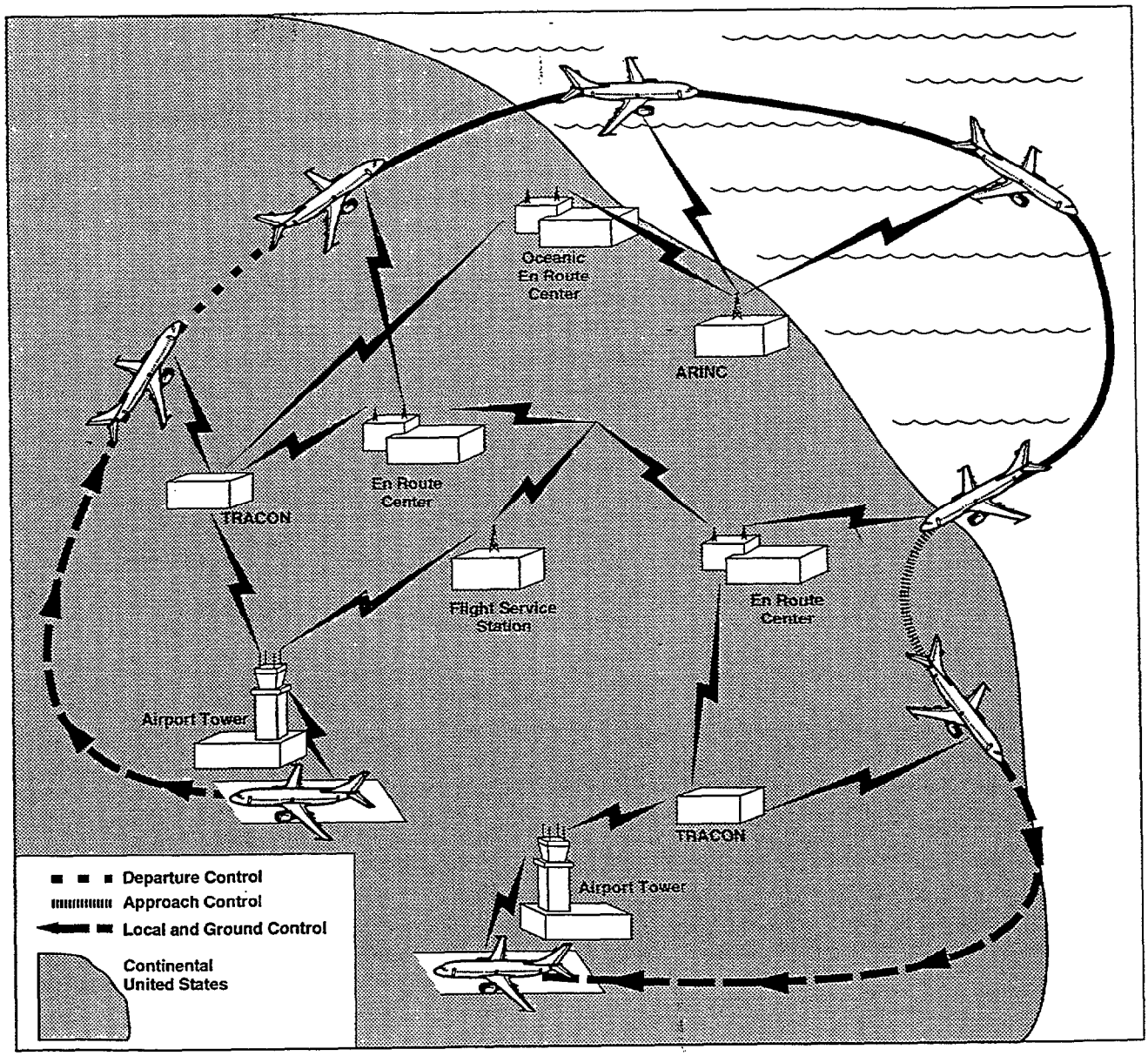
[2]Another type of ATC facility–flight service stations–provide such pre-flight and in-flight services as filing flight plans and updating weather reports, primarily for general aviation aircraft. The focus of this review was on facilities that direct aircraft in the national airspace; therefore, we do not discuss equipment outages at flight service stations.

facility is co-located with a tower facility; the Kansas City, Missouri, facility is such a case.

- En route centers control planes in transit over the continental United States and during approaches to some airports. Each en route center handles a different territory of airspace, passing control from one center to another as respective borders are reached until the aircraft reaches the terminal's airspace of its destination. Most of the en route centers' controlled airspace extends above 18,000 feet for commercial aircraft. En route centers also handle lower altitudes when dealing directly with a tower facility or when agreed upon with a terminal facility. The en route center located in Olathe, Kansas, covers portions of Kansas, Missouri, Illinois, Oklahoma, Nebraska, Iowa, Texas, Colorado, and Arkansas.

Figure 1 illustrates the ATC system over the continental United States and oceans.

Figure 1: Summary of ATC Over the Continental United States and Oceans

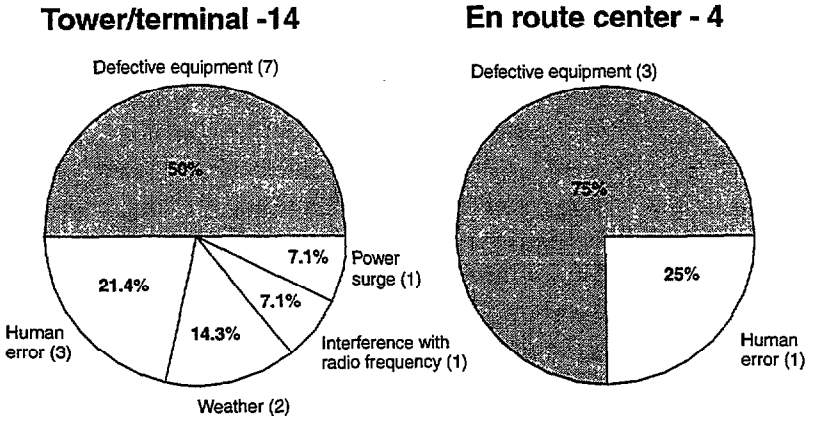


SUMMARY OF EQUIPMENT OUTAGES
AT TWO KANSAS CITY ATC FACILITIES

From December 1997 through June 1998, FAA identified 18 equipment outages, 14 of which were at the Kansas City tower/terminal facility and 4 at the Kansas City en route center. Of the 14 outages at the tower/terminal facility, 7 were caused by defective equipment, 3 by human error, 2 by weather, 1 by a power surge, and 1 by interference with the radio frequency; of the 4 outages at the en route center, 3 were caused by defective equipment and 1 by human error. For example, on March 12, 1998, the surveillance radar at the tower/terminal facility failed to perform because cold temperatures caused the antenna switch, which rotates the radar, to shut down. The outage at the en route center, on April 15, 1998, which involved the equipment that merges data from the 16 radars, was caused by a failure in the circuit that supplies power to that equipment (see fig. 2).

Figure 2: Summary of Equipment Outages Two Kansas City ATC

- From December 1997 through June 1998, the two ATC facilities experienced 18 equipment outages.



SAFETY NOT COMPROMISED, BUT DELAYS RESULTED IN AN ECONOMIC IMPACT

According to FAA, safety was not compromised during any of the 18 outages because the agency has procedures to safely handle air traffic when equipment fails to perform. Furthermore, the agency noted that no reportable incidents of violations to safety standards by controllers or pilots were recorded during any of the equipment outages. As for the impact on airline operations, FAA has acknowledged that some aircraft were delayed, which increased operating costs for the airlines and inconvenienced passengers.

Outages Did Not Compromise Safety, But Some Outages May Pose a Potential Risk to Safety

FAA's regulations require the reporting of incidents, such as when the required separation between aircraft is not maintained by the controller or two aircraft come close to colliding because of the pilots' actions.[3] Our review of FAA's documentation on the 18 outages found no reports that controllers had not maintained the required separation between aircraft and no reports of aircraft incidents involving pilots.

However, while an equipment outage does not necessarily mean that FAA's ability to safely control aircraft is impaired, certain types of outages could pose a potential risk to air safety. The risk depends on such factors as the type of equipment, the time of day the outage occurs, and the duration of the outage. For example, on December 18, 1997, the en route center experienced a power failure that resulted in the loss of all communications with aircraft for 2 minutes and the loss of radar tracking for 12 minutes before the back-up equipment began functioning. During the loss of communications and tracking ability, planes were still travelling in the Kansas City en route center's airspace. FAA officials noted that this outage greatly affected the en route center's ability to provide air traffic services, and some controllers expressed a concern that this type of outage could pose a potential risk to air safety. In contrast, during the outage on June 1, 1998, when the back-up computer system that processes radar and other

[3]In the en route airspace, aircraft flying up to and including the flight level of 29,000 feet are required to maintain 1,000 feet of vertical separation. Levels above 29,000 feet require 2,000 feet between them. In-trail separation (aircraft flying behind each other) requirements depend upon the type of aircraft, but are generally 5 miles in the en route airspace and 3 miles in the terminal airspace.

data malfunctioned, the en route center's ability to control aircraft was not impaired because the primary system continued to function.

Airlines Incur Costs From Delays, and Passengers Are Inconvenienced

One measure of the impact on airline operations resulting from an outage is the number of reportable delays.[4] Four of the 18 outages resulted in reportable delays. The most significant of these was a power outage that occurred at the Kansas City en route center on December 18, 1997, and delayed 298 flights. According to FAA, these delays occurred when all the air traffic that was in or approaching the airspace of the Kansas City en route center had to be handled by adjoining centers. The other three instances delayed the arrivals and departures of aircraft in the airspace between 5 and 50 miles from the airport. FAA has also acknowledged that aircraft may experience delays associated with other outages that are not reported because they do not meet FAA's requirements to report delays that are at least 15 minutes in duration.

When a flight is delayed, airlines incur costs for extra fuel and for accommodating passengers who miss their connections, among other things. Although specific data on the cost of these delays to the airlines are not available, according to the Air Transport Association of America--an organization representing major U.S. airlines--each minute of delay costs an airline nearly $39. Therefore, the 298 reportable delays--of at least 15 minutes--cost the airlines a minimum of $174,000. For the airlines' passengers, the inconvenience associated with a delay may include missed and rerouted flights, which may result in an economic impact as well.

FAA HAS BACK-UP PROCEDURES TO HELP ENSURE THE SAFETY OF THE ATC SYSTEM DURING EQUIPMENT OUTAGES

When the equipment that FAA uses to communicate with and keep track of aircraft fails to operate as intended, FAA has back-up equipment to help ensure that it can continue to control aircraft. In the case of communications equipment, FAA's first level of back-up provides the same functions as the primary equipment. For example, if controllers in the terminal facility lose voice communications with aircraft, they can switch to such back-up equipment as transmitters, telephones, and walkie-talkies to maintain air-to-ground and ground-to-ground communications. Likewise, in an en route center, controllers can switch to the back-up channel on the same communications system with no loss in capability (see encs. I and II).

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[4]FAA tracks delays that are at least 15 minutes in duration.

However, if the systems that display radar tracking and other data on controllers' screens in the terminal facility and/or the en route center go out, the back-up systems do not provide all of the information that is available with the primary equipment. The back-up systems provide such information as aircraft flight data, origin and destination, and assigned and present altitude, but do not provide a warning when planes are too close and might collide. To compensate for this lack of information, FAA requires these procedures to help maintain safety whenever back-up modes of operation are being used: increasing distances between aircraft, holding aircraft on the ground, and assigning aircraft to adjoining facilities (see encs. III and IV).

AVAILABILITY OF EQUIPMENT AT THE TWO FACILITIES COMPARED FAVORABLY WITH THE NATIONAL AVERAGE

FAA tracks and compares the time that equipment at each facility has been operating satisfactorily against a national average.[5] We found that the percentage of time the equipment at the Kansas City en route center was available was slightly better than the national average. For the equipment at the Kansas City tower/terminal facility, the percentage was slightly worse than the national average. However, FAA officials do not view this difference as significant because the percentages are very close (see enc. V).

IN COMPARISON TO OTHER FACILITIES, SOME EQUIPMENT HAD FEWER OUTAGES WHILE OTHER EQUIPMENT HAD MORE OUTAGES

FAA's data for the December 1997 through May 1998 time frame indicate that equipment at the Kansas City en route center generally experienced fewer outages than the national average, while the equipment at the Kansas City tower/terminal facility had more outages than the national average. For example, the en route center's HOST system, which processes radar and other data, did not experience a single outage, whereas, nationwide, the 20 HOST systems experienced three outages, or 0.15 outages per system. Likewise, the tower/terminal facility's airport surveillance radar experienced 3 outages, whereas, nationwide, the 120 radars experienced 78 outages, or 0.65 outages per radar. Despite the tower/terminal facility's having more

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[5]Through its National Airspace Performance Reporting System, FAA tracks the performance of its ATC equipment. One measure of performance is the equipment and service availability ratio, which is the time that equipment is operating satisfactorily, expressed as a percentage of the time the equipment is required to be operational. This measure excludes the time that equipment is not operating because of scheduled maintenance.

outages than the national average, FAA officials stated that the equipment's performance was within acceptable ranges. These officials indicated that they would monitor performance of the equipment and would initiate a special inspection if the performance remained below the national average (see enc. VI).

FAA HAS TAKEN SEVERAL ACTIONS TO ADDRESS EQUIPMENT FAILURES

As a result of the outages at the two facilities, FAA has taken several steps to help guard against future outages. For example, at the en route center, FAA replaced defective equipment, reconfigured the center's power system to reduce the potential for a catastrophic equipment failure, and installed alarms on the power system to reduce the potential for human error to disrupt the center's power during maintenance. At the tower/terminal facility, FAA also replaced defective equipment and implemented new procedures for performing maintenance on the airport's surveillance radar. In addition, FAA conducted a special inspection of equipment at the tower/terminal facility in June 1998. During this inspection, officials identified concerns about the adequacy of the power system and its protection against lightning and power surges. Officials expect to begin upgrading the portion of the system that supplies power to the airport's radar in October 1998. The time frame for installing power supply protectors has not been determined. Furthermore, the agency plans to upgrade the tower/terminal facility's power system in fiscal year 2001 to help ensure that a disruption in the power supply would not lead to a catastrophic failure.

SCOPE AND METHODOLOGY

As agreed with your office, we limited our scope to those unscheduled equipment outages of 1 minute or more that occurred from December 1997 through June 1998. To address our objectives, we analyzed documentation provided by FAA on the 18 outages. We confirmed this information through discussions with air traffic and national airspace system operations personnel at headquarters in Washington, D.C., the Kansas City en route center in Olathe, Kansas, and the tower/terminal facility in Kansas City, Missouri. We verified the information FAA provided with related records in FAA's Operational Error and Deviation System and its National Airspace Performance Reporting System. For the equipment at the two Kansas City facilities, we correlated the average number of unscheduled outages with the data that FAA provided on outages during that same time frame. However, we did not independently verify FAA's data on the equipment's availability or the national outages. We conducted our work from June

from June through July 1998 in accordance with generally accepted government auditing standards.

AGENCY COMMENTS

We provided copies of a draft of this report to FAA. FAA indicated that the report was clear and concise and accurately presented the facts surrounding the equipment outages.

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As agreed with your office, unless you publicly announce the contents of this report, we will not distribute it until 7 days from the date of this letter. At that time, we will send copies of the report to interested congressional committees and Members of Congress, the Secretary of Transportation, and the Administrator of FAA. We will also make copies available to others upon request.

If you or your staff have questions or need additional information, please call me at (202) 512-3650. Major contributors to this report were Belva Martin, Pete Maristch, Jean Brady, and Lynne Goldfarb.

Sincerely yours,

Phyllis F. Scheinberg

for Gerald L. Dillingham, Ph.D.
Associate Director, Transportation Issues

Enclosures - 6

ENCLOSURE I

TOWER/TERMINAL MODES OF OPERATION FOR COMMUNICATIONS

Communications capabilities for air traffic control system	Normal[a]	Loss of system[b]
Air-to-ground	X	Battery back-up transmitters
Ground-to-ground	X	Battery back-up transmitters, telephone, walkie talkie
Intrafacility	X	Telephone, walkie talkie
Interfacility	X	Telephone

[a]All systems functional, primary as well as standby frequencies

[b]System failure of the Integrated Communications Switching System and the Rapid Deployment Voice Switch

Source: FAA.

ENCLOSURE II

EN ROUTE CENTER MODES OF OPERATION FOR COMMUNICATIONS

Air traffic control system capability	Voice Switching and Control System (VSCS) channels[a] A	Voice Switching and Control System (VSCS) channels[a] B	VSCS Emergency Access Radio Systems (VEARS)[b]	Commercial telephone service[c]
Air-to-ground communications equipment	X	X	X	
Ground-to-ground communications equipment				
Intrafacility	X	X		X
Interfacility	X	X	X	X

[a]Normal operating mode, channel A and back-up channel B

[b]Emergency back-up system

[c]Total communications system failure

Source: FAA.

ENCLOSURE III

TOWER/TERMINAL MODES OF OPERATION FOR RADAR TRACKING

Air traffic control system capability	Normal[a]	CENRAP[b]	Mode 3A[c]	Nonradar[d]
Screen readout				
Status information area	X	X		
Airline, flight number, three-digit identification number	X	X		
Altitude readout	X	X		
Ground speed	X	X		
Other time-shared information	X	X		
Target tracking	X	X	X	
Automated position sign/on/off and automated hand off capability	X	X		
Automated flight plan processing	X	X		
Paper back-up of flight information	X	X	X	X
Minimum safe altitude warning	X			
Conflict alert	X			

[a] All systems functioning.

[b] Terminal radar and/or ATC Radar Beacon System failure. The Center Radar ARTS Presentation (CENRAP) provides back-up by displaying digitized en route originated primary and secondary targets.

[c] ARTS failure.

[d] Catastrophic failure, en route center must assume airspace and tower reverts to nonradar separation standards

Source: FAA.

ENCLOSURE IV

EN ROUTE TRAFFIC CONTROL MODES OF OPERATION FOR RADAR TRACKING

Air traffic control system capability	Normal mode[a]	DARC-HOST mode[b]	DARC-alone mode[c]
Screen readout			
Airline, flight number, and 3-digit identification number	x	x	x
Assigned and present altitude	x	x	x
Ground speed	x	x	x
Sector plane will be handed off	x	x	x
Origin and destination	x	x	
Automated hand off (one controller to another)	x	x	
Automated flight plan processing	x	x	
Paper back-up of flight information (called "flight strips")	x	x	
Route projection	x		
Warning when planes are too close/ might collide	x		
Minimum safe altitude warning	x		

[a]All systems functioning

[b]Computer Display Channel (CDC) failure

[c]CDC and HOST computer failure

Source: FAA.

ENCLOSURE V

TO WHAT EXTENT HAS EQUIPMENT MET AVAILABILITY REQUIREMENTS?

Location and type of equipment	Equipment and service availability percentage[a] Dec. 97 - May 98 Kansas City	Nationwide
En route		
HOST	100.00	100.00
Computer display channel	100.00	99.77
Composite flight data processors (CFAD)	99.96	99.98
Composite radar data processors (CRAD)	99.96	99.96
Direct access radar channel (DARC)	100.00	99.98
DARC radar data	100.00	99.98
Tower/terminal		
Automated radar terminal system	99.95	99.98
Terminal automated radar service	99.99	99.86
Airport surveillance radar-9	99.50	99.90
Terminal radar service	99.49	99.90
Mode-S data link	99.49	99.88
Terminal secondary radar service	99.48	99.89
Remote transmitter/receiver	99.94	99.98
Terminal communications service	99.86	99.91

Below national average

[a] Equipment availability is the time equipment is operating satisfactorily, expressed as a percentage of time the equipment is required to be operational.

Source: FAA.

ENCLOSURE VI

HOW DOES KANSAS CITY'S EQUIPMENT OUTAGE RATES COMPARE TO RATES AT OTHER FACILITIES?

Location and type of equipment	Unscheduled average outage number[a] Dec. 97 - May 98	
	Kansas City	Nationwide
En route		
HOST	0.00	0.15
Computer display channel	0.00	1.40
Composite flight data processors (CFAD)	1.00	0.81
Composite radar data processors (CRAD)	3.00	1.86
Direct access radar channel (DARC)	0.00	1.35
DARC radar data	1.00	1.90
Tower/terminal		
Automated radar terminal system	2.00	0.50
Terminal automated radar service	1.00	1.17
Airport surveillance radar-9	3.00	0.65
Terminal radar service	4.00	0.89
Mode-S data link	3.00	0.27
Terminal secondary radar service	4.00	0.62
Remote transmitter/receiver	1.13	0.04
Terminal communications service	1.12	0.07

Above national average

[a]Ratio of total equipment outages to total available equipment.

Source: FAA.

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