STATEMENT OF THE HONORABLE QUENTIN S. C. TAYLOR, DEPUTY ADMINISTRATOR OF THE FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE COMMITTEE ON WAYS AND MEANS, SUBCOMMITTEE ON OVERSIGHT, CONCERNING RADAR DISPLAY INTERRUPTIONS. NOVEMBER 26, 1979.

Mr. Chairman and Members of the Subcommittee:

You have asked me to appear before you today to discuss with you the subject of radar display interruptions. I am pleased to have the opportunity to do so, because I believe that the recent incident at the Leesburg Center has raised public concerns about the safety of our air traffic system. I would like to set those concerns to rest today.

During the course of today's hearing, there are a number of points I will cover. For one thing, I think it's important to recognize that our air traffic control system is the best in the world. But at the same time, because of its complexity, we experience and will continue to experience system interruptions. I also want to stress that we are doing all we can to aggressively seek out the causes of system interruptions and to cure them. In recognition of the fact, however, that system interruptions will occur, we have worked to assure that a high level of controller skill and training is maintained

in order to safely deal with the difficulties associated with the transition from one mode of air traffic to another. These points will be further developed in my prepared statement.

Before discussing specifically the issue of radar interruptions, I believe it would be helpful to focus briefly on today's air traffic control system and how it has evolved to this point.

The Federal Government first became involved with civilian air traffic control in 1936 when the Bureau of Air Commerce took over the airway traffic control centers at Newark, Chicago, and Cleveland which were then being run by private airline companies. The "air traffic control system" of that era can best be described as rudimentary; for that matter, until the end of World War II, the civilian air traffic control system consisted solely of radio communications between pilots and controllers, with controllers noting on paper strips (flight strips) the latest time and altitude data for aircraft. The controller's basic function was to remain aware of the information contained on the flight strips to assure that no two aircraft were at the same altitude at

the same time. This very basic system of manual control is considered today as the first generation of air traffic control.

In the mid 1950's, the first long-range radars for en route air traffic control were added to the system, with installations at the New York, Chicago, and Norfolk centers. This equipment, provided to the Civil Aeronautics Administration by the military, had a number of limitations and was replaced by more sophisticated ARSR-1 radars beginning in 1958. Positive air traffic control was initiated for the first time in 1958, with selected positive control airways running primarily between the east and west coasts, with some supplemental and interconnected routes, at altitudes of 17,000 and 22,000 feet inclusive.

The first computers in the system were Univac file computers commissioned for use at the New York and Washington centers in 1959. These general purpose electronic computers were designed for use in preparing flight progress strips and in assisting controllers with bookkeeping tasks.

Less than 20 years ago, in late 1960, our Nation's long range radar network consisted of only 40 locations; this number has progressed to more than 100. In that same time frame, secondary radar, which receives target information from beacons, was introduced into the system, providing improved target identification.

The advent of jets in the late 1950's and increasing traffic prompted a hard look at that second generation of air traffic control which employed broadband radar. In 1961, "Project Beacon" recommended that the Federal Aviation Agency make a broadgauged use of automation in air traffic control. That report formed the catalyst for the development of today's third generation automated system. After an intensive research and development effort, FAA had completed, by 1966, field appraisals of two prototype automated air traffic control systems--one for en route use and one for terminal use. By the end of 1970, limited capability automated terminal systems had been installed at Atlanta and New York; the computer component of the en route automated system was installed at the majority of centers in the contiguous United States; and a complete en route system, which was not operational, was installed at the Jacksonville Center.

Since that time, full Flight Data and Radar Data Processing systems have been commissioned at all 20 centers in the contiguous United States. In contrast with the second generation's broadband system which provides two-dimensional data--range and bearing--requiring voice communications to obtain altitude data and the use of shrimpboats for tagging and tracking targets, today's system has many automated features resulting in more efficient use of a controller's time, and, with its tremendous computer capabilities, has enabled us to progressively add additional safety functions such as Conflict Alert. All along the way, we have continued to expand the capability and coverage of our radar, to improve the antennaes used in the system, to refine our air traffic control procedures, and to develop feasible collision avoidance devices; all with the intent of improving the safety of our air transportation system.

As is readily apparent, the air traffic control system has evolved significantly since its inception, with many of the significant strides forward having occurred in the very recent past.

The air traffic system in use today in our 20 air traffic control centers nationwide is a technology intense, interrelated system comprised of radar, visual displays, air/ground communications, equipment, and computers. Let me focus for a moment on the computer network which drives the system. All centers have a Central Computer Complex (CCC) which is the master computer containing the National Airspace System operational program, 15 centers have a Computer Display Channel (CDC) and 5 a Display Channel Complex (DCC) which are the computers that process and display the radar data for the controller.

The Leesburg CCC, which employs a reconfigurable IBM 9020D, is comprised of the following major elements: 3 Computer Elements; 3 Input/Output Control Elements; 6 Storage Elements; 3 Peripheral Adapter Modules; 3 Flight Strip Printer Control Modules; 3 Tape Control Units with 17 Drives; 3 Disc Control Units with 6 Drives; 2 High Speed Printers; and 1 Card Reader Punch.

The DCC in use at Leesburg has 3 Computer Elements; 2 Input/Output Control Elements; 4 Storage Elements; 2 Tape Control Units with 8 Drives; 1 High Speed Printer; 1 Card Reader Punch; 5 Radar Keyboard Multiplexors; 4 Non Radar

Keyboard Multiplexors; 12 Display Generators; and 2 Data Adapter Units.

The typical CDC in use at fifteen of our centers has the following major elements: 2 Central Processors; 2 Input/Output Controls; 2 High Speed Filters; 2 Refresh Memory Controls; 8 Buffer Memories; 12 Display Generators; 2 Refresh Memory Input/Output Controls; 2 Memory Refreshers; 4 Non Radar Keyboard Multiplexors; 3 Radar Keyboard Multiplexors; 1 Configuration Control Monitor; and 1 Operations/Maintenance Support Station.

Each Center's automated system contains more than 50,000 printed circuit boards with over 1,000 different types of circuits. The CCC software program entails over 1/2 million words; the CDC program 128,000; the DCC program 144,000; and it has been suggested that the software developed and used for this integrated system comprises the most complicated "real time" system in the world. There are literally tens of thousands of solid state electronic devices as well as tens of thousands of physical connectors, and a large software program which is in a constant evolution of improvements and functional changes or additions. Though the reliability of the

electronic devices is very high, they can and do fail. The same applies to the physical connectors used for cables and printed boards. Modifications to the software program are thoroughly tested before implementation, but situations can arise which were not contemplated, some of which the program cannot handle. I think it's also significant to note that the computers in a typical center receive and analyze 180,000,000 bits of data each hour from the radars alone.

The point I want to stress is that to provide the safest air traffic control system in the world it has been necessary to develop an air traffic control system which is a highly complex structure, and that with such a complicated system there will inevitably be system interruptions that can be brought on by a variety of causes. This fact was recognized even before our automated system was brought on line. We have worked both to reduce system interruptions to the minimum possible, and to try to minimize the difficulties associated with transition from the narrowband mode to broadband. Before discussing those efforts, let me first discuss what system interruptions are.

We have defined two classes of service interruptions by our computers. The first and most prevalent class is unscheduled startovers which are of a duration of less than 1 minute. These startovers account for about 80 percent of the outages at Leesburg and result in frozen radar displays. The other class, referred to as outages, includes interruptions lasting 1 minute or longer which can result in complete loss of narrowband radar data.

Interruptions of less than a minute can occur when a system element malfunctions and is automatically replaced with a standby unit. This could take as little as 5 seconds but is still, in fact, classified as an interruption. As a result of our continuing technical efforts, we have reduced the number of startovers from 15-20 per week just 2 years ago to the present level of about 7 per week per center. When they occur, rather than blanking the situation display, last known aircraft positions and other information are simply not updated or refreshed. In this way, the effect on the controller is minimized.

Interruptions of more than 1 minute are of more concern. At the Leesburg facility these have occurred at the rate

of about one each week. The average duration of these outages is approximately 7 minutes. Most result in a loss of computer generated display information for the controller.

Unscheduled interruptions are primarily caused by hardware (equipment) failures and software problems. The system continuously monitors itself in order to detect these abnormalities, and is designed to prevent presentation of erroneous data to the controller. Consequently, when the system detects erroneous data which could mislead the controller, it either corrects that data with no interruptions or flushes that data from the system by inducing a "startover." In a startover, the system analyzes the problem, corrects the problem, recovers, and presents the correct data to the controller. Startovers normally require less than 10 seconds but, dependent on the problem which needs to be corrected, may exceed this time-frame. Rarely would a startover reach a minute in duration.

In some instances, the system attempts to startover but is unable to correct itself. This would then require manual intervention to correct the problem. Most often this

would result in a system interruption of more than a minute.

A point I would like to emphasize here is that a startover is itself a beneficial aspect of the system since it (1) corrects erroneous data and (2) reduces the length of time that would otherwise result from manual intervention to correct the problem. From the standpoint that it is not technologically possible to reduce computer errors to zero, startovers avoid the adverse consequences that could otherwise arise from presenting erroneous data to the controller. It is readily apparent that providing erroneous data to the controller could have disasterous effects.

Recently, there have been blanket charges made that system interruptions pose a hazard to aviation safety. It is the exception when such interruptions pose any significant threat to safety. While it is understandable that interruptions might raise concerns about safety, the reality is that the system, itself, as well as air traffic procedures, is designed to accommodate interruptions without creating safety problems.

As I previously stated, most system interruptions generally last only for a few seconds. In this connection, I should note that radar data shown on a controller's display is only updated every 10 to 12 seconds. The effect of a momentary interruption is therefore generally negligible. The concerns with momentary interruptions, then, are essentially that: (1) they are a source of concern to the controller which, if unchecked, could damage system credibility, (2) an increasing number of momentary interruptions is generally a prelude to longer system interruptions, and (3) they signify errors within the system that should be corrected. For these reasons, we are aggressively working, as I will describe later, to reduce momentary interruptions.

System outages last longer than momentary interruptions and therefore require different actions than momentary interruptions. When a system outage occurs, the controller switches to broadband radar--our backup system--to continue tracking or controlling the aircraft he is concerned with. Broadband radar was the system used in all centers until 1974 when we began switching to our present Radar Data Processing (RDP or narrowband) system. There is nothing hazardous in our use of broadband radar;

in fact, this is the system used when our primary system is undergoing scheduled maintenance or certification. Even if broadband radar were to fail, we still have another back-up system available to control traffic. This is achieved through the use of flight progress strips, which results in "manual control" of aircraft. Manual control is the most basic form of air traffic control that we use and was the only system available for use prior to the introduction of broadband radar.

The basic impact from using broadband radar rather than RDP, or manual control rather than broadband, is a loss of efficiency in the system. RDP has a number of automatic features which free the controller from performing tasks required with broadband. Therefore, delays may occur when broadband is used rather than RDP. Similarly, broadband is significantly more efficient than manual control of traffic. For one thing, manual control dictates substantially greater separation standards between aircraft than does broadband or RDP for which separation standards are essentially the same. By imposing greater standards for separation, the impact is inconvenience in the form of delays caused by less efficiency in the system. And, since broadband has more housekeeping chores

associated with it than does RDP, the need to resort to broadband is clearly a source of aggravation for our controller workforce.

The central point is that various contingencies which might arise have been previously considered and have been accommodated by system design and air traffic procedures to prevent the derogation of aviation safety.

At the outset, let me point out what I believe to be a frequent misunderstanding of probable air traffic circumstances when a system interruption does occur. I believe it is a common misconception that when a failure occurs many aircraft are pointed at each other and that the lack of immediate action by the controller will result in midair collisions. This is not the case. In the en route environment, a controller simply does not allow even two aircraft, let alone several groups of aircraft, to be in a position that they will require control instructions within the next one to two minutes to avoid a possible midair collision. Further, in the busy arrival and departure sectors, the traffic flow is basically one way, not head on. In the en route sectors, traffic may be converging or overtaking or crossing; however, vertical

separation is normally established well in advance of the time that a critical situation would result.

When an RDP outage occurs, the radar controller is made aware of the outage by one of several indications on his display. The message or lack of a message on the display may give him an indication as to the likely duration of the outage, but there is no certainty that that likelihood will in fact occur. The controller must, therefore, first make an assessment based on traffic circumstances as to how long he can wait before he begins a transition to the broadband system. During the period of time it is appropriate to delay transitioning to broadband, the controller scans his flight progress strips. Based upon that information, the controller determines what altitude information may be needed from the various aircraft under his control and which control instructions are most likely to have to be issued in the event the RDP display does not return.

Once a controller has decided that a transition to broadband is necessary, all he needs to do is to push a single button to get broadband data displayed. At this time, all aircraft will be displayed; however, the

aircraft under his control will not specifically be identified as such nor will altitude be reflected on the screen.

The display at this time will be in a vertical position. Accordingly, the controller will have to lower the display to a horizontal position, identify aircraft by one of several means, and place "shrimp boats," which are identification tags, next to the aircraft under his control.

If the transition is during a peak traffic time, the radar controller may be assisted by his team supervisor or by the controller who occupies the position next to him reviewing flight progress strips. Also, during a transition when traffic is heavy, departures from airports within a sector are delayed until the transition is complete, and adjacent RDP centers may be requested to hold aircraft within their airspace until the transition is accomplished. These actions are intended to lessen the number of actions a controller must take prior to the completion of the transition.

There is no doubt that transitioning from narrowband to broadband can be a busy time, and, as we expressed before,

there are more controller tasks associated with the use of broadband than there are with narrowband. But there is nothing unsafe about the use of broadband radar. It is a fully adequate system for controlling air traffic, though a less efficient one than narrowband. And our controllers are a highly trained group of individuals who are fully capable of making the transition from narrowband to broadband safely and professionally.

A significant point I should make here, Mr. Chairman, is to reemphasize that it is not possible to completely eliminate system interruptions in any computer system - particularly one which is as complex and sophisticated as ours. Therefore, at least into the forseeable future, there will inevitably be times when it will be necessary to transition from narrowband radar to broadband radar to keep the system going.

This does not mean it is a desirable situation; to the contrary, any time there is a transition, whether it be as a result of a shift change or a change in mode of traffic control, the possibility of a system error - though still small - can increase. On the other hand, it is clear that the only way we could avoid the need to revert from one

mode of traffic control to another is to rely solely upon manual control of air traffic--a clearly unacceptable solution. At the same time, it is clear that transitioning from RDP to broadband radar is far preferable to the situation just five years ago when system failures in broadband required a transition to manual control as the only backup system. Recognizing, then, that the situation today is better than it was a few short years ago, but recognizing too that it is still less than optimum - since air traffic control transitions remain a fact of life - leads us to the inescapable question of "what can be done to improve upon the existing situation?" The answer is twofold: improvements to the system to increase its reliability and lessen interruptions, and training of the people who are called upon to safely make the transition from one mode of traffic control to another. I'd like to touch on the subject of training first.

Immediately following the initial implementation of narrowband in 1974, the transition from narrowband to broadband was probably less difficult than at the present time since the controllers in the workforce at that point had been trained and worked throughout their careers on

the broadband system. Narrowband was the new and less familiar system. Transition to broadband was, therefore, more a case of going from the new and less familiar to the old and more comfortable situation.

By 1976, the work force began to include radar controllers who, although they had been provided training on broadband and were fully qualified to work broadband, had no extensive operational experience with the broadband system. The transition for them was from the familiar system to the less familiar. Recognizing this problem, FAA's Director of Air Traffic discussed alternatives to accommodate this developing problem with all of the FAA regional Air Traffic Division Chiefs. As a result of that discussion, it was recommended that each develop computer simulated training problems to include simulated narrowband failures.

Following the issuance of that recommendation, the instructional program guide for en route air traffic controllers was modified to require training which included narrowband radar failures and the subsequent transition to broadband as part of the training for developmental controllers. Subsequent program guides have

strengthened this training requirement.

This effort was further strengthened in 1977 at a national conference of facility training officers from each center. During the conference, there was an exchange of results of different techniques used by the facilities to meet this need. The objective was to bring forth all alternative techniques and make that information available to each facility. Today, even before starting radar training at a facility, each developmental controller is provided training in transition from RDP to broadband. And later, during radar training, RDP "failure" training is administered as part of the developmental controller's required radar simulation training problems.

I'd like to address now some of the specific actions we have taken to improve system performance as well as some of the future actions we will be taking.

Since 1977, we have refined our reporting system for interruptions to provide a better management tool to address the problem. We have conducted periodic conferences of our sector managers to emphasize management awareness of the problem and to develop plans for further

solutions. We have formed a national group to categorize problems in the system and to track solutions; in effect, we have established a "10 Most Wanted List" so that we can systematically address major problems that arise. We have worked to stress to our field personnel the need for aggressive maintenance and follow up of each system interruption. We have made certain organizational refinements at our National Aviation Facilities Experimental Center to assure that new software is comprehensively checked out. This has resulted in new software being tested five times instead of one, and at two locations instead of one, before handoff to facilities for operational implementation. We have worked to develop a better system of key site testing of proposed system improvements. We have tried to improve our response time to problems experienced with the system and on many occasions immediately fly members of our support staff to operational facilities when problems occur. In this respect, I should note that at our centers we have a round-the-clock maintenance presence to respond immediately to maintenance problems which occur. We have provided new and more advanced test equipment, such as logic analyzers, to our facilities so they can better diagnose problems that occur. We have provided improved

lightning protection to our centers to reduce the possibility of power failures. And we have worked on the development of a new system, Direct Access Radar Channel (DARC), to replace broadband.

DARC, which is an automated system, will serve as the future backup system to RDP. It will provide the controller with limited data blocks, altitude readout, weather, maps, and an improved display presentation over broadband. Four systems have been delivered and deliveries are continuing at the rate of one a month. The first DARC is scheduled for commissioning three months from now in February 1980. Because of the additional information provided beyond that offered by broadband, DARC should provide for an easier transition when narrowband is interrupted.

Also, through ongoing management attention, we are continuing to refine and strengthen our maintenance practices. Further, in the near term, we plan to provide additional improved test equipment to our field personnel, and to complete a number of additional equipment modifications to the system.

In the longer term, there are a variety of improvements planned. Sometime in the mid 1980's we hope to have installed in our facilities an Electronic Tabular Display System (ETABS) which will replace our present flight strip printers with electronic displays and touch entry devices. We have plans for a Remote Maintenance Monitor (RMM) to provide real-time monitoring of equipment. Before the end of 1982, we hope to implement an Automated Data Distribution System to provide an electronic data transmission system for transmitting computer tapes to field facilities. And, sometime in the mid to late 1980's we are planning to replace our entire existing network of air traffic control computers at a cost on the order of $1.5 billion; a project on which we have been working for over two years and which may well be the biggest computer project ever undertaken. And there are a variety of other actions planned.

To sum up, Mr. Chairman, we have in place the finest air traffic control system in the world - both in terms of equipment and personnel - but the system has its imperfections. You may be assured we will continue to work to lessen those imperfections and to improve upon the system. We have every confidence, Mr. Chairman, that our

current system will continue to safely meet the needs of our air transportation system through the time that our future computer replacement program has been completed.

That completes my prepared statement, Mr. Chairman. My associates and I will be pleased to respond to questions you may have at this time.