ORDER DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

1811.2

7/13/78

SUBJ: SYSTEM REQUIREMENTS STATEMENT/ACQUISITION AUTHORIZATION FOR THE LOW LEVEL WIND SHEAR ALERT SYSTEM (LLWSAS)

1. PROBLEM STATEMENT.

a. Concise Definition of the Problem. Since June 1975 there have been four major air carrier accidents in which low level wind shear was a primary causal factor. In each case the wind shear was associated with a thunderstorm. During such conditions the wind directions and speeds at and near the surface varied greatly from one point to another along the approach or departure path. A suitable network of anemometers encircling an airport could provide a warning for such a horizontal low level wind shear. However, a single anemometer sited near the center of the airport (in accordance with Order 6560.3A, Siting Criteria for Airport Wind Sensor) cannot provide a wind shear warning.

b. Background.

(1) On August 7, 1975, a Boeing 727 with 134 people on board was cleared for takeoff on Runway 35L at Denver. Weather was VFR, and winds were reported to the pilot as 230 degrees at 12 knots. According to the National Transportation Safety Board, the actual winds at the north end of the runway were tailwinds in excess of 60 knots caused by the arrival of a thunderstorm gust front. (The gust front had engulfed the north end of the runway but had not reached the south end or the official center field anemometer.) Shortly after the aircraft lifted off, it encountered the wind shear, lost 41 knots of indicated airspeed in 5.0 seconds, and crashed near the north end of the runway. In the accident investigation it was discovered that several workmen near the north end of the runway had taken shelter in their trucks before the accident due to the high winds. In fact, the winds blew the roof completely off a shed. However, the person who needed most to know about the high tailwinds - the pilot - had no such information. A simple anemometer near the north end of the runway would have provided the basic information needed to alert the pilot that an extreme wind shear engulfed his takeoff flightpath. It is believed that such knowledge would lead any reasonable pilot to delay the takeoff, thus avoiding an accident.

(2) On June 24, 1975, a Boeing 727 crashed on approach to JFK airport, killing 113 people and injuring 11 others. Witnesses at the crash site on Rockaway Blvd. stated that a violent wind was blowing there at the time. However, the reported center field wind was only 10 knots, since the thunderstorm winds had not reached there at the time.

Distribution: W-1 (Minus WEM/RD/AF/AT/FS/BU/VP/SP/LG) WEM/RD/AF/AT/FS/BU/VP/SP-2; WLG-3; RAT/AF-2; RLG-3; NC-1; R-1

Initiated By: AFS-203

If there had been an anemometer at the middle marker, it would have shown violent tailwinds in comparison to the 10-knot headwinds at center field. It is felt that if the pilot had been aware of the extreme nature of the horizontal wind shear, he would not have attempted the fatal approach.

(3) A DC-9 crashed on approach to Philadelphia airport during a summer thunderstorm on June 23, 1976. Localized winds were so strong that one trijet refused to takeoff when cleared, because it was being blown so severely while sitting stationary on the taxiway. The accident aircraft separated into several pieces, and 86 of the 106 people on board were seriously injured.

(4) On June 3, 1977, a Boeing 727 was cleared for takeoff in Tucson. A headwind of about 20 knots at the start of the takeoff roll sheared into a tailwind of 25 to 30 knots at the far end of the runway. The aircraft barely got airborne by the end of the runway and struck wires, trees, and poles. Although a fuel tank was ruptured and significant damage was done to the wings, flaps, and landing gear, a safe emergency landing was made. It is believed that the pilot would not have attempted the takeoff if he had known about the large horizontal wind shear between the two ends of the runway.

2. MISSION NEED AND OPERATIONAL (FUNCTIONAL) REQUIREMENT. The operational requirement for low level wind shear is included in the FAA general hazardous weather requirement, which is: "To provide hazardous weather information (low level wind shear) to the pilot as well as to the controller with sufficient warning and accuracy to permit the pilot to avoid the hazard and/or the controller to assist the pilot in avoiding the hazard." This System Requirement Statement addresses ground-based equipment which provides wind shear information to the controller for assisting the pilot in avoiding the hazard. As described in paragraph 1, accidents have occurred in the past where a pilot is given a wind report of an innocuous wind direction and speed as measured at center field. The pilot then proceeds to takeoff or land into a region which, in fact, has been engulfed in the hazardous wind field of a thunderstorm (thunderstorm gust front or thunderstorm downburst cell). A logical way to attempt to avoid this type of accident in the future is to install an anemometer in each runway's takeoff and landing corridors. Any significant difference between the windspeed and/or direction at a peripheral anemometer and the windspeed and/or direction at the center field anemometer constitutes a potentially hazardous horizontal low level wind shear. (This is, in fact, the definition of horizontal low level wind shear.) If such shear occurs, the wind readings at both anemometers should be displayed to the local controller for immediate voice transmission to the affected pilot(s). Suggested guidelines include:

a. Continuous comparison of the wind at the center field anemometer and the winds at the peripheral anemometers should be performed by a computer rather than a human being.

b. The wind vector (i.e., wind direction and speed) at each peripheral anemometer should be compared (one at a time) with the wind vector at the center field anemometer. The difference between the two vectors should be computed (every 10 seconds or less). Whenever the magnitude of this vector difference exceeds 15 knots, a wind shear alert should be signalled to the local controller. The center field wind and the wind at the differing anemometer(s) should then both be displayed to the local controller for transmission to the affected pilot(s) as soon as possible. (Note: The 15-knot difference limit given above is approximate and may require adjustment for various sites or peculiar air flow patterns. It may also prove desirable to make the limit a function of the wind velocity.)

c. The suggested nominal location for each peripheral anemometer is near the respective middle marker site. A location slightly farther out may be more desirable for arrivals, whereas a location slightly closer in may be more desirable for departures. However, the middle marker location is felt to be an adequate compromise for both arrivals and departures. In addition, property ownership and electrical power problems should be minimal at the middle marker location. (If a runway does not have a middle marker, the anemometer should normally be placed about 3500 feet from the threshold near the runway centerline.)

d. During a very large percentage of the time no significant wind shear will be present at an airport, and only the center field wind need be displayed. However, the capability should exist for the controller to have displayed at will any peripheral wind reading.

3. POTENTIAL RULEMAKING ACTIONS. At this time, no rulemaking actions are planned. The wind and wind shear information will be given to the pilots as advisories. It is anticipated that an advisory circular will be prepared to provide pilots with suggested criteria as to when an approach should be abandoned or when a takeoff should not be attempted. It is believed that pilots will exercise due caution upon the receipt of a wind shear alert. If this does not prove to be the case, rulemaking actions can be initiated.

4. RELATED FACTORS.

a. Potential Benefits Assessment. Since June 1975 there have been four major air carrier accidents attributed to low level horizontal wind shear. The major potential benefit of the LLWSAS is that it will reduce the potential for this type of accident in the future. A benefit/cost analysis of LLWSAS was conducted and the results are summarized in paragraph 5.

b. Expected Public and User Impact. The public and users should derive the potential benefit described in paragraph 4a. There are no expected adverse impacts on the public or users.

c. Regulatory Aspects. As described in paragraph 3, no regulatory or rulemaking actions are planned at this time.

d. Previous Congressional Attention or Mandates. Congressional interest in FAA actions to prevent wind shear accidents has been high since June 1975, when 113 people were killed in the JFK wind shear accident.

e. Environmental Assessment. It is anticipated that the LLWSAS will produce no adverse environmental impact.

f. Evaluation of Proposed Alternatives. See paragraph 6b.

g. Anticipated Impact on Human Factors. During a LLWSAS alert the local controller's workload will increase, since the extra wind information must be transmitted to the pilot. In addition, the orderly flow of traffic may be temporarily affected since pilots cleared for takeoff may elect to remain on the ground, and pilots cleared to land may elect to miss the approach. Also, the active runway may have to be changed more often than in the past as increased knowledge of the location of wind shears causes pilots to request a change of runways. Fortunately, low level horizontal wind shear conditions generally occur less than 1 percent of the time, so this increase in controller workload will not occur often. In any case, it is felt that the temporary occasional instances of increased local controller workload are far preferable to the alternative of not warning the pilot of hazardous wind shear. With respect to human factors in the cockpit, all effects of the LLWSAS should be positive.

5. BENEFIT/COST ANALYSIS.

a. A benefit/cost analysis has been performed for the LLWSAS (reference paragraph 11g). The purpose of the analysis was to determine if the LLWSAS is justified economically and, if so, at which airports. A summary of the results are presented in this section.

b. In conducting the analysis a number of factors were considered, such as:

(1) The cost of installing and maintaining the LLWSAS over its projected life.

(2) The cost of lives, property lost, and injuries sustained due to past wind shear accidents which may have been avoided had an LLWSAS been in operation at the airport.

(3) Thunderstorm activity at candidate airports.

(4) Forecast of air carrier activity at candidate airports.

c. As would be expected, each airport's benefit/cost ratio was nearly proportional to the number of thunderstorms per year at the airport multiplied by the number of air carrier operations per year at the airport. This, in turn, is proportional to the number of air carrier operations per year which are potentially exposed to thunderstorms and associated wind shear.

d. A dollar value was calculated for the expected benefits of an LLWSAS installation (over a projected 20-year life) at each of 150 candidate airports. (Ninety-three percent of all U.S. domestic air carrier operations are conducted at these 150 airports.) A dollar value was also calculated for the cost of an LLWSAS installation. This was based on an initial cost of procurement and installation of $250K and a yearly cost of operation and maintenance of $15K. The discounted present value of the cost of an LLWSAS installation over 20 years is $378K. Of the 150 candidate airports, 110 are calculated to have benefit/cost ratios in excess of 1.0. The leading airport is Atlanta with a benefit/cost ratio of 45.

6. ALTERNATIVES AND MILESTONES.

a. Alternative Selected and Major Reason for this Selection. As described in paragraph 2, the selected alternative was a computer monitored network of four to six anemometers around the outer periphery of the airport. This selection was finalized in an AOA-1 Decision Paper signed by Administrator McLucas on October 20, 1976. The major reason for this selection lay in the belief that this was the quickest and most economical way to accomplish the goal of preventing further thunderstorm wind shear accidents. This appears valid today.

b. Rejected Alternatives.

(1) A scanning laser may eventually be developed to detect thunderstorm wind shears along the approach and departure paths. However, this alternative involved too much technical risk and was considered a far-term solution.

(2) A modification to the airport surveillance radar was also proposed. This involved the same general risk and delay as the laser.

(3) A network of about 80 microbarographs (pressure jump sensors) has been installed at Dulles and O'Hare airports to test its capability to detect the approach of thunderstorm wind shears. The system has achieved a measure of success. However, its major drawbacks are inability to determine the magnitude of the wind and wind shear, and inability to determine when the wind shear has ceased.

c. Milestone and Decision Point Schedule for 20 Systems in FY-78.

TSARC waiver granted to proceed with procurement of initial 20 systems prior to submission of Acquisition Paper (AP submission in 10/78)	3/1/78
Delivery of technical data package from ARD/ANA to AAF	3/15/78
Procurement Request to ALG	6/15/78
Contract Award	9/15/78
Delivery of first system from contractor (4 months from Contract Award until delivery of first system; delivery of one system per week thereafter).	1/15/79
First site becomes operational	3/31/79
All FY-78 systems installed and operational	8/15/79

d. Milestone and Decision Point Schedule for 40 Additional Systems (FY-79 and -80)

Acquisition Paper to TSARC	10/78
Procurement Request to ALG	11/78
Contract Award	6/79
Delivery of first production system	6/80
First system operational	8/80
All systems installed and operational	4/81

7. COSTS.

a. R&D Costs. In FY-77, $350K R&D money was spent. In FY-78, $300K has been programmed for NAFEC to complete work on the LLWSAS program.

b. F&E Costs (Service Test and Demonstration, Six Sites). In FY-77, $700K F&E money was spent. In FY-78, $225K has been made available to keep those sites on line, and to make improvements and updating changes.

c. Boston Site. To date, $138K in F&E money has been identified for the Boston LLWSAS; $32K of that amount has been sent to Boston.

d. F&E Costs (Production and Installation). The initial estimates are $150K per site for installations with radio links (FY-78 buy - 20 sites) and $250K per site with landlines (FY-79 and thereafter - 20 sites in FY-79; 20 sites in FY-80). It is hoped that these estimates will decrease as further experience is gained.

e. Life Cycle Costs.

Personnel - estimated 1/3 MY/site	9K/site/yr.
Recurrent training	1K/site/yr.
Spare parts	4K/site/yr.
Power	1K/site/yr.
TOTAL	$15K/site/yr.

(One-time initial training: $6K/site)

f. Total Program Cost Over 20 Years (First 60 Sites).

20 sites @ 150K	3,000K
40 sites @ 250K	10,000K
60 sites x 15K/sites/yr. x 20 yrs.	18,000K
TOTAL	$31,000K

g. Present Value of Total Program Cost, Discounted Over 20 Years (First 60 Sites). Assuming a 10 percent discount rate and a 20-year system life, the present value cost of each FY-78 system is $278K. For each FY-79 and -80 system, the figure is $378K. The total is 20 x $278K plus 40 x $378K, or $20,680K.

8. MINIMUM BENEFITS OF ANY PROPOSED SOLUTION TO BE ACCEPTABLE. Since June 1975 four major air carrier accidents have occurred due to thunderstorm-generated low level wind shears. As a minimum, any proposed solution must decrease the potential for this type of accident by providing pilots with a timely warning of hazardous wind shears.

9. RELIABILITY, MAINTAINABILITY, PRODUCTIVITY, SAFETY, ENERGY, ENVIRONMENTAL, AND STAFFING GUIDELINES GOVERNING THE SYSTEM ACQUISITION. No deviations from current FAA policies and philosophies are required by the LLWSAS for any of the above considerations except that the FY-78 systems procurement will be "off-the-shelf," and only the normal commercial standards for reliability and maintainability will be provided.

10. IMPLEMENTATION PARAMETERS.

a. If total program costs over 20 years for the first 60 installations exceed $62 million, the requirement should be revalidated. Assessment will be conducted by the program sponsor at appropriate milestone points to ensure that this cost limitation is being met. As a minimum, these reviews should be made when the Acquisition Paper is submitted to TSARC and at contract award.

b. Operational briefings, indoctrination, and training will be provided for controllers and supervisory personnel at each location in a timely fashion prior to commencing operation.

11. REFERENCES.

a. NTSB Aircraft Accident Report #NTSB-AAR-76-14, Continental Air Lines, Inc., Boeing 727-224, N88777, Stapleton International Airport, Denver, Colorado, August 7, 1975.

b. NTSB Aircraft Accident Report #NTSB-AAR-76-8, Eastern Air Lines, Inc., Boeing 727-225, N8845E, JFK International Airport, Jamaica, New York, June 24, 1975.

c. NTSB Aircraft Accident Report #NTSB-AAR-78-2, Allegheny Airlines, Inc., Douglas DC-9, N994VJ, Philadelphia, Pennsylvania, June 23, 1976.

d. Decision Paper: Thunderstorm Wind Shear Detection, signed by AOA-1 (McLucas) October 20, 1976.

e. Letter from Edwin Kessler, Director of the National Severe Storms Laboratory and Environmental Research Laboratories, NOAA, to Director, FAA Wind Shear Program Office, dated July 30, 1976, proposing a system which developed into LLWSAS.

f. An Operational Application of Mesonet Network for Warning of Translating Surface Wind Boundary Changes, R. Craig Goff, FAA NAFEC, April 1978.

g. Benefit/Cost Analysis of the Low Level Wind Shear Alert System, K. Lauterstein, ASP-120, April 1978.

12. ACQUISITION AUTHORIZATION.

a. This Acquisition Authorization pertains to the first 60 LLWSAS installations, currently scheduled for funding at the rate of 20 installations per year in FY-78 through FY-80. Implementation beyond the first 60 installations will be dependent upon an updating of the benefit/cost analysis after cost figures are further refined.

b. Installation of an LLWSAS is certified as a valid System Requirement. This certification is granted subject to the implementation parameters of paragraph 10.

c. Authorization is granted for the LLWSAS program and the first 60 installations, as described herein, to move into an implementation phase as defined in Order 1810.1A, System Acquisition Management.

Langhorne Bond
Administrator