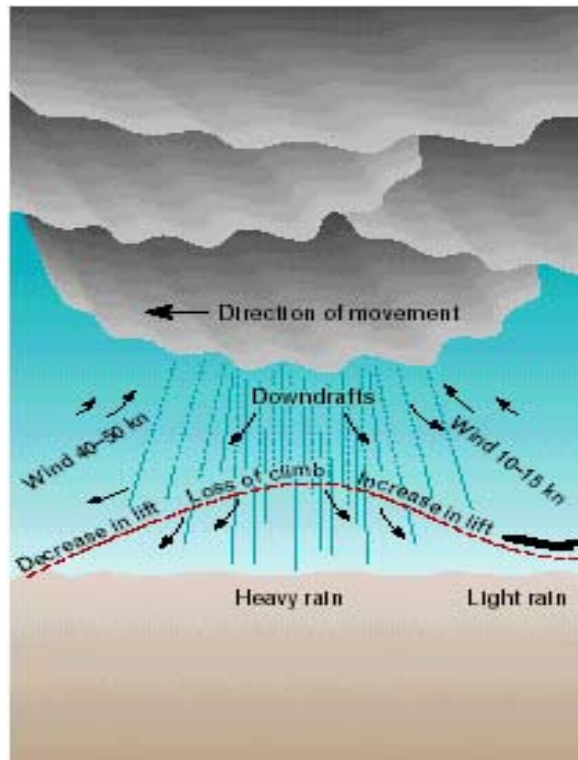


# Low Level Windshear Alert System (LLWAS)

◇An integral part of the U.S. FAA Wind-shear safety program◇

Low-level windshear is a hazard to aircraft in the airport runway corridors. With **Climatronics LLWAS**, operational at airports throughout the U.S., air travel safety is enhanced through the timely detection and reporting of hazardous wind shear in and around the terminal approach and departure zones.

## Microbursts



**Microbursts** are the greatest danger to aircraft during final approach and takeoff. Microbursts begin as small powerful downdrafts, typically inside thunderstorms that descend from 3000 to 6000m above ground level. When these cold downward rushes of air reach the ground, they spread out, or burst, horizontally in all directions, creating a locally intense divergent wind shear that is very shallow.

Wind shear with loss values greater than or equal to 30 knots is typically considered as a **Microburst Alarm**.

## Wind Shear

**Wind shear** with loss values greater than or equal to 15 knots, but less than 30 knots, is typically considered as a **Wind Shear Alert**.

## Gust Fronts

**Gust Front** is a boundary of changing wind speed and or direction. A divergence analysis detects the occurrence of microbursts and gust fronts. Microbursts are associated with wind divergence while gust fronts (shears) are associated with wind convergence.

## Climatronics LLWAS-RS is FAA-Certified:

- ❖ Field proven to meet FAA performance criteria
- ❖ Deployed at 41 operational airports world wide
- ❖ FAA proven UCAR Phase III Algorithm
- ❖ Meets FAA required Probability of Detection (POD)



## Wind Shear Safety in Runway Corridors

The ability to measure accurately and predict rapidly changing weather conditions in runway corridors is of significant concern to the aviation community. Wind shear, acting on an aircraft, drastically alters lift forces and can cause an abrupt change in air speed and flight characteristics. This sudden and extreme wind shift, both in velocity and direction coupled with a center downburst, provides the scenario for an aircraft accident.

When an aircraft encounters a microburst wind pattern, which often develops quite suddenly (within one to two minutes), the aircraft first experiences a headwind, which actually serves to increase the flow of air over the wings, thus increasing the lift. If the pilot is trying to approach on the glide slope, the pilot may attempt to correct for this lift by bringing the aircraft's nose downward so as not to overshoot the runway. Immediately after encountering the headwind, though, the aircraft experiences a downdraft, which forces the plane downward. Finally, the aircraft encounters a strong tailwind, which reduces the net airflow over the wings, thus reducing the lift. Because this divergent wind pattern is encountered near the ground, the aircraft has little or no room to descend before recovering airspeed and flying out of the microburst. Microbursts generally cover an area of 2 miles or less.

## Field Proven FAA-Certified LLWAS-RS System

**Climatronics LLWAS** provides real time collection and processing of wind data to detect the presence of hazardous wind shear and microburst events near an airport and provides the location of the hazard relative to the runways. Wind data is retrieved from an array of wind sensors that are placed at remote locations along the runway corridor. The system is optimized to warn of wind shears that may constitute a hazard to aircraft approaching or departing the airport.

**LLWAS** gives visual and audio alerts to air traffic controllers and other airport personnel, in clear and concise numerical and/or graphical form, in order to warn pilots so they can take appropriate evasive action. LLWAS provides its output to the display systems typically located in the Air Traffic Control Tower and TRACON room.

### LLWAS-RS for FAA

- LLWAS-RS for Federal Aviation Administration (FAA) has been environmentally tested and field proven to meet FAA high performance criteria.
- LLWAS-RS deployed at 40 operational airports throughout the United States.
- The Remote Station has field proven performance in various uncontrolled environments.
- The FAA proven UCAR algorithm implemented by **Climatronics**.
- Meets FAA required Probability of Detection (POD)
  - LLWAS-RS POD is as effective as most weather radar systems at about 1/10th of the cost
  - **Climatronics LLWAS-RS** system has had the only recent POD analysis by FAA.

### Data Retrieval, Processing, Distribution:

- Gathers wind data from the airport area via RF (radio frequency) telemetry (or land-line) from the Remote Stations (RS) and automatically detect hazardous low-level wind shear.
- Measures the level of wind shear hazards (including microburst) and determine their locations.
- Measures the winds at the center field RS, and calculates the 30-second and 2 minute average. Outputs these values, with gust information.
- Measure the winds at the RS around the airport and calculate the 30-second average.
- Provides system maintenance & control
- Provides archival storage capability.
- Provides the wind data and warning information to the various displays.



## HAZARDOUS WINDSHEAR DETECTION PROCESSING

The **Climatronics LLWAS** algorithms were developed for the FAA by the National Center for Atmospheric Research, part of the University Corporation for Atmospheric Research (UCAR), Boulder, Colorado, USA for the LLWAS-3 implementation. The LLWAS-3 algorithms are referred to as the UCAR algorithms. **Climatronics** has a user license from UCAR for its use in the LLWAS. The processing of the wind data to determine the presence of hazardous wind shear is performed using the UCAR LLWAS-3 algorithms. These algorithms are the latest proven design, which have shown a probability of detection of more than 90% and a very low false alarm rate of less than 10%. Hazardous wind shear and microbursts are detected and alarms are generated relative to the runway. The LLWAS is capable of supporting up to physical (8 directional) runways in all functions relating to runway oriented message and data.

**Network Statistical Analysis:** The validated and filtered data from each wind sensor are used to compute the airport mean and standard deviation estimates. LLWAS uses a Chi-squared outlier trimming strategy to eliminate contamination of the mean and standard deviation values if one or more wind sensor(s) is significantly different from the mean of the previous computation.

**Divergence Analysis:** A divergence analysis detects the occurrence of microbursts and gust fronts. Microbursts are associated with wind divergence while gust fronts (shears) are associated with wind convergence. In practice, the divergence consists of two parts. Firstly, the derivatives of the winds, using the edges and triangles of the sensor sites, are computed to estimate the occurrence of divergence or convergence. A microburst model is employed to estimate the head loss to an aircraft if divergence is occurring. Secondly, if a head wind gain or loss persists, the shear along the runway is computed.

**Alert Analysis:** Analysis of the alert condition is performed to determine the shear type, which runways are affected, and to determine which shear is most likely to impact the active runway if multiple shears are present.

## SYSTEM COMPONENTS

### • MASTER STATION

The Master Station (MS) consists of the following major components:

- Master Station Computer and System Console to monitor LLWAS performance
- Master Station Transceiver: The RF signal from the radio transceiver is transmitted to the Remote Stations via the MS omni-directional antenna.

### • DISPLAYS

The Master Station Computer provides interfaces to the following remote displays and display control devices:

- TRACON Displays – display center field wind speed, direction and gust information
- Ribbon Display Terminals (RBDT) tabular plasma display or optional 17" TFT-LCD Graphics Display Terminal (GDT).
- Displays provide current wind data for each of the currently displayed runway configurations and wind shear and microburst conditions, alerts and alarms
- Display Selection Device (Keypad/Display) to select and display predefined runway configuration for each RBDT
- Produces an audible warning for detected wind hazards

- **REMOTE STATION**

The Remote Station consists of the following major components:

- Wind Sensor: sonic anemometer mounted on a quick disconnect slide pipe
- Remote Station Enclosure: stainless steel junction box with radio transceiver, power supplies, and microcomputer interface card. Enclosure is mounted on a quick disconnect slide bracket plate
- Directional antenna
- Solar Panel (optional)

### Remote Station (RS)

A Remote Station is a group of equipment located at one of up to 32 sites on or near the airport from which wind data are measured and retrieved. Measurements of the current wind velocity and direction are continuously gathered from wind sensors located at the RS. The wind measurements and LRU performance information are formatted for efficient, reliable transmission to the MS for further processing and validation.



The Remote Station has field proven performance in various uncontrolled environments.

- **Radio Modem/Transceiver:** The radio modem/transceivers used in the Remote Station are the same as those used in the Master Station Transceiver. The RF signal from the radio transceiver is transmitted to the Master Station.
- **Wind Sensor:** The wind sensor for the LLWAS is a sonic anemometer. Acoustic transmitters emit an ultra sound. Changes in the transit time of the ultra sonic pulse caused by the wind are measured by the internal electronics, and the horizontal wind components are calculated from these measurements.
- **Power Supply:** The RS power supply converts the mains power to DC power to operate RS and to charge the sealed, lead-acid battery that is also in the RS junction box. An optional solar power panel can be provided to power the Remote Station.
- **Battery for Backup Power:** The sealed lead-acid rechargeable battery for the Remote Station has a reserve capacity of 34 Ampere-hours. The battery has a reserve capacity of sufficient to operate the RS for a minimum of 32 hours.
- **Stainless Steel Weather-tight Housing:** The RS power supply, battery, and radio transceiver or land line interface are contained in a stainless steel weatherproof enclosure.

## RUNWAY ALARM GENERATION

The Alarms are processed with respect to the runways to determine location and magnitude of hazardous windshear. Persistent windshear conditions result in runway alert generation. The generation of runway alarms is accomplished by utilizing the UCAR Algorithms. The UCAR algorithms generate hazardous windshear and microburst warnings.

**Persistence:** Runway messages are distributed to the display systems only if a windshear condition persists for pre-set parameter number of times.

**Runway Messages:** Runway messages indicate the type of alerts, threshold wind direction and speed, location of expected first encounter, runway oriented expected loss or gain, multiple windshears, and possible windshear outside the LLWAS network. The alerts indicate the presence of hazardous windshear.

**Microburst Alert (MBA) and Windshear Alert (WSA):** There are two types of messages

- **Microburst Message** – A MBA is issued when a Microburst is detected within the network. A Microburst is a detected divergence with a loss estimate greater than or equal to a pre-set parameter level in knots. A microburst is always a loss.
- **Windshear Alert** – A WSA is issued if a shear condition is detected within the Network with runway-oriented loss (ROL) or gain (ROG) exceeding a pre-set parameter level in knots. A shear condition is a weak divergence alarm of less than a pre-set parameter level (typically 25 to 30 knots) but greater than a set parameter level (typically 15 knots).

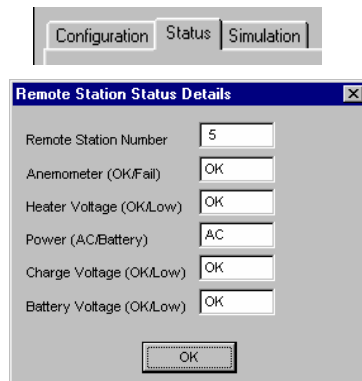
**Master Station Computer**



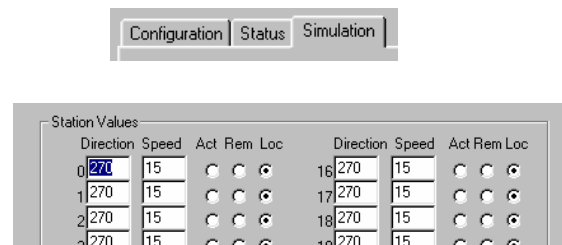
**Master Station Computer – Main Screen**



The current state of each remote station is displayed in the Status display.



You can manage the simulation of Remote Station data from the **Simulation display**. This display contains data entry text boxes for entering simulation wind speed and direction values. You control the source of the Remote Stations data by the simulation options



# LLWAS-RS - FAA-Certified System

