The Front

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Technology at work for your safety

Conceived and deployed as stand alone systems for airports, weather sensors and radar systems now share information to enhance safety and efficiency in the National Airspace System.

Jim Roets, Lead Forecaster
Aviation Weather Center

The National Airspace System (NAS) is a complex integration of many technologies. Besides the aircraft that fly you and your family to vacation resorts, or business meetings, many other technologies are at work - unseen, but critical to aviation safety. The Federal Aviation Administration (FAA) is undertaking a modernization of the NAS. One of the modernization efforts is seeking to blend many weather and aircraft sensors, surveillance radar, and computer model weather output into presentations that will help the flow of air traffic and promote air safety. One of those modernization components is the Automated Surface Observing System (ASOS).

There are two direct uses for ASOS, and the FAA's Automated Weather Observing System (AWOS). They are: Integrated Terminal Weather System (ITWS), and the Medium Intensity Airport Weather System (MIAWS). The technologies that make up ITWS, shown in Figure 1, expand the reach of the observing site from the terminal to the en route environment. Their primary focus is to reduce delays caused by weather,

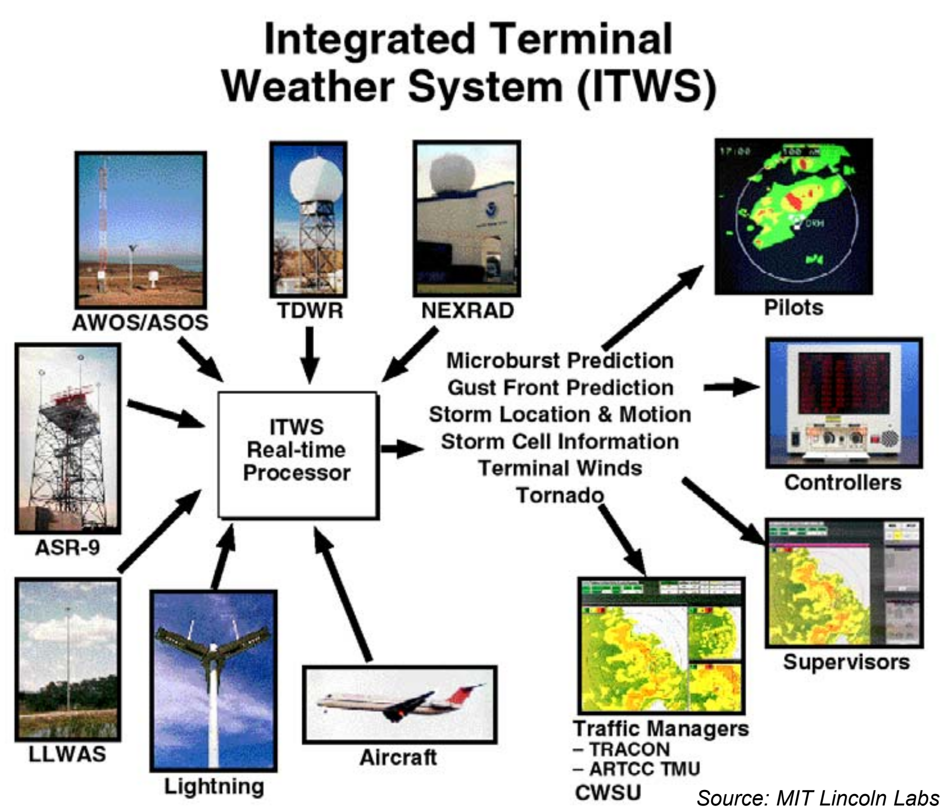


Figure 1. ASOS is an important component in the FAA's Integrated Terminal Weather System. ITWS is a weather monitoring and short range prediction system designed to aid air traffic controllers and pilots for the safe and efficient movement of air traffic.

In this issue:

__Mission Statement__

To enhance aviation safety by increasing the pilots' knowledge of weather systems and processes and National Weather Service products and services.

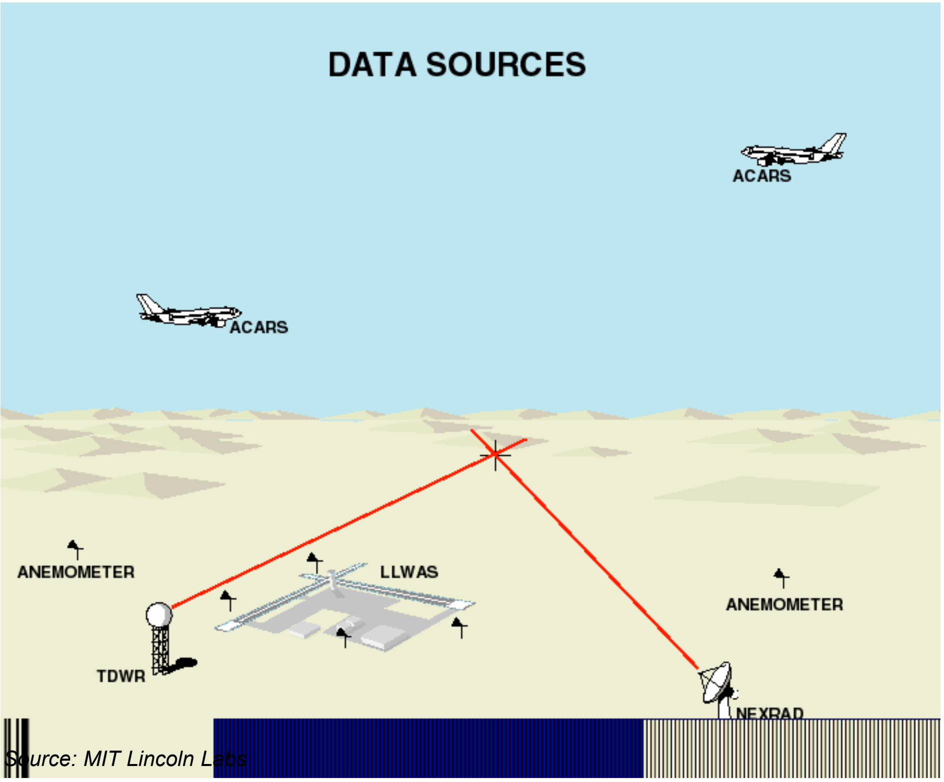


Figure 2. ITWS blends information from several technologies to give controllers an integrated assessment of storm impact.

especially at the busiest airports. The integration of these many airport and weather systems and sensors into a cohesive and easily understandable display will greatly enhance the safety of flight operations within the usually busy terminal environment.

Integrated Terminal Weather System:

Developed by MIT Lincoln Laboratories, ITWS provides weather products for air traffic automation systems by using data from FAA and National Weather Service (NWS) sensors, aircraft reports, and NWS numerical weather prediction to provide short-term forecasts (out to 30 minutes) for the terminal area. See Figure 2. The FAA operational users access the ITWS products through a color situation display. ITWS provides information on microbursts, gust fronts, tornadoes, storm location and motion, hail, and winds at the airport terminal area. Besides ASOS and AWOS, ITWS uses the following sensors:

- TDWR - Terminal Doppler Weather Radar (FAA)
- NEXRAD - Next-Generation Weather Radar (NWS)
- ASR-9 - Airport Surveillance Radar (FAA)
- LLWAS - Low Level Wind Shear Alert System (FAA)
- NLDN - National Lightning Detection Network
- MDCRS, ACARS - Aircraft Reports
- RVR - Runway Visual Range Sensors (later).

The information is disseminated via color displays to pilots, controllers, and traffic managers.

According to Lincoln Laboratories, ITWS installation began at major airports in 2001. Figure 3 shows end state deployment goals. Lincoln Laboratory is continuing to operate ITWS functional prototypes in Memphis, Orlando and Dallas/Ft. Worth in order to increase the ITWS operational and meteorological database and to provide operational user benefits.

Medium Intensity Airport Weather System:

The MIAWS program was established to develop a weather processing and display system for airports with a medium level of operations, but which lack the abundance of dedicated weather sensors found at larger airports. Its goal is to provide near-term, low-cost weather information to these airports. According to the FAA, airports of this size have too few operations to justify the cost of a dedicated weather system such as the Terminal Doppler Weather Radar (TDWR), an ASR-9 Weather System Pro-cessor (WSP), or ITWS, but could benefit from the higher level of safety that a MIAWS system would provide. MIAWS seeks to provide weather coverage to these airports by using existing, nearby sensors.

MIAWS, an enhancement of NEXRAD, has an initial objective of providing real-time display of storm positions and storm tracks using NEXRAD product data as the input to a weather service processor product generation and display system. Wind speed and wind gust information is provided through ASOS/AWOS input to the LLWAS - relocation/sustainment anemometer network. The NEXRAD reflectivity data will be displayed in the NWS 6-level thresholds. Storm position and motion vectors showing direction and speed of storm cells, will provide extrapolation lines with 10 and 20 minute leading edge positions. The system will also show airport wind vectors depicting wind speed and direction, and any current airport runway impact alerts.

The main users of this information, as with ITWS, will be controllers, pilots, and traffic managers. Two operational prototype systems have been providing controllers with weather alerts at the Jackson International Airport, MS, and Memphis, TN, since September 2000. Two new MIAWS prototypes were scheduled to be installed at Little Rock, AR, and Springfield, MO airports in the Spring of 2002.

Figure 3. ITWS will serve:
49 ATCTs,
37 TRACONs
18 ARTCCs
3 support facilities
The areas served have the most season-wide thunderstorms and severe weather that affect air traffic and air safety.

(Sources: FAA and MIT Lincoln Laboratories) For more information, visit www1.faa.gov/aua/ipt_prod/weather/itws//menusys.htm

Wind shear detection by NEXRAD, ITWS and MIAWS

Gust fronts and microbursts may show obvious, visual signs of their presence, but in the less obvious situations, ITWS and MIAWS are enabling controllers to see the hidden dangers.

If you think the thunderstorm season ended, think again. The record thunderstorm event of November 10-11, 2002 spread destruction across a large portion of the southern and eastern U.S. Much of it occurred in the area where ITWS and MIAWS are being deployed. Judgement on this deployment appears rock solid.

Traditional pilot training inundates the students with ominous images of approaching thunderstorms. Gust fronts are often marked with roll clouds or shelf clouds as shown in Figure 4.

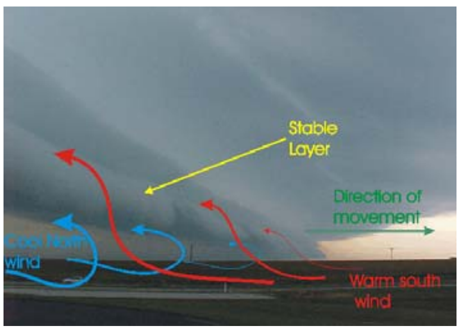


Figure 4. Roll clouds form where the warm inflow and cool outflow pass one another. These are the obvious "No Fly Zones" for thunderstorms.

These monsters are not the storms you read about in wind shear accidents. Rather, storms of intensity level 3 have led to tragic accidents in years past because weak wind shear was not observed or detected by instruments on the field or by weather radar.

Decaying thunderstorms can leave the sky mostly clear and the air cooler. One would justifiably believe that the danger has passed.

A broader satellite imagery may give clues that the danger has not passed. As a thunderstorm evolves from the mature stage to the dissipating stage, it becomes increasingly dominated by downdrafts and drops its cool rainfall. This cooler air spreads out in all directions and forms what's known as an outflow boundary. Convection is suppressed in this air and the sky clears. This scenario is depicted in Figure 5.

The dark cloud-free circles mark the stabilized air. The cool air spreading out from the decayed thunderstorm acts like a cold front. The cooler, denser air moves through the warm environment and lifts the air to promote new convection along the outflow boundary. To a pilot with a very local view, things seem pretty benign, but what may well be depicted on an ITWS or MIAWS terminal is a developing wind shear event.

In a line of thunderstorms composed of multiple cells, any number of storms could be dissipating and producing outflow boundaries. Where these boundaries meet, new convection fires up thanks to the combined lift of the intersecting boundaries.

Radar reflectivity imagery, the type shown most often on TV and on NWS web sites, may show an outflow boundary as a thin curved line. See Figure 6. Note that the reflectivity diplay shows no echoes in the area south of the main storm except for the thin curved line. METAR reports from around the region show southerly flow. However, between the gust front and the main thunderstorm northerly flow dominates. The subtle, stealthy wind shear event is well underway.

The curved line marks the region where the cooler and denser air is emerging. Doppler radar can detect these events in regions where the radar beam is low enough.

Figure 7 is a depiction of how this event might occur if it were approaching a major airport. The main thunderstorm is

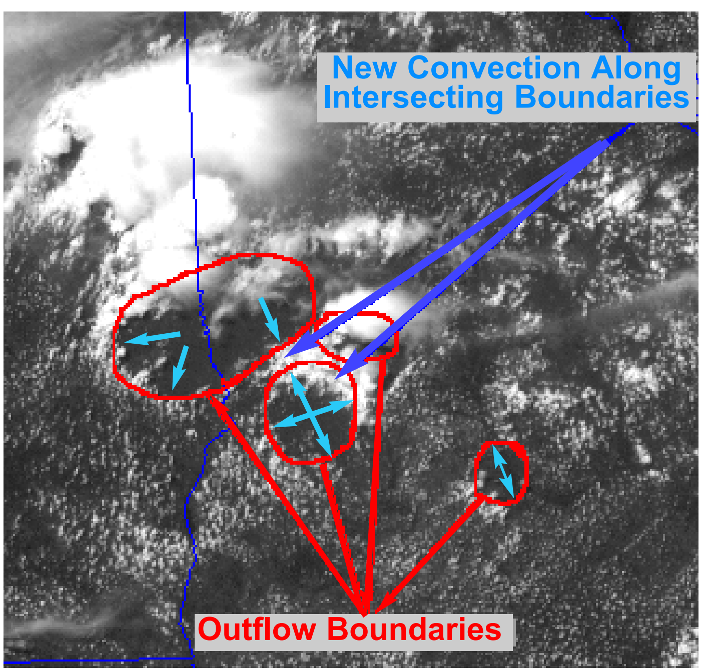


Figure 5. When outflow boundaries (blue arrows) from nearby thunderstorms intersect, new convection can begin. The radar data ingested into ITWS can provide clues about wind shifts associated with these outflows.

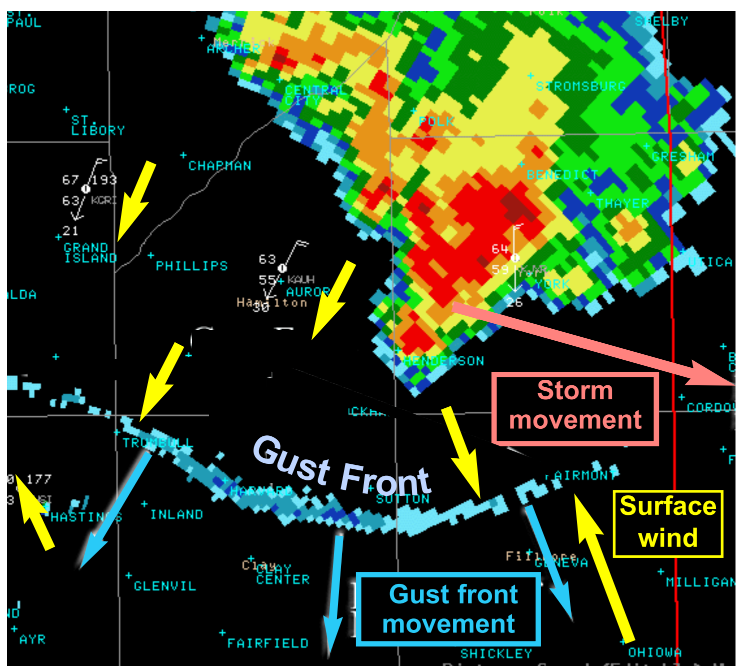


Figure 6. Thunderstorm outflow called a gust front may produce strong wind shear. Sometimes the gust front is visible on NWS Doppler radar. ASOS observations would provide solid ground truth to confirm the presence and strength of the outflow.

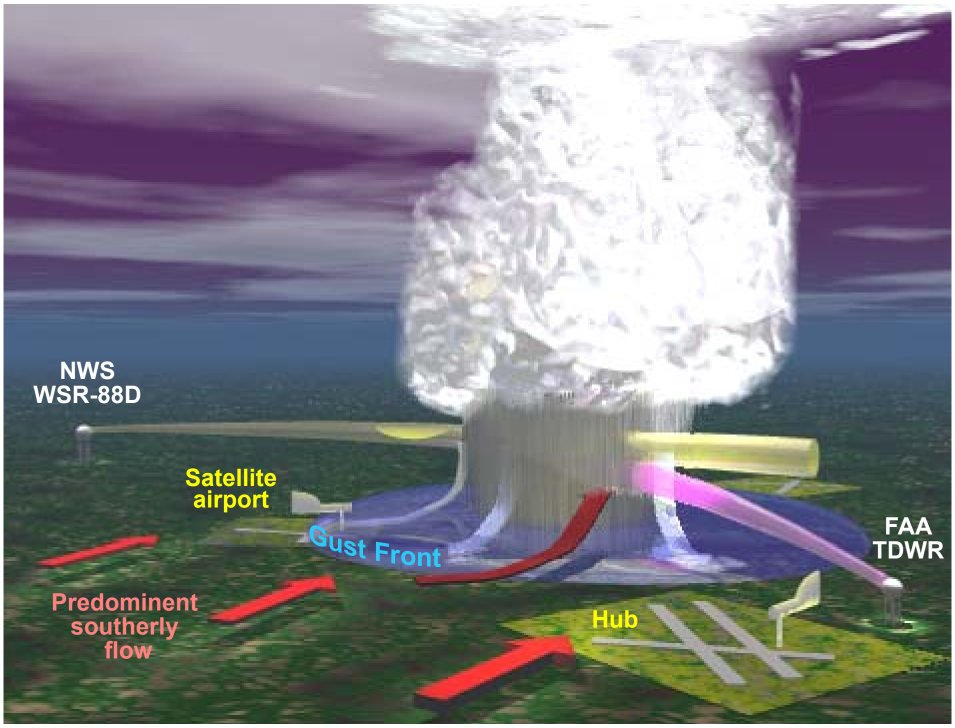


Figure 7. Cool ouflow from thunderstorms produces a gust front. The wind direction may be opposite to the general winds in the area. The cold, dense air can be detected as a fine curved line by Doppler radar. (See Figure 6). The beam from WSR-88D radars at NWS offices may be slightly above the main portion of the gust front, but TDWRs are in prime position to detect the gust front. ASOS reports from satellite airports in the terminal area help confirm the gust front in the ITWS system.

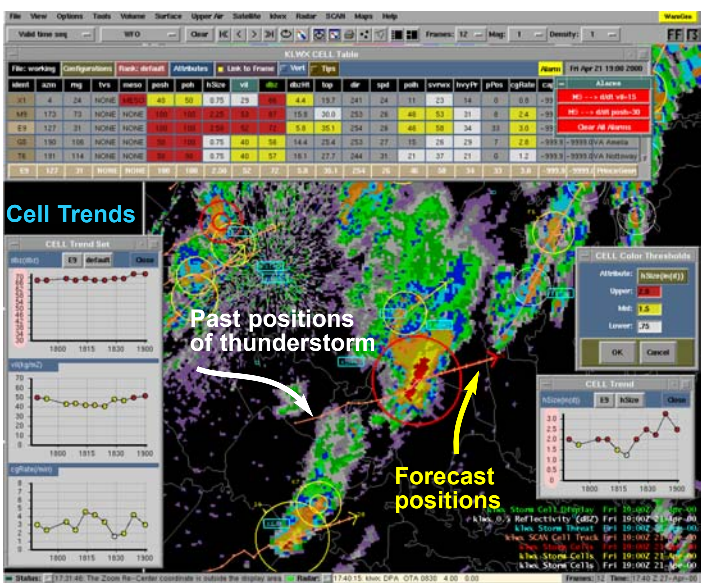


Figure 8. Workstations at NWS Weather Forecast Offices identify and track storms. Trends of storm strength, movement, hail size, and internal storm circulation help forecasters provide excellent lead times for tornado and severe thunderstorm warnings. These storm attributes are passed to ITWS.

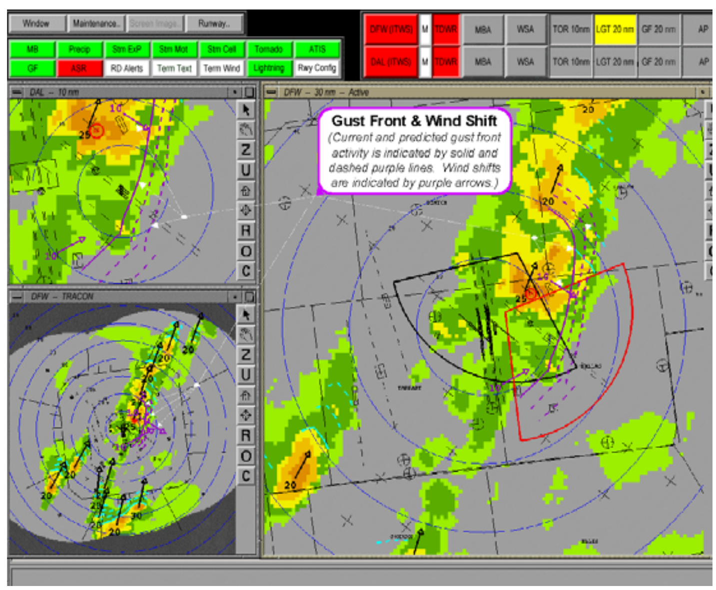


Figure 9. ITWS displays in the TRACON contain thunderstorm information similar to that on NWS displays because the annotation is derived from NEXRAD analysis systems. These displays give present and forecast positions of gust fronts and tornadoes, in addition to the storm reflectivity in the six standard levels.

seemingly a ways off and does not appear to be a major impact yet. No alerts are coming from the Low Level Wind Shear Alert System (LLWAS) yet. ASOS at the hub airport still reports a south wind. To the west, at the satellite airport, the gust front has arrived, and the ASOS confirms a wind shift into the north. ASOS reports this to the ITWS.

The TDWR may well begin to see the outflow as it scans the low levels in the terminal area. An NWS NEXRAD, some distance away scans just at the top of this 1500 foot deep gust front, but the radar is still able to accurately detect any internal tight circulation, or large hail within the thunderstorm. These storm attributes are sent to the ITWS for integration into the TRACON display.

The NWS forecasters use a display shown in Figure 8 (left side). It's packed with an abundance of storm attributes that keep forecasters abreast of events. The ITWS and MIAWS systems display gust fronts, hail, and possible tornadic rotation within the thunderstorm. These systems use data from NWS Doppler radar, ASR-9 radar, LLWAS, ASOS, aircraft reports, output from NWS atmospheric forecast models to provide a threat assessment and short term forecast for controllers.

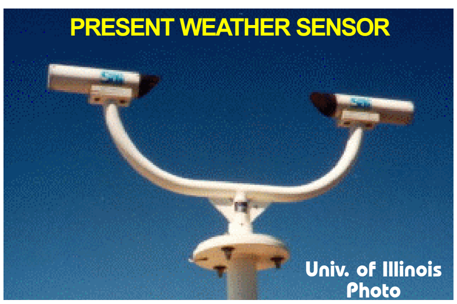
Final Approach

Emerging technology and increased number crunching by computers is doing for aviation weather what GPS, multi-function displays, and flight management systems has done for navigation. They're opening a new era in aviation safety. Never before has the technology been better or the communication better. Displays are available for use by the TRACON, Center Weather Service Unit, and users with a need to know. The most effective coordination occurs when all parties view the same image. The FAA is getting it done.

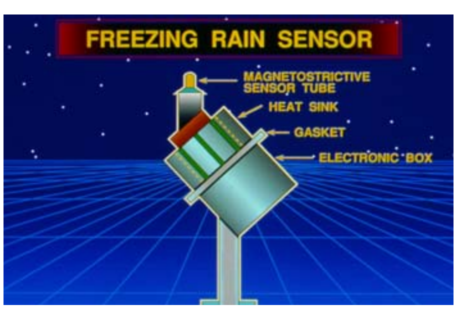
Automated Surface Observing System

Sally Pavlow, Forecaster
NWS Indianapolis, IN

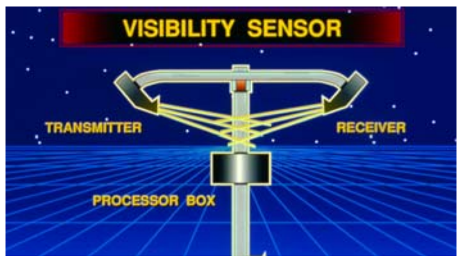
Major U.S. airport and scores of smaller airports use ASOS (Automated Surface Observing System). ASOS reports current sky conditions, weather, visibility, wind direction and speed, altimeter setting, temperature and dewpoint. The sensors record data many times an hour and offer METAR reports hourly and whenever meaningful changes occur. The data are also used by ITWS and MIAWS to optimize safety and efficiency. Here's brief look at the main sensors.



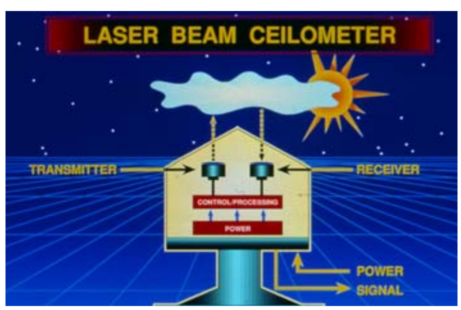
The present weather sensor consists of a transmitter head and a receiver head. The transmitter head aims a beam of infrared light through the atmosphere to the receiver. When there is no precipitation falling, the amount of light received will be nearly equal to the light transmitted. When falling precipitation is present, the amount of light received by the receiver head is reduced. The physical properties of each precipitation type that is detected (rain, snow and drizzle) is determined by the drop size, number of drops passing through the sensor stream and speed at which the precipitation falls. From this information, the present weather sensor can report which precipitation type is present and at what rate it is falling.



In order to detect freezing rain, the freezing rain sensor must first communicate with the present weather sensor to confirm that precipitation is actually occurring. Then it determines whether or not the precipitation is in the form of freezing rain. The freezing rain sensor is a nickel alloy tube which oscillates at a frequency of approximately 40,000 hertz. When liquid precipitation collects on the sensor probe, the frequency decreases and FZRA or FZDZ is reported.

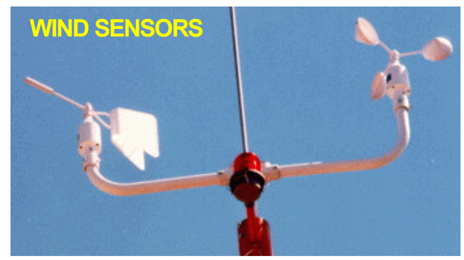


The visibility sensor, like the present weather sensor, uses a transmitter and receiver. A technique called forward scattering is used. Flashes from a xenon bulb produce visible light for scattering As light passes through the atmosphere, it is scattered. The receiver detects the light and measures the light level to determine the amount of light lost. A formula is applied which translates the light lost into a statute mile visibility.



The ceilometer reports cloud heights. It transmits an invisible laser beam vertically. As this beam is being transmitted it also senses the light return that is reflected back toward the ceilometer by objects in its path. The ceilometer calculates the time between the transmission and reception of the laser beam. From this, the height of water or ice droplets in the atmosphere are reported.

The temperature-dewpoint sensors report temperatures between -80 F and +130 F. To determine dew point, a chilled mirror is used. The mirror is cooled to the point where a thin film of moisture condenses on the mirror surface. The condensation is detected by the reflection of infrared light off the surface of the mirror. A precision thermal sensor is embedded in the mirror and measures the temperature of the mirror which is then translated into the dewpoint.



The wind sensor measures wind speed and direction and computes 5 second averages of these measurements. The wind speed is measured by a 3 cup photointerruptor device and wind direction is measured by a split vane along with a potentiometer.

Ground-To-Air Radio

Many ASOSs communicate their data to pilots and other listeners. This is done via the ground-to-air radio system. Frequencies and phone numbers are in the Airport Facility Directory and other prominent airport and navaid directories.

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