Honeywell

into the BLUE

EYE OF THE STORM

The Future Of Weather Radar

Inclement weather – it is a global problem and a major contributing factor in travel delays and costs for airlines. Weather detection and analysis can be one of the most complicated of airborne arts, requiring heavy pilot workload and extensive training. At the same time, pilot meteorology knowledge and equipment training varies widely across the industry.

Weather costs the commercial air transport industry USD$18 billion a year, and turbulence-related injuries cost the airline industry more than USD$100 million a year in delays and damage/inspection costs alone, and that doesn't even include the training expenses. Severe turbulence costs airlines on average USD$150,000 per incident. Additional fuel burned due to weather related incidents and delays can also be an additional expense for airlines in today's high fuel price environment.

Airborne weather radar is a powerful tool for pilots to see and understand the weather that lies ahead – including turbulence and wind shear. But the proper operation and interpretation of weather radar is dependent on aircrews having an adequate understanding of its capabilities, the provision of dedicated crew training and appropriate standard operating procedures.

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A Revolution in Radar and Weather Detection

The next generation of airborne weather radar addresses many of the shortcomings of traditional weather radar systems, including more automation to ensure a smoother ride, increase safety of flight, reduce workload and minimize training requirements. Honeywell led the way in 2006 with the release of its next generation radar system, the RDR-4000, the first totally new design in onboard weather radar. The new radar system is currently operating as standard equipment on the Airbus A380 and the military C-17, and is specified as standard equipment on the Gulfstream 650 and Airbus A350 when they enter service. It is also certified and flying on the Boeing 777 and 737NG and will be certified for the A320, A330 and A340 in 2010 and 2011.

Now the RDR-4000 is the first member of Honeywell's new family of radar products: the IntuVue™ family of 3-D volumetric weather radars, coined for its intuitive view of the weather. The IntuVue family of fully automatic weather radar systems reduces pilot workload and product training through intuitive displays, simplified operation and the elimination of the need to manually tilt the antenna or manage gain requirements.

During the development of Honeywell's *next* generation weather radar, part of the design strategy was to establish a clear understanding of how *current* generation weather radar was used by flight crews and to identify areas of difficulty and concern for pilots. Honeywell uncovered a number of important findings related to the operation of conventional weather radar during its research, which helped shape the design. The specific areas of focus were weather radar training; flight crew knowledge of weather radar fundamentals; and the role of weather radar operation in accidents/incidents. The techniques used to scrutinize these areas of research included a survey of flight crews around the world; human factors evaluations involving pilots using weather radar; and analysis of incidents/accidents where the flight crew operation of conventional weather radar was included in the investigation. The results of the study helped shape the future of Honeywell's next generation radar with the primary design goal of simplifying the crew's task of system operation.

Separating True Weather from Ground Clutter

One of the biggest issues with current generation weather radar systems is that they often require significant interpretation for the pilot to decipher between true weather returns and ground clutter. With traditional weather radar, true weather data is often tainted by ground clutter – the returns generated by terrain features, including steep elevations in the land and man-made structures. Even in moderate weather and ground clutter situations, the mixed returns hamper accurate detection of unique hazards such as wind shear and localized areas of strong turbulence. Until recently, separation of true weather returns and ground clutter has been accomplished by the pilot's use of the radar tilt control to gradually raise the radar beam so that it no longer scanned the ground. Some radar systems address this problem with ground clutter suppression filters, but these filters can attenuate or even completely reject legitimate weather returns.

IntuVue is the first weather radar designed to extract ground clutter without significant weather data degradation. It automatically allows real-time analysis of storms on the flight path, which can reduce operational costs and increase safety. IntuVue radar is "smart" enough to look for relevant hazardous weather along an aircraft's vertical flight plan, anticipating storm threats along the climb and descent route. Forward-looking wind shear and Doppler turbulence detection, coupled with altitude-based reflectivity compensation, give flight crews a true picture of a storm's intensity regardless of altitude. By providing longer-range weather detection, automatic and more accurate assessment of real weather hazards, and discrimination of non-hazards, IntuVue enables pilots to easily identify the best and most direct routing to avoid turbulence.

Reducing Pilot Workload, Increasing Safety of Flight

Coping with constant changes in weather conditions can add to the challenge of a safe flight. For the airline pilot, it can involve interpreting weather radar information or determining if portions of airspace should be avoided or if a potential wind shear problem may exist at a destination or departure airport.

With IntuVue, the decision to request routing around a storm system or to abort a landing has been made much easier due to the radar's complete volumetric 3-D scan buffer and associated processing. The system automatically scans from zero altitude to 60,000 feet as well as out to 320 nautical miles ahead of the aircraft. Within that airspace, weather data is captured and stored within the radar's memory. The pilot can then select the weather data pertaining to the complete volume of airspace or just within a specific slice of that airspace, and view that information on the radar display screen.

For example, if the pilot needs to evaluate the weather condition at a certain altitude, he or she is at liberty via the "manual" mode to select and display only the data specific to that altitude. Once selected, the data is automatically displayed in a horizontal plan-view, or one-dimensional perspective, using standard radar color coding – solid red, yellow or green. In another analysis mode, if the pilot needs to evaluate the weather at a certain angle, or azimuth, from the nose of the aircraft, he or she can, via the "manual" mode, select and display only the data specific to that azimuth. Once selected, the data is automatically displayed in a vertical-view – a view that shows the elevation of the weather along the selected azimuth from the aircraft nose out to the selected display range distance.

Automation and Safety

As airlines around the world look to control costs, they are standardizing fleet types and introducing new, more capable and efficient aircraft. They are also looking for technology to provide safety and operational benefits, while lowering overall life cycle costs. IntuVue can help address these goals by providing increased levels of automation and safety.

For air transport pilots, the IntuVue is ultimately designed to be fully automatic with minimal flight crew training required. To access weather information, the flight crew selects the set-and-forget auto mode. The weather information is then automatically displayed, without the need for periodic adjustments to any of the radar operating parameters, including antenna tilt angle. Weather detection is based on flight plan data drawn from the aircraft's flight management system (FMS) and is constantly updated.

IntuVue also incorporates the most advanced signal processing techniques, including pulse compression technology. Until now, pulse compression technology, due

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to its high costs, was only used in military airborne radar applications. The benefits include increases in long-range detection and information resolution at the same time. Technologies currently used in conventional civil airborne systems, on the other hand, sacrifice higher resolution for long-range weather detection. With IntuVue, this trade-off has been eliminated, and for the first time this expensive technology is part of an affordable civil aviation weather radar system.

Along with this, IntuVue is the first commercial weather radar to employ Ethernet technology between modules within the radar processor, providing weather data to the display system and data loading and downloading. Using Ethernet and digital radio techniques in tandem with other advanced data collection and storage capabilities, the software makes a variety of information available to the pilots for real-time analysis and is constantly updated to compensate for aircraft movement.

Improved Weather Situational Awareness

IntuVue's vertical weather and display capabilities permit the flight crew to combine weather and terrain data into a single, selected vertical profile. By doing this, the flight crew realizes a significant increase in weather situation awareness, giving it the ability to visualize more accurately both the horizontal and vertical extent of real-time weather dynamics, with no need to make manual radar adjustments. This reduces workload and contributes to an improved decision-making process in determining the safe way to avoid hazardous weather. At the same time, this feature provides a useful tool for weather analysis at other potential altitudes and flight paths, which could be selected by the flight crew.

Greater Turbulence Detection

Previous generation radar systems only provided reflectivity information (black, green, yellow, red) for pilots to make important flight decisions. Reflectivity is a measurement of the energy returned from a storm cell and is proportional to rainfall rate, but it provides no direct information about turbulence. Strong storms can be free of turbulence and light storm cells can contain severe turbulence. Current generation radar systems can detect turbulence but require strong storms with high reflectivity for detection. Also, there are no industry standards for when alerts should and should not be provided.

Recent studies have shown that more than 50 percent of the time, turbulence is related to convective activity, which can be detected by airborne weather radar systems. These studies determined that many turbulence encounters previously reported as being Clear Air Turbulence (CAT) were in fact due to turbulence near convective activity. One example is turbulence encountered when flying under the anvil of a storm cell.

Certified by the new FAA enhanced turbulence Detection Minimum Operational Performance Standard (MOPS), IntuVue provides pilots with more sensitive and more accurate turbulence detection capability. In the past, each manufacturer determined what levels of turbulence would be displayed. There were no criteria for determining the level of turbulence the system could detect and display, so pilots had no way of determining the severity of the turbulence. The new enhanced turbulence MOPS establishes the levels of turbulence in gravitational (G) forces that the system must detect for display and also the levels that the system must detect but must NOT display (false alerts). This means that flight plan divergences for nuisance displays of turbulence can be avoided, while at the same time the crew can have greater confidence that what is displayed as turbulence should be avoided.

The system can also see turbulence that was not previously detectable due to its low moisture content. Much of what pilots believe is CAT is actually not CAT – there is some moisture content, but it cannot be detected by current-generation systems. With the sensitivity of IntuVue, that turbulence can be detected.

A Lightweight, Low Maintenance Design

When Honeywell designed the IntuVue weather radar, it was acutely aware of the market demands for more capable, yet less complex, lighter weight systems with lower life cycle costs. To accomplish this, major design changes were made with the antenna, eliminating the gears and motor bearings required

IntuVue 3-D Weather Radar Family

Honeywell's IntuVue family of 3-D volumetric weather radar – serving the air transport, regional, business and military aircraft markets – is the most advanced 3-D weather radar available. IntuVue enables better on-time performance by providing the most accurate, real-time long-range weather data and analysis tools available to support both strategic and tactical flight decisions and minimize time and fuel costs while providing passengers with a more comfortable, safer ride. The system can pay for itself in a relatively short period of time through reduced weight, decreased operational costs and reduced maintenance and training investments.

IntuVue is the first and only weather radar system certified to the FAA's enhanced turbulence Detection Minimum Operation Performance Standard (MOPS), providing pilots with the ability to detect and avoid previously unforeseen turbulence. It is the first fully automatic weather radar system that decreases pilot workload and improves in-flight decision-making by offering weather analysis tools for viewing storms in three dimensions at up to 320 nautical miles ahead of the aircraft.

These technological advances allow pilots to be better informed about air turbulence, wind shear and overall weather conditions so they can make more informed route decisions — thereby increasing passenger comfort and safety — and decreasing weather-related costs due to injuries and aircraft damages. Honeywell's advanced weather radar is the only commercial radar that utilizes pulse compression for greater accuracy at longer range – a technology used previously only in military radars.