WXR-2100 MULTISCAN™ RADAR
FULLY AUTOMATIC WEATHER RADAR

Presented by:
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Cedar Rapids, Iowa
52498

TABLE OF CONTENTS

Introduction

Rockwell Collins' WXR-2100 MultiScan™ Radar is a revolutionary approach to the way weather information is processed and refined. The WXR-2100 is a fully automatic radar that displays all significant weather without the need for pilots to input tilt or gain settings... all with an essentially clutter free display. When operated in automatic mode, the pilot has the weather information that is currently available only to the most experienced radar operator, thus standardizing and simplifying airline pilot training requirements. The system's MultiScan Radar functionality significantly reduces pilot work load while at the same time enhancing weather detection capability and passenger/crew safety.

The key to MultiScan operation is the radar's ability to look down, towards the bottom reflective portion of a thunderstorm, and then eliminate the ground clutter with advanced digital signal processing. The system combines multiple radar scans at preselected tilt angles in order to detect short-, mid- and long-range weather. The result is superior weather detection.

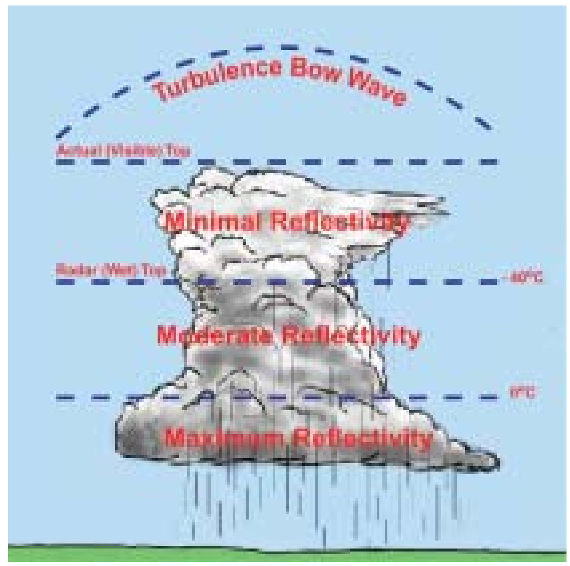
The MultiScan Radar's ability to eliminate ground clutter with advanced algorithms allows it to skim the radar horizon and provide pilots with true strategic weather out to 320 nautical miles (nm). The system also provides OverFlight™ Protection, allowing crews to avoid inadvertent thunderstorm top penetrations, which today account for a significant portion of aircraft turbulence encounters. OverFlight Protection ensures that any thunderstorm that is a threat to the aircraft will remain on the radar display until it no longer poses a danger to passengers and crew.

Advanced Features Include

– Fully Automatic Operation
– Optimized Weather Detection
– OverFlight Protection
– True 320 nm Weather Detection
– Extended-range Weather at Low Altitudes
– Adaptive Radar Threshold Techniques (ARTT)
– Improved Turbulence Detection
– Windshear Detection
– Ground Mapping
– Active Gain in all Modes
– Path Attenuation Compensation (PAC) Alert
– Split Function Control
– Simultaneous Display Updates in all Range/Mode Combinations

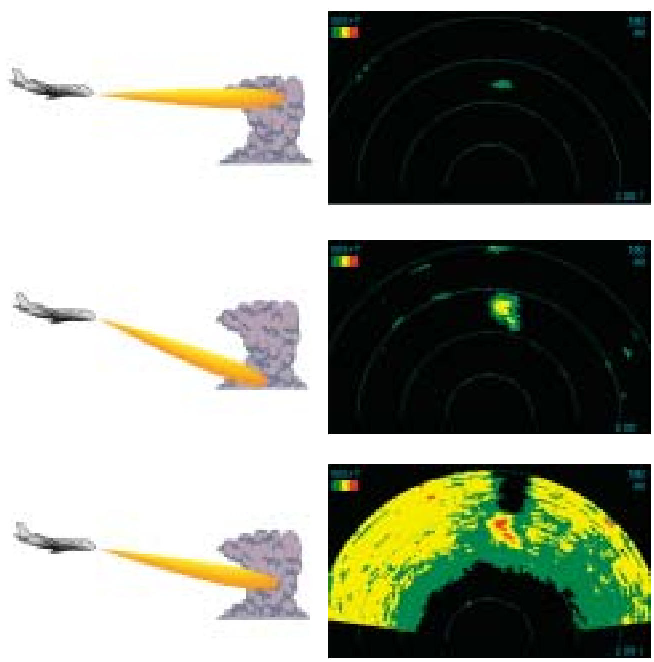
Thunderstorm Reflectivity

Understanding thunderstorm reflectivity is the key to understanding how the Collins MultiScan Radar works. In general, thunderstorm reflectivity can be divided into three parts (see figure 1.1). The bottom third of the storm below the freezing level is composed entirely of water and is the part of the storm that most efficiently reflects radar energy. The middle third of the storm is composed of a combination of super cooled water and ice crystals. Reflectivity in this part of the storm begins to diminish due to the fact that ice crystals are very poor radar reflectors. The top third of the storm is composed entirely of ice crystals and is almost invisible to radar. In addition, a growing thunderstorm will have a turbulence bow wave above the visible portion of the storm.



1.1 - Thunderstorm reflectivity levels.

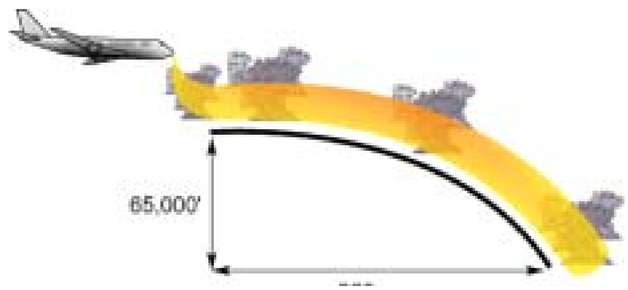
The pictures in figure 1.2 show an actual thunderstorm and the corresponding radar picture as tilt is increased. In practice, finding the proper tilt angle during manual operation often becomes a compromise between observing the most reflective part of the thunderstorm and reducing ground clutter returns.



1.2 - Observed thunderstorm and corresponding radar display at three different tilt settings.

THE IDEAL RADAR BEAM

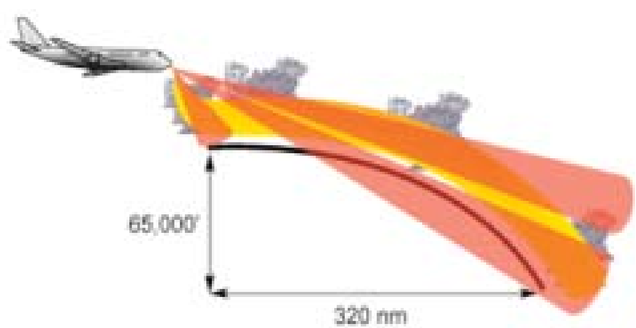
Understanding thunderstorm reflectivity and the effect that radar tilt angle has on it allows us to envision a hypothetical ideal radar beam for weather threat detection. The ideal radar beam would look directly below the aircraft to detect building thunderstorms and then follow the curvature of the earth out to the radar's maximum range (figure 1.3). Thus, the ideal beam would keep the reflective part of all significant weather in view at all times, from right in front of the aircraft out to 320 nm.



1.3 - Ideal radar beam (note earth's curvature causes a drop of approximately 65,000' over a distance of 320 nm).

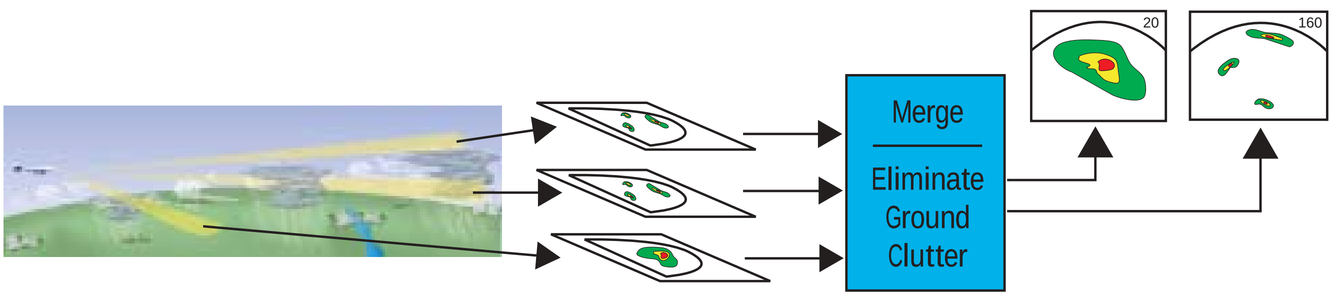
MULTISCAN EMULATION OF THE IDEAL RADAR BEAM

The Collins MultiScan Radar emulates an ideal radar beam by taking information from different radar scans and merging the information into a total weather picture. Rockwell Collins' patented ground clutter suppression algorithms are then used to eliminate ground clutter. The result is the ability for flight crews to view all significant weather from 0 - 320 nm on a single display that is essentially clutter free (figures 1.4 & 1.5).



1.4 - MultiScan emulation of ideal beam.

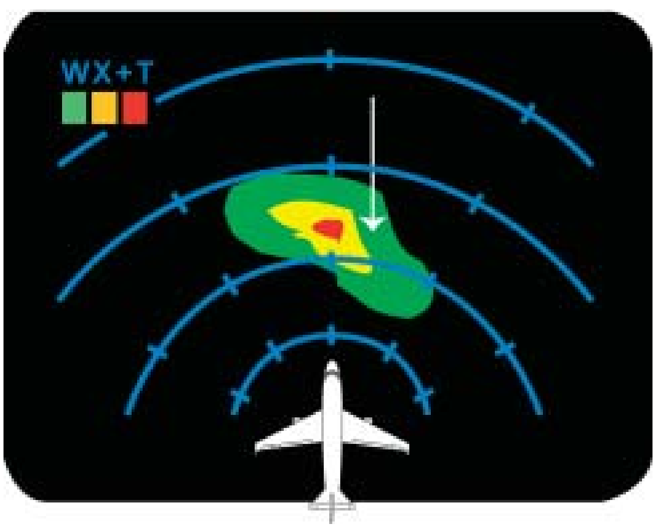
Figure 1.5 illustrates the MultiScan process. Multiple antenna scans are performed. Each scan is optimized for a particular region in front of the aircraft (short-, medium- or long-range weather) by automatically adjusting tilt and gain. The computer merges the data into a digital picture, refines the image and then eliminates ground clutter using Rockwell Collins' patented ground clutter suppression algorithms. Thus, an optimized weather picture from 0-320 nm is stored in computer memory. The flight crew simply selects the portion (range scale) of the optimized picture that they desire.



1.5 - The MultiScan process.

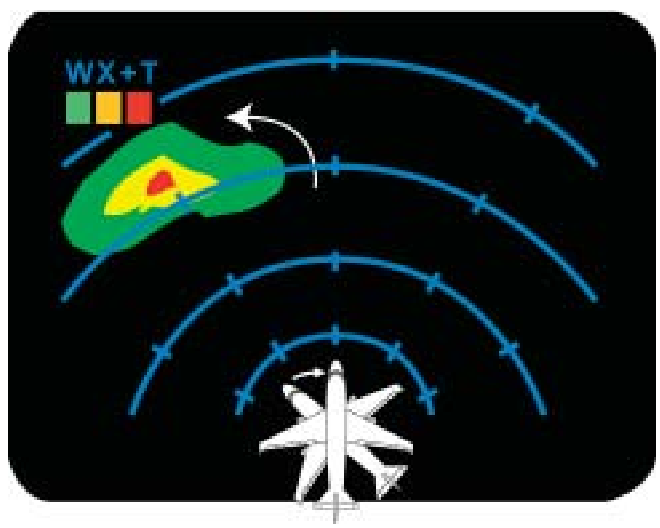
The total time required to complete one cycle of the MultiScan process in all modes except windshear is eight seconds. When in windshear mode the total cycle time for both the MultiScan and windshear processes is 11.2 seconds. Thus, there is no significant change to observed weather during one cycle of the MultiScan process. What does change is the relationship of the aircraft to the weather. To compensate for this, the system translates (figure 1.6a) and rotates (figure 1.6b) the stored digital image to compensate for aircraft movement. The result is that the Collins MultiScan Radar updates all radar displays every four seconds in all modes except windshear in which case the displays update every 5.5 seconds. One interesting element of this process is that the antenna scan is no longer tied to the display sweep. This frees the antenna to perform multiple functions without interrupting the pilot's weather presentation.

Aircraft Heading 360°



1.6a - MultiScan Radar translates the stored digital image to compensate for the forward motion of the aircraft.

Aircraft Heading 045°



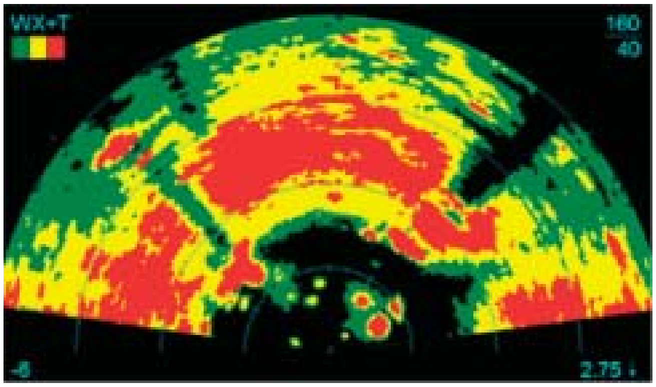
1.6b - MultiScan Radar rotates the stored digital image to compensate for aircraft turns.

AUTOMATIC GAIN

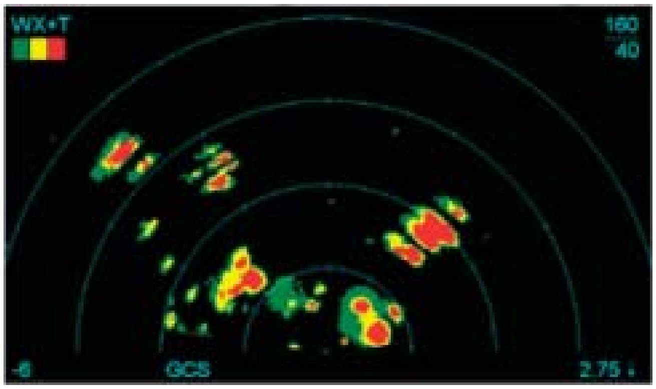
During automatic operation the MultiScan Radar uses variable gain based on atmospheric temperature profiles to compensate for variations in geographic location, time of day and altitude so as to optimize weather returns in all phases of flight. Gain is thus adjusted to best suit the environment in which the aircraft is flying and provide the optimum weather picture in the prevailing conditions.

THE END RESULT

Because the MultiScan Radar can examine the weather in front of the aircraft using multiple tilt settings and because the radar is able to look down into the ground clutter to pick out significant weather (figure 1.7a), MultiScan is able to display all the weather from 0-320 nm that will affect the aircraft on a single, essentially clutter-free, display (figure 1.7b). And the whole process is entirely automatic, freeing the flight crew to concentrate on weather avoidance rather than weather detection and interpretation.



1.7a - MultiScan Radar is able to look down into ground clutter to detect the reflective portion of thunderstorms. The picture at right (1.7b) shows the radar picture with the ground clutter suppression turned off. Weather is masked by the ground clutter.



1.7b - When Ground Clutter Suppression (GCS) is activated, all significant weather (in this case from right in front of the aircraft out to 160 nm) is visible on a single, essentially clutter free, display. Significantly, the radar operator no longer needs to compromise between a tilt that will eliminate ground clutter and a tilt that will give the best weather returns.

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