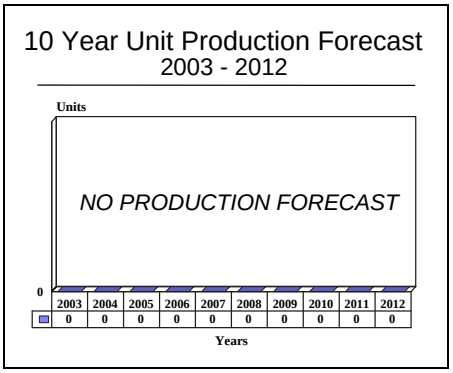
FMR-200X(V) - Archive 7/2004

Outlook

- Part of USAF C/KC-135 Pacer CRAG avionics upgrade
- State-of-the-art weather radar features windshear detection
- Production complete



Orientation

Description. Forward-looking weather radar. A missionized version of the commercial WX-700 weather radar featuring windshear detection.

Sponsor
US Air Force
Oklahoma Air Logistics Center (OCALC)
Tinker AFB, Oklahoma (OK) 73145
USA
Tel: +1 405 884 1110
Web site: http://www.tinker.af.mil/ocalc

Contractors
Rockwell International Corp
Collins Air Transport Division (CATD)
400 Collins Road NE
Cedar Rapids, Iowa (IA) 52498
USA
Tel: +1 319 395 1821
Fax: +1 319 395 5429
Web site: http://www.collins.rockwell.com

Status. In production, logistics support.

Total Produced. Through 2002, an estimated 563 units had been produced.

Application. C/KC-135

Aircraft Breakdown: Active – 270
Reserve – 70
ANG – 223

Price Range. Estimated unit price for the radar alone is US$420,000. This varies, depending on particulars of the installation. The complete upgrade, including the upgraded Flight Management System and GPS, is roughly US$1.5 million per airframe.

Price is based on an analysis of contracting data and other available cost information, and on a comparison with equivalent items. Individual acquisitions may vary depending on program factors.

Technical Data

	Metric	US
Dimensions		
WRT-701X Receiver/Transmitter	19.6 x 25.7 x 35.6 cm	7.7 x 10.1 x 14 in
	14.1 kg	31 lb
WMA-701X Antenna Pedestal	12.7 kg	28 lb
WCP-701 Mode Control Panel	6.7 x 14.6 x 15.2 cm	2.6 x 5.8 x 6 in

WFA-701X Flatplate Antenna	71.12 x 86.36 cm	28 x 34 in

Characteristics

Frequency	9.33 GHz
Peak power	15º W (nominal)
PRF	180 (up to 9,000) pps
Pulse width	1 to 20 μsec
Range	320 nm (max)
Windshear	
Coverage area	±30º
Detection range	5 nm
Beam width	2.5° (el) X 3.5° (az)
Scan angle	±90° (Weather and turbulence) ±60° (Windshear)
Scan rate	4 sec (Weather and turbulence) 3 sec (Windshear)
Scan increment	0.25° nominal
Elevation range	±40°
Elevation increment	0.25°
Stabilization range	±40° (combined P, T, R)
Stabilization accuracy	±25°(combined P, T, R)
Sidelobe performance	>30 dB
MTBF	15,000 hr (6,900 hr MTBUR)
MTTR	30 min
Radar functions	Weather detection Turbulence detection Path Attenuation Compensation (PAC) PAC alert Target alert Turbulence alert Ground clutter suppression Sector scan
Operating modes (Dual/Interleaving)	Weather Weather/turbulence detection Ground map Windshear detection Skinpaint (15 nm for tanker-sized aircraft)
Features	High reliability Ground clutter suppression Mode interleaving Dual mode capability Built-in test

Design Features. The Collins FMR-200X Flight Multi-mode Weather Radar System is a non-developmental item/commercial off-the-shelf (NDI/COTS) ARINC 708A X-band coherent Doppler color weather radar system. This "missionized" system provides full precipitation detection, turbulence detection, and forward-looking windshear detection, and has an additional active skinpaint mode capable of detecting tanker-size aircraft at ranges up to 15 nautical miles.

New multi-mode weather radar software was designed and certified to RTCA DO-178B level D standards. The system has been qualified to meet environmental standards described in RTCA DO-160C with a few exceptions. Operation at -40°C is required only after a warmup period of 30 minutes for temperatures below -15°C. Mil-STD-461D is used for radiated emissions and harmonics. All operations other than the skinpaint mode, 16-level mapping, and minor display and control bus modifications are defined in accordance with ARINC 708A (Airborne Weather Radar with forward-looking windshear detection capability). This system is based on the Collins Air Transport Division WXR-

700X Radar System that has been installed on 6,600 aircraft worldwide.

Enhancements include a one-channel multiplier assembly that maintains the 150 W nominal output. The FMR-700X also has a newly designed power supply and simplified power amplifier. The modifications cut RT power consumption by more than 85 W. Transmitter adjustment complexity and tuning time were reduced. When windshear detection is active, the radar antenna is time-shared between flight crew radar parameters and automatic windshear detection parameters.

The full Pacer CRAG installation includes a Rockwell FMS-800 Flight Management System, EFIS-90 Flight Displays, GPS, and the FMR-200X. The FMR-200X was designed to be a direct replacement for the current APN-59(V) and APS-133(V) radars.

Operational Characteristics. The weather radar on the KC-135 was designed to provide the flight crew with data on weather conditions ahead of the aircraft. The system provides full precipitation detection, turbulence detection, and forward-looking windshear detection, and has an additional active skinpaint mode capable of detecting tanker-size aircraft at ranges up to 15 nautical miles. Path Attenuation Compensation adjusts the radar display to allow for the attenuation of signals passing through nearby storms.

The forward-looking windshear detection is activated below 2,400 feet. Visual and aural alerts become active in the cockpit at 1,200 feet, alerting the flight crew to windshear within 3 nautical miles and ±30° of the aircraft's heading. All other radar information is continuously displayed during windshear detection.

Windshear within 5 nautical miles and plus or minus 30° is displayed on the radar indicator or Electronic Flight Instrument System (EFIS). Crew warnings are issued to 1.5 nautical miles on landing and 3 nautical miles on take-off. Depending on the location of the windshear, the crew will receive a caution to "monitor radar" or a warning to "go around" the event. With up to 90 seconds warning of danger, flight crews can avoid deadly downdrafts and windshear capable of slamming an aircraft into the ground.

TCAS (traffic alert and collision avoidance system) advisory information can be added to the WXI-711 indicator, and FMR-200X information can be displayed on the EFIS to integrate the radar returns with flight route, waypoint, and other navigational information.

FMR-200X Multimode Weather Radar

Source: Rockwell Collins

Variants/Upgrades

No variants are designated. Limited modification may be needed to adapt the system to different aircraft.

Hailed as the "glass cockpit," Pacer CRAG upgrades allow the aircraft to fly with just a pilot, copilot, and

boom operator. The upgrades include four multifunctional displays, two flight management systems, and the radar.

The Block 30 KC-135 Fleet additional modifications include:

Enhanced Ground Proximity Warning System. Uses aircraft position and a digital terrain database to provide look-ahead awareness to the aircrew.

Reduced Vertical Separation Minima. Equips the Fleet to operate in reduced vertical separation airspace and includes an additional digital air data computer (DADC).

Navigation and Safety Modifications. Installs a flight data recorder, cockpit voice recorder, and emergency locator transmitter.

Program Review

The KC-135 has always carried a weather radar, and current systems have been satisfactory but limited. Over the past decade, radar developers, the FAA, NASA, and the US Department of Defense have been keenly interested in developing new sensors capable of detecting the presence of deadly windshear and alerting flight crews. This is critical during take-off and landing, when an aircraft is too close to the ground to recover from unexpected windshear.

Ground-based systems, the WSR-88D Next-generation Radar (NEXRAD) and Terminal Doppler Weather Radar (TWDR), detect windshear around an airport, but aircraft must be able to carry this capability with them. NEXRAD and TDWR inform air traffic control operators of weather problems, and the hazard alerts can be passed to flight crews; but this does not have the immediacy of detecting such events from the aircraft itself, a very important consideration given the short ranges involved in dealing with killer downbursts.

The original WSR-700X entered service in 1980 and was the first air transport airborne radar to incorporate a Doppler turbulence detection feature. In 1986, Collins began a cooperative program with NASA to expand the system's capability to detect windshear/microburst events ahead of the aircraft. An FAA/NASA development contract was awarded in 1989. Testing of windshear detection began in January 1994. Also in 1994, the FAA mandated a requirement for windshear detection systems on all aircraft. Reactive systems were installed, but later in the year the windshear detection and warning features of the radar were FAA certified.

At the same time, the Air Force developed plans to upgrade its KC-135 fleet, and including a new windshear radar was an obvious and important decision. In late 1995, the Oklahoma City Air Logistics Center awarded Rockwell a US$35 million contract to be the prime contractor for the Pacer CRAG (compass, radar, and GPS) upgrade to modernize the KC-135 cockpit.

This cockpit modernization program replaced the existing compass and radar. It adds a GPS receiver (embedded GPS/inertial navigation unit) and TCAS integrated through a commercial off-the-shelf/non-developmental item flight management system which includes new multifunction displays. This program does not degrade the capability of the KC-135 in an NBC (nuclear, biological, and chemical) environment. The program is the foundation of the GATM (Global Air Traffic Management) modification. FY96 and FY97 installations were delayed due to additional requirements (ETCAS) with associated integration/testing.

Although these activities forced delays, contracted annual kit buys were maintained to protect quantity buy cost breaks. This drove the use of partial prior year funding for installs in FY99 through FY02. This also drove average installation costs to appear to fluctuate when actual install costs are about $220,000 each.

The FY98 program was influenced by the fact that 24 of the Fleet aircraft (RC, TC, WC, EC combination) require only a subset of Pacer CRAG hardware that would be installed in a configuration outside of the Pacer CRAG baseline. These aircraft (and corresponding kits and installations) are not included in installation totals.

FY00/01 change orders included EGI (embedded GPS/INU) upgrades, ECP-022/023 and save stat software packages, and DADC retrofit. FY00 to FY02 data include Block 35 changes and enhancements to tech data troubleshooting matrices.

The FY01 warranty is the extension to the current reliability warranty on Pacer CRAG line replaceable units. FY01/02 installations realize economies of scale through delivery orders under current installation. The FY01 installation funds line is significantly lower than those of prior years due to the use of prior year funding for installations. This was accomplished to achieve installation economies of scale and to account for the lack of installation funds in FY02.

These are the last contract options for Pacer CRAG. Beginning October 1999, this modification became part

of Block 30 and is baselined with RVS (Reduced Vertical Separation), Navigation/Safety, TAWS, and High Reliability Maintenance Free Battery. In addition, it is part of the Block 35 installation on special purpose C-135 aircraft and D-model tankers.

Funding

US FUNDING

	FY02		FY03		FY04(Req)		FY05(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
Pacer CRAG	-	3.2	-	0.0	-	-	-	-

All $ are in millions.

Recent Contracts

(Contracts over US$5 million.)

Contractor	Award ($ millions)	Date/Description
Rockwell Int'l	10.8	Sep 2000 – Mod to time and materials contract to provide Phase 1 of the Pacer CRAG Special Purpose Aircraft upgrade for C/KC-135 aircraft. Completed October 2001. (F34601-00-C-0042, P00007)
Rockwell Int'l	29.2	Dec 2000 – Mod to an FFP contract for 41 Group A and 41 Group B Pacer CRAG/GCAS production kits, 41 10-year warranties, one lot data, and one lot program support for KC-135 aircraft. Completed September 2001. (F34601-00/C-0042, P00009)
Rockwell Int'l	9.3	Apr 2001 – Mod to FFP contract for the initial readiness spares package, initial peacetime operating stock spares, and applicable reliability warranties for 14 line replaceable units supporting the Pacer CRAG program. (F34601-00-C-0041, P00013)

Timetable

Month	Year	Major Development
	1980	WXR-700X entered service
	1986	Start of cooperative program with NASA to extend radar's capability
	1989	FAA/NASA windshear development contract
	1992	KC-135 cockpit overhaul begun
	1993	New Technology Value engineering
	1994	Forward-Looking Windshear certified
May	1995	RFP for Pacer CRAG released
Nov	1995	Pacer CRAG contract award
	1996	First deliveries planned
Aug	1998	First 54th Air Refueling Squadron Pacer CRAG-modified KC-135 completed
	2002	End of current production program
	2040	Estimated life of the C/KC-135

Worldwide Distribution

The **Netherlands** selected the FMR-700X for its C-130s.

Singapore has contracted for some upgrades as part of a KC-135 contract.

Turkey is upgrading some of its KC-135 aircraft.

The **United States** is replacing the radars on its C/KC-135s as part of a major cockpit/avionics upgrade.

Forecast Rationale

Because plans call for flying the C/KC-135 until 2040, the aircraft needed a state-of-the-art flight management system, new displays, and a GPS capability, enhanced traffic collision avoidance system, and sensors. Adding a new radar with windshear-detection capability made it possible for flight crews to detect deadly weather in the flight path, a capability that did not exist when the original radars were installed on the tankers. This sensor capability is baseline for today's aircraft.

Windshear on landing and take-off is the most common killer of aircraft and crews, the only practical option is to avoid windshear and deadly downdrafts. The Collins' WXR-700X radar was a proven system, with over 6,200 WXR-family sensors in worldwide use, making it possible to get an advanced capability without having to invest in costly and time-consuming RDT&E. These radars were available off-the-shelf and fit right into the Air Force's plan to manage the upgrades under Lighting Bolt acquisition streamlining.

Since Collins radars are in such widespread use on commercial aircraft around the world, other militaries will probably be interested in eventually acquiring them through commercial procurement contracts. The radar does not have to be installed with the Collins Flight Management System, so radar-only installations are possible and less costly. Experience with the radars indicates a potential maintenance savings of US$10.2 million using the Pacer CRAG system. Upgraded aircraft fly around 538 hours more before experiencing any avionics failure, compared to the older systems.

Ten-Year Outlook

Production is essentially complete.

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