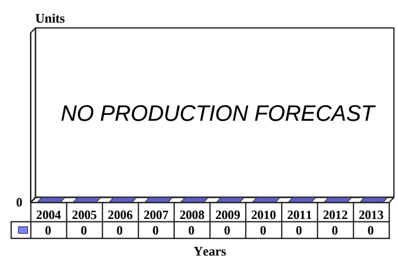
Precision Runway Monitor (ESSR-128) - Archived 6/2005

Outlook

- Used to increase capacity at some parallel runway airports
- Independent, non-radar approach based on investigation of GPS may impact future acquisitions
- Future production very uncertain

10 Year Unit Production Forecast
2004 - 2013



Orientation

Description. ESSR-128 Runway Monitoring Secondary Surveillance Radar.

Sponsor
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591
USA
Tel: +1 202 267 3484
Web site: http://www.faa.gov

Status. In service, ongoing logistics support.

Total Produced. An estimated seven production units have been produced.

Application. Air traffic/approach control for parallel runway operations.

Price Range. Estimated unit cost is $4.2 to $9.1 million.

Contractors

Raytheon - Air Traffic Management Systems, http://www.raytheon.com, 1001 Boston Post Rd, Marlborough, MA 01752 United States, Tel: 1 (508) 490-3045, Fax: 1 (508) 490-3322, Email: Robert_W_Meyer@res.raytheon.com, Prime

Technical Data

	Metric	U.S.
Dimensions		
Antenna		
Diameter	5.2 m	17.1 ft
Height	1.6 m	5.1 ft
Elements	128 columns, 10 dipole radiators each	
Characteristics		
Range	59 km	32 nm

	Metric	U.S.
Expandable to	370 km	200 nm
Accuracy	+/- 18.3 m	+/- 60 ft
Resolution	<185 m	<0.1 nm
Azimuth		
Resolution (lateral spacing @ 10 nm)	184 m	600 ft
Characteristics (continued)		
Accuracy	Within 0.057º (1 milliradian)	
Coverage		
Azimuth	360º in 4,096 discrete beam positions	
Elevation	40º	
Accuracy	0.057º (1 milliradian)	
Runway spacing	<3,400 ft lateral separation	
Frequency		
Transmit	1,030 MHz	
Receive	1,090 MHz	
Power	1,100 W peak	
PRF	450 pps max	
Track capacity	40	
Update rate	1.0 sec	
Displays	3-4 standard Updates every second	

Design Features. The ESSR-128 E-scan Secondary Surveillance Radar, designated the Precision Runway Monitor (PRM), uses an electronically scanned phased array antenna and high-resolution displays to monitor air traffic landing at airports with parallel runways. By using electronic scan techniques, the system can instantly switch between any of 4,096 beam positions in microseconds.

The system interrogates aircraft Identification Friend or Foe (IFF) transponders and is compatible with both Mark X and Mark XII systems. The PRM is upgradable to Mark XV operation. Baseline operating modes are Mode-A and Mode-C, although it can be upgraded to Mode-S. Replies are measured for range, azimuth, and reply amplitude. Update rates are operator selectable or can be automatically set based on target criteria such as velocity, proximity to other aircraft, or status. Processors track target position and project a future flight path.

Unlike conventional rotating radars, which update aircraft position once every four to five seconds, the PRM updates targets once every second. This makes it possible to more quickly detect flight path deviations, an important safety feature in parallel runway operation, especially in bad weather. The established update rate for controlling traffic with runways down to 3,400 foot spacing is less than 2.4 seconds. PRM has a 1.0 second update rate, mean azimuth accuracy of 1.0 milliradians, and a capacity of 35 tracks. High-resolution displays have specific blunder alarms for alerting operators to developing problems, with the electronics contained in three cabinets.

When the system is not updating information on known tracks, it searches for new targets entering the control area. It continually self-monitors system operation, and a redundant dual-channel architecture enhances the reliability and availability of the ESSR-128. The antenna, RF system, interrogators, system controllers, and signal/data processors are located in or near a tower close to the runways. Display stations and operator processors are located in the airport control tower and other approach control facilities. Individual operators can tailor their display to meet unique operational needs.

Operational Characteristics. Under existing air traffic control rules, simultaneous approaches cannot be made at airports with parallel runways closer than 4,300 feet. Using the Precision Runway Monitoring system, simultaneous parallel approaches are allowed on runways as close as 3,400 feet. Reduced runway lateral separation capability increases the traffic handling of airports by up to 50 percent in poor weather. At least 10 existing U.S. airports are candidates for installation of a PRM system.

Installations have been commissioned at:

- Minneapolis/St. Paul, Minnesota
- St. Louis, Missouri

Installations are planned or being considered at:

- JFK International Airport, New York
- Philadelphia, Pennsylvania
- San Francisco, California
- Atlanta, Georgia
- Detroit, Michigan

Planners believe there are at least 12 U.S. airports that could benefit from parallel runway operation. The FAA has options on up to three more radars.

International installations include:

- Hong Kong Chek Lap Kok
- Kingsford Smith Airport, Sydney, Australia

During standard operation, the runway centerline is extended along an approach path to a range of approximately 15 nautical miles (27.8 km). A 2,000-foot-wide (610 m) Non-Transgression Zone is established between the extended centerlines. Based on continually updated track information, the processor estimates aircraft position 10 seconds into the future. The PRM has seven displays and will be located in a stand-alone tower between the runways. This tower will serve as a backup and disaster recovery area. The main tower hosts the surface movement radar.

If data indicate the possibility of an aircraft entering the established Non-Transgression Zone between the runways, the target display changes to alert the controller of the possible conflict. If an aircraft actually enters the Non-Transgression Zone, alarms prompt air traffic controllers to take action to prevent a collision.

Besides performing the FAA parallel runway monitoring application, the ESSR-128 could be used to monitor traffic on converging runways, for airport surveillance, for airport surface traffic monitoring, and for en route surveillance gap fillers. There may also be applications at test ranges and military training areas.

Variants/Upgrades

There are none to date. Initial enhancements will be planned software upgrades.

Program Review

Background. Air traffic load exceeds airport capacity at many locations. Congressional and traveler pressure on the FAA prompted the construction of parallel runways where technically and economically feasible. Available airport surveillance equipment, however, cannot provide aircraft position information updates at a rate that ensures flight safety during simultaneous approaches unless runway separation is greater than 4,300 feet. Not all airports provide this separation; spacing as close as 2,500 feet exists. Under current operating rules, 10 U.S. airports cannot take advantage of simultaneous approaches to increase capacity. Due to space and/or financial constraints, five additional airports have construction plans in place based on close runway spacing.

In 1987, the FAA developed specifications for data management and alert systems that would allow air traffic controllers to run safe simultaneous parallel approaches. In late 1988, two systems were installed at different airports to evaluate alternate surveillance concepts. A system using back-to-back antennas was installed at the Memphis (Tennessee) airport. A prototype ESSR-128 system was installed at the Raleigh-Durham airport in North Carolina.

Evaluations were conducted throughout 1989 and 1990, with runway spacing of 3,000 feet subsequently approved for simultaneous approaches. During 1990, the E-scan system was upgraded. The FAA awarded a production contract to AlliedSignal in early 1992, and the upgraded prototype system at Raleigh-Durham was commissioned in late 1993. Deliveries of the production systems were then scheduled for 1994 through 1997.

An enhanced ESSR-128 PRM was selected for the Hong Kong Chek Lap Kok airport. In addition, between January 1997 and September 1998, the FAA commissioned the Minneapolis-St. Paul PRM, and began installation of the St. Louis and JFK International systems.

<u>Airborne Information for Lateral Spacing (AILS)</u>. As in many aspects of air traffic control, methods are being investigated to move away from ground-based control to more independent operations by aircraft and pilots. NASA has been developing concepts that would permit independent instrument approaches to closely spaced runways in adverse weather or limited visibility. The goal is to maintain traffic capacity in bad conditions by supporting independent approaches to dual and triple parallel runways spaced as close as 3,000 feet apart.

NASA is managing the Airborne Information for Lateral Spacing (AILS) program as part of the Reduced Spacing Operations segment of its Terminal Area Productivity program. AILS is evaluating new technology that can increase traffic capacity at existing airports. There are two major components to the AILS program. The first is to provide accurate navigation to aircraft flying parallel approaches. The second is finding ways to protect each aircraft if one deviates from its assigned approach path. The development of an initial approach concept is being managed by the Langley Research Center.

The initial approach concept was based on two parallel runways, but the procedure could be applied to three or four parallel runways. The Ames Research Center participated in the AILS research, centering its efforts on developing a TCAS-type guidance system for use during the initial approach phase.

The Reduced Spacing Operations program at Langley's Crew System and Operations Branch is investigating ways in which differential GPS (D-GPS) could be used for precise navigation to the runways, along with an automatic dependent surveillance-broadcast (ADS-B) system that would allow each aircraft to broadcast its position, heading, bank angle, and airspeed throughout the approach procedure. Each aircraft in the area would receive that data and maintain an accurate fix on the other aircraft. Transmitted data would provide the flight crew of each aircraft with an indication of whether other traffic is deviating from course.

The AILS concept relies on keeping aircraft in their assigned airspace. To accomplish that, Langley researchers are studying whether a conventional ILS system localizer can be replaced with guidance from D-GPS. Langley is assessing the use of a two-dot localizer capture region that would provide 2,000 feet on either side of the extended runway centerline. Approach paths would be separated by 1,000 feet vertically.

In this plan, starting about 12 nautical miles from the runway, these paths would gradually narrow until they extend 500 feet on either side of the extended centerline at 10 nautical miles. At that point in the approach, the aircraft at the higher altitude would begin its descent, and vertical separation would be terminated. The 500-foot width of the approach path would be maintained to the middle marker, where D-GPS guidance would be abandoned and the standard localizer recaptured and flown to landing.

During the D-GPS guidance phase, if an aircraft deviated one dot or more from its approach path, an alert would be given to the pilot to return to course. The alert would be displayed in amber alphanumeric and symbolic formats on the aircraft primary flight displays (PFDs) and navigation displays. If the deviation exceeded two dots, a break-off maneuver would be commanded directing the aircraft away from parallel traffic in a maneuver that requires a 45-degree climbing turn away from traffic.

An onboard algorithm in each aircraft would use heading, angle of bank, and airspeed data transmitted on the ADS-B link to detect any threats and give pilots an intrusion alert on the PFD. As the danger of a collision increased, the algorithms would provide a red alert to the pilots of the on-course aircraft. Alert configurations under study at Langley incorporate special displays that portray the threat aircraft's projected flight path, allowing pilots to assess the situation. If the red alert persisted, a computer-controlled message, "Turn, climb, Turn, climb," would be displayed, and the threatened aircraft would execute an immediate 45-degree turning climb away from the intruding traffic.

According to reports, researchers completed a series of simulator-based tests using 16 pilots from major U.S. airlines and freight carriers. With runways spaced 3,400 feet and 2,500 feet apart, each pilot flew about 50 parallel approaches, with about one-third involving near-miss or collision threats. Reaction times for the pilots were recorded, and preliminary results indicate that all were under the two-second limit established by the AILS design team. The 500-foot minimal lateral separation was not violated. The closest distance detected between aircraft was 1,183 feet.

As a result of the test program, in July 1996 NASA conducted additional simulator tests at runway spacings as close as 1,200 feet. Although that distance is considered to be the lowest limit feasible for proposed AILS technologies, Langley researchers are confident that the concept can be applied safely to runways 1,500 feet apart.

<u>Wide Area Augmentation System (WAAS)</u>. This system, commissioned in FY03, uses special ground stations to validate the accuracy of GPS signals. WAAS makes use of 25 ground reference stations and two Master Stations that monitor GPS signals around the nation. By comparing GPS L1 (1575.42 MHz) and L2 (1227.60 MHz) signals received at the reference stations to meticulously surveyed, exact location data, the system transmits a correction signal to geosynchronous satellites that send out a correction signal to any GPS receiver equipped for both GPS and WAAS operation. By applying this correction, a user can realize 1- to 2-meter vertical accuracy, and 20- to 30-centimeter accuracy on the horizontal plane. The WAAS signal corrects for distortion of the GPS signals by the ionosphere.

Agricultural pilots (crop dusters) have been using the system to ensure accurate spraying, a way of reducing overspray. Maritime users have found the system helpful, and other ground users find that WAAS can provide better signal availability and location information in urban canyons, which tend to block GPS signals. Search and rescue officials at ground zero in New York City specifically asked that WAAS not be turned off or changed because it was proving invaluable in pinpointing the location of remains so that recovery teams could find them.

WAAS can be used as a primary means of en-route navigation. The FAA's 2001 Federal Radionavigation Plan released in April 2002 said that GPS and GPS enhanced by WAAS and the Local Area Augmentation System (LAAS) would become the only satellite-based navigation service required in aircraft operating within the National Airspace System. This "end-state WAAS" is planned to be operational in 2009. This will follow the phased addition of more ground reference stations, the addition of another geosynchronous satellite (the WAAS added to a satellite launched for other uses), and further software enhancements.

Multi-lateration. The program is supporting research into a low-cost alternative to the electronically scanned system. Multi-lateration will use small, strategically placed sensors outside the airport and on the airport surface to triangulate an aircraft's position based on transponder beacon replies. This approach will capitalize on work being performed under the Airport Surface Target Identification System program. A system demonstration was scheduled at Atlanta Hartsfield Airport.

Other Approaches. FAA officials are considering other ways to ensure parallel operation safety. In addition to changes to airspace and approach/departure design, they are looking at ADS-B/TIS-B (Automatic Dependent Surveillance Broadcast/Traffic Information Service Broadcast), CDM (Collaborative Decision Making), FMA (Final Monitor Aid), and RNP (Required Navigation Performance). Some of these other systems have the advantage of performing other ATC needs as well, making it possible for the FAA to get more for its money as opposed to funding a single-purpose program.

Funding

U.S. FUNDING

	FY03		FY04		FY05		FY06	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
Facilities & Equipment (FAA)								
Precision Runway Monitors (PRM)	-	18.5*	-	-	-	-	-	-

*In FY03 congressional plus-up funding was added for Atlanta, Detroit, and other systems. The FAA included no funding for PRM in the FY04 budget.

All $ are in millions.

Recent Contracts

(Contracts over $5 million)

Contractors	Award (US$ millions)	Date/Description
AlliedSignal	33.8	Apr 1992 – Contract for five Precision Runway Monitoring (PRM) radars. Deliveries were scheduled to start in 1994. Options for three additional systems contractually specified.

Timetable

Month	Year	Major Development
	1987	Specification development begins
Late	1988	Demonstration program begins
Feb	1992	Contract award
	1993	Prototype upgraded and commissioned, engineering tests, air traffic controller evaluations completed
2Q	FY93	CDR completed
1Q	1995	First system delivered, to Minneapolis/St. Paul
1Q	1996	Shakedown testing completed, OT&E

Month	Year	Major Development
	1996	First system commissioned, low-cost alternative demonstrated
2Q	1997	First Operational Readiness Demonstration (ORD), at Minneapolis/St. Paul; site commissioned
3Q	1998	ORD at St. Louis
	1997	Contract deliveries completed
Late	1998	Hong Kong Chek Lap Kok PRM operational
1Q	1999	ORD at JFK
1Q	2000	ORD at Philadelphia
	2000	Production installations begun at St. Louis, Logan, JFK
	2001	Philadelphia and JFK installations commissioned
	2002	Production contract for Atlanta initiated
	2004+	**Atlanta installation commissioned (likely delayed by runway construction delays)**

Worldwide Distribution

International sales are possible, especially as airports are upgraded to parallel operations. **Hong Kong** and **Sydney**, **Australia**, installed the system, while **Seoul**, **Korea**, and **Madrid**, **Spain**, are candidates, as they are constructing new airport facilities. **London Heathrow** has also expressed interest. This writer flew over the new field being constructed in Madrid. Some of the equipment had already been installed, and a PRM was not seen. The new tower had what appeared to be an SSR radar on top of the cab. Further information was not available.

Forecast Rationale

The Precision Runway Monitor system uses a combination of phased array scanning and advanced processors to help relieve air traffic capacity limits at certain airports. Standard airport traffic control radars cannot update track information frequently enough for air traffic controllers to confidently allow aircraft to use parallel runways unless they are separated by nearly a mile. Any closer, and one aircraft could blunder into the flight path of another before controllers could detect the hazard and call for corrective action. Electronic scanning makes it possible to update track information and predict a developing conflict early enough for a controller to call for preventive maneuvers.

The PRM/ESSR-128 uses existing, operational IFF equipment in the aircraft for tracking. This simplifies hardware design, since many potential radar design problems can be avoided. Lack of radar data does not pose a problem using this approach, since aircraft without an operational IFF system would be handled as emergency or not allowed into the traffic pattern. This supports future growth as IFF systems become more sophisticated and more data exchange approaches are developed.

PRM features a smaller set of airport equipment and lower operating costs. The ability to use parallel runways is critical to increasing airport capacity. Equally important, however, is the economic pressure to reduce the cost of building or expanding airports. For example, closer spacing of the runways at the new Chek Lap airport in Hong Kong was projected to have reduced construction costs by at least US$1.5 billion. Similarly, new facilities in Sydney, Australia, may be able to take advantage of PRM availability. As time and confidence build, so could market opportunities for the ESSR-128 and follow-on or competing equipment. With respect to airport operating costs, the first PRM installation site at Raleigh-Durham, North Carolina, was projected to save the airport US$32 million annually.

The United States identified at least 10 airports that are suitable for installation of PRM or some other parallel runway traffic control system. The original program called for five, with options for one to three more. In the outyears, if money can be made available, the FAA could decide to procure additional systems to keep up with increasing air traffic volume. The FY04 budget did not allocate and funds for PRM. FAA officials told Forecast International that the overall budget reductions made it necessary to seriously consider all line items. The Precision Runway Monitor is an expensive system that adds five controllers to an airport's staffing. In addition, planners are considering less expensive ways to accomplish approach and landing control. Also, near-term construction of added runways puts the need further out in the planning cycle, so there is no need to spend the money right now.

The WAAS and other GPS-based systems provide such accurate horizontal and vertical position data that, once approved for commercial operations, the FAA may consider allowing certain parallel approaches with WAAS, monitored for safety by controllers. It could eventually become part of a standard approach technique, reducing the need for a ground-based system like PRM. This could eliminate the need for the options on the FAA PRM contract. A full-up WAAS is not likely for a few years, but FAA budget constraints will likely slow PRM as well, making a switch feasible. The FAA is committed to parallel runway operational safety; but is willing to adopt whatever works and they can pay for.

The international economic and political climate is such that the Pacific Rim presents U.S. PRM suppliers with an international marketing opportunity. Chek Lap and Kingsford Smith were important stepping stones into that market. In Europe, local manufacturers have a significant advantage. The development of less expensive systems may push PRM out of the market in the future, but it is too early to tell for sure.

Ten-Year Outlook

No near-term production currently anticipated.

* * *