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PACIFIC BARRIER RADAR III
(PACBAR III)

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PACIFIC BARRIER RADAR III (PACBAR III)

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Abstract

PACBAR III will become a Space Division tracking (C-band radar) site in the Pacific, filling a gap in the worldwide tracking network. The C-band signature and metric radar system was removed from a tracking ship, the USNS General H. H. Arnold, prior to its deactivation in 1982. The C-band radar was a one-of-a-kind system designed by Sperry Gyroscope Co, Greatneck, N.Y. in the 1960's. Over the years the system was extensively modified by the Eastern Space and Missile Center (ESMC) to perform orbital and reentry tracking and recording of missile bodies. The data is collected on a primary target plus all secondary targets within the beam width and range cell. The Western Space and Missile Center (WSMC), Vandenberg Air Force Base, Calif is the Lead Range for PACBAR III. WSMC will construct the onsite facilities and ESMC will modify, refurbish, install, and check out the radar onsite.

I. Introduction

The PACBAR III (Pacific Barrier Radar, Station 3) is a new addition to the spacetrack network for surveillance of missile and satellite systems whose trajectories pass through a mid-Pacific ocean corridor. As a spacetrack sensor, PACBAR III will share the general spacetrack functions: to provide detection and ephemeris of new foreign launches; to identify and target space objects; and to maintain a catalog, including maneuvers and decay, of orbital objects.

The USAF Spacetrack Network consists of more than 15 radars, both ADCOM and non-ADCOM sensors, which support the Spacetrack mission. These sensors vary in type from the VHF interferometer fence across the continental United States to the 120-foot diameter X-band Haystack radar. Figure 1 illustrates the network's radar coverage. The "Southern Gap" or hole in the coverage is obvious in this illustration. The addition of PACBAR III will give Revolution 0 detection of most new foreign launches.

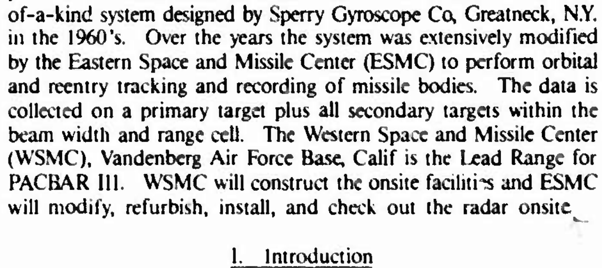

Fig. 1 Spacetrack Network Radar Coverage

*Member IEEE

II. Considerations/Available Assets

The general performance requirements of the PACBAR III radar were established as follows:

1. Search a predesignated 15-degree azimuth sector with a 97-percent probability of detecting a 6-square meter target in a 400-km orbit.
2. Acquire and track high-interest satellites at orbital altitudes as high as 800 km.
3. Metric accuracy comparable to the Ascension AN/FPQ-15 (±0.1 mil).
4. Range resolution of approximately 2 MHz (approximately 80 yd).
5. Provide realtime payload vs. rocket body discrimination with digital recording of at least one target in the beam in addition to the "line track" target.
6. Transmit two-way digital message traffic between the site and the NORAD Cheyenne Mountain Complex at 2400 b/s.

Funds for a new radar system to meet these requirements were not available so a search was made of available/surplus radars that might be obtained to fill the Pacific coverage gap. About then the Eastern Space and Missile Center (ESMC) at Patrick Air Force Base, Florida was deactivating a range tracking ship (USNS General H. H. Arnold) which had been deployed to gather data on foreign missile launches. The equipment on this ship, including a 30-foot diameter C-band radar, was advertised as surplus and available to any user who would remove it from the ship. The Space Division (SD) and the Western Space and Missile Center (WSMC) requested and were given the C-band radar system to fullfill the PACBAR III requirements. SD knew the signature and metric capability of the radar and knew the modifications that had been made on an identical radar on the USNS Vandenberg, a sister ship. A design-to-cost philosophy for the PACBAR III radar dictated that specific subsystems from the USNS Arnold C-band radar be interfaced with both new equipment, using the design developed for the USNS Vandenberg system, and the previously developed software from the ESMC land-based on-axis radar systems. This approach results in a radar that meets SD needs at a reasonable cost.

To meet the radar system requirements while staying within the budget constraints, the following design criteria have been followed.

Search and Acquisition Capability

The search and acquisition capability of the existing system will be augmented by search detection of both interlaced vertical and horizontal pulses. A second video detection unit will be added to the existing range machine. The system will search in a 15-degree azimuth sector and will achieve a 97-percent cumulative probability of acquiring and tracking a 6-square meter target in a 566-km orbit. Additional design consideration will be given to acquiring and tracking scintillating targets.

Metric Accuracy

Metric accuracy of the complete system will be comparable to that of the Ascension AN/FPQ-15. The required metric accuracy will be obtained by control of random and systematic angle errors. A boresight tower will be included as a part of the system for calibration. On-axis tracking capability will provide realtime control of random errors of the encoder data. The physical construction of the pedestal will not allow a full 180 degree plunging capability, but approximately 140 degrees will be obtained by minor modifications to elevation mechanical stops.

Realtime Payload vs. Rocket Body Discrimination

The range and angle system is designed to operate in a multitarget environment. The existing range machine tracks two targets via the digital range tracker (DRT) and the auxiliary range tracker (ART). A modification will be made to obtain output-buffered 15-bit relative range data for the ART target. A second range track position will be added to the console for the ART so that while the ART, or second, target is being tracked, the primary target will be separately observed by the primary range operator. In the past, tracking a second target was often difficult because of the scintillation of the primary target and subsequent loss of angle track and all other data.

Two-Way Digital Message at 2400-b/s

An encrypted 2400-b/s AUTODIN data circuit will be set up between the radar site and NORAD headquarters.

Modification and Equipment Fabrication

Existing equipment consists of the antenna system (pedestal, dish, and feed system), the transmitter, and the digital ranger subsystem. These systems will be rehabilitated or modified to meet the PACBAR III requirements.

New equipment includes:

- RF receiver subsystem
- Solid state servo subsystem
- Automatic Mode Switching console
- SEL comput[illegible]
- Microprocess[illegible] interface buffers for data handling
- Timing subsystem
- Communication subsystem

The new equipment being fabricated is of existing design and has been proven in operational use. Only these changes necessary for this particular application will be made.

III. System Performance Parameters

The PACBAR III radar system resulting from this integration of existing and newly fabricated equipment will produce a radar with the f[illegible]owing system performance parameters.

Transmitter

Frequency range
 Wideband: 5.4 to 5.65 GHz
Frequency
 stability: 1 part in 10^9/day
Pulse repetition
 frequency: 320 p/s (interlaced transmitters)
Peak power: 0.8 MW (derated from 1.2 maximum)
Average power (max):
 3.8 KW ea transmitter
Beacon pulse coding:
 1 to 3 pulse coding
 1 to 11 μs spacing
Pulse width
 Skin: 30 μs
 Beacon: 1 μs nominal;
 0.50, 0.25 alternate

Receiver

Frequency range (coherent):
 5.4 to 5.65 GHz in
 5.245 MHz steps
Sensitivity: −109 dBm at 0 dB
 S/N in 4-MHz bandwidth
Dynamic range: 70 dB plus IF attenuation
Compressed received pulse width:
 0.6 μs
Time sidelobe level: −35 dB
All oscillators coherent with range master clock
Loop gain 30 μs, 320 PRF:
 258-dB meters single pulse

Antenna

Diameter: 30 ft.
Type: parabolic dish
Polarization: horizontal & vertical
Gain: 52.5 dB (5.4 to 5.65 GHz)
Beamwidth: 0.4°
Mount: elevation over azimuth
Feed: Multimode horn/Cassegrain subreflector
Azimuth rotation: 540°
Elevation rotation: −10° to 140°

Mount Dynamic Characteristics

Slew	
Maximum Elevation Velocity	280 mils/s
Maximum Train Velocity	390 mils/s
Maximum Elevation Acceleration	100 mils/s^2
Maximum Train Acceleration	100 mils/s^2

Rate Limits (Toward Buffers)

Selection: Automatic in all modes	
15° from buffer	180 mils/s
5° from buffer	0 mils/s
mechanical buffer	

Precision

Range (DRT)	[illegible] bits (LSB = 1.953 yd)
Relative Range (ART)	15 bits (LSB = 31.25 yd)
Angles	19 bits (LSB = 0.012 mrad)
Range Designate (DRT)	25 bits (LSB = 1.953 yd)

Range Tracking

Nonambiguous range	32,768 nmi
Nonambiguous acquisition rng	4,096 nmi
Slew rate	200,000 yd/s
Acceleration	±2,000 yd/s^2
Tracking rate	20,000 yd/s
Range master clock coherent with receiver local oscillators	

Acquisition Aids

Angle scans
Auxiliary range tracker
Automatic acquisition, vertical and horizontal channels, 1024 cell
Computer designate

Data Recorded

Digital time of day, millisec	80 p/s
Digital azimuth pedestal position	80 p/s
Digital elevation pedestal position	80 p/s
Digital range primary target	80 p/s
Digital range error, primary target	80 p/s

Digital range secondary target	80 p/s
Primary target amplitude vertical	160 p/s
Primary target amplitude horizontal	160 p/s
Primary target delta azimuth position vertical	160 p/s
Primary target delta elevation position vertical	160 p/s
Secondary target amplitude vertical	160 p/s
Secondary target delta azimuth position vertical	160 p/s
Secondary target delta elevation position vertical	160 p/s
Transmitter power vertical	160 p/s
Transmitter power horizontal	160 p/s

Video Output Available

- Full bin logarithmic amplitude video
- Full bin elevation video
- Full bin azimuth video

IV. Assignment of Responsibilities

A Memorandum of Understanding exists between the WSMC and the ESMC. In general, WSMC serves as the PACBAR III Program Manager, defines the operational scenario, and furnishes the radar shelter and support facilities on site. ESMC serves as Project Director to rebuild, modernize, install, and check out the radar system.

In addition, mutual interfaces exist between WSMC and ESMC. Equipment interface is split between the radar (ESMC) and communications (WSMC). Facilities will be accomplished by WSMC with design and radar requirement inputs from ESMC (i.e., boresight tower, power, HVAC, demineralized cooling water). Security will be worked jointly by both agencies, with WSMC having the lead.

V. Installation/Testing/Turnover to Operations

The basic integrated test will be made at Patrick AFB and nearby Cape Canaveral Air Force Station. The system will then be transferred by ship to the island site, off-loaded, moved to the site, installed, retested, and sold off to WSMC.

Full training (both classroom and OJT) will be given to WSMC O&M personnel by ESMC. Additionally, all documentation (software and hardware) will be updated and turned over to WSMC, thus reflecting the as-built configuration. One year of initial spare parts will be supplied with the instrumentation system.

VI. Conclusion

The PACBAR III system will meet the goals and objectives established by the Space Division to close the gap in the Pacific coverage in their worldwide tracking network. Existing Government instrumentation equipment, modified and updated through proven designs applied to similar equipment, allows the task to be accomplished at low cost, on time, with a minimum of technical risk, and with long-term supportability.