THE PACIFIC MISSILE TEST CENTER'S AIRBORNE TELEMETRY COLLECTION CAPABILITY

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ABSTRACT

Providing realtime telemetry collection to the Pacific Missile Test Center's (PMTC) range users presents some unique problems. Operations are staged in an open sea environment with participants often at very low altitude and/or far from land based collection instrumentation. This paper will present an overview of the airborne telemetry collection instrumentation that has been developed at PMTC to overcome these problems and will discuss some of the operational problems encountered in its use.

INTRODUCTION

The Pacific Missile Test Center is located in Ventura County, California, approximately 50 miles northwest of Los Angeles. It was established on Point Mugu Beach in 1946 as the Naval Air Missile Test Center and has existed there since then, undergoing several name changes while growing in size and importance to its present position as the Navy's center of excellence for weapon systems test and evaluation and leading range development organization. The most significant features associated with PMTC are its sea test range and its ability to conduct highly controlled test and evaluation programs in an open sea environment.

The physical size of PMTC's sea test range and its location are indicated in Figure 1. The area available for staging operations is approximately 125 miles wide by 250 miles long. Land based instrumentation sites, including telemetry collection, are located on Point Mugu Beach and San Nicolas Island. In addition, the instrumentation assets of the Western Space and Missile Center at Vandenberg Air Force Base can be scheduled to augment PMTC's capability. As can be seen, the available ground instrumentation is all concentrated to one side of this approximately 30,000 square mile test area. Also evident is the potential for signal shading of low altitude sources for certain portions of the range from the chain of Channel Islands (Anacapa, Santa Rosa, Santa Cruz and San Miguel).

TYPICAL TEST SCENARIOS

Figures 2 and 3 indicate the participant ground tracks for several typical test scenarios. In the first case of a missile/target intercept the test must be staged far from inhabited areas to insure range safety. Both the target and missile have the potential to travel large distances at high velocities and thus must be kept within safe areas of the range, a constraint that usually places them far from land based instrumentation. (RF signal ducting can extend the reception range, but this phenomenon cannot be reliably predicted in planning for the instrumentation coverage for a particular operation) If both the missile and target are operating at high altitude, the land based instrumentation could provide adequate reception of telemetry data. However, if the target is flying at 50 feet above the water it will present a reception problem as would a surface launched missile or a look down/shoot down air launched missile at the terminal portion of the intercept. In the second case, a long range land attack or anti-ship engagement is being simulated and a major portion of the total sea test area is required. This might be the ground track for a long range missile which can hug the surface for its entire flight. Again, the land based telemetry gathering equipment will be almost useless for direct telemetry reception for a major portion of the flight. Obviously, a better mouse trap is called for.

AIRBORNE TELEMETRY INSTRUMENTATION

Faced with the above physical and operational scenario constraints, an airborne telemetry reception capability is a must for effective data gathering. The majority of this capability has been installed on PMTC’s Lockheed P-3 aircraft. In addition, self contained telemetry pods have been developed for installation on high performance aircraft. With the exception of speed, the P-3 is an ideal platform from which to operate. The aircraft can carry a large amount of collection equipment and personnel and has a flight duration time in excess of 10 hours. Additionally, it is relatively inexpensive to operate when compared to jet aircraft. In many cases the same P-3 that will be used to collect telemetry data serves a dual purpose, being sent out hours prior to an event to clear the operational area of surface contacts for range safety purposes.

Table 1 indicates the types and some characteristics of the various equipment installed on the P-3 aircraft for telemetry collection. The various types of equipment are spread among several aircraft with no single aircraft having everything. The helix antennas are mounted in pairs, one right hand circular polarization and one left hand to provide signals to separate preamps and receivers. They have a 3 db beamwidth of 30 degrees and are mounted in the nose of the aircraft for a forward look angle. They are the only antennas mounted in a forward looking position; the three other systems are side looking with their boresight directly to the port (left) side of the plane. The horn and dish antenna are used almost exclusively for off range strategic missions to collect data in the terminal area on reentry vehicles. The horn has a 3 db beamwidth of 20 degrees with the dish having a beamwidth of 7 degrees in azimuth and 10 degrees in elevation. The dish can be directed and can be pointed plus/minus 20 degrees in azimuth and plus 20 to minus 25 degrees in elevation. It also has autotrack capability in azimuth and an operator initiated, programmable downscan rate. The phased array antenna system has become our most valuable airborne telemetry asset. It is the Airborne Instrumentation Station (AIS) portion of the Extended Area Test System. The AIS has five independent beam tracking capability within angular limits of plus/minus 66 degrees in azimuth and plus 45 to minus 20 degrees in elevation. The entire system operated under computer control with autoacquisition and autotracking. While the phased array is limited to right hand circular polarization, this limitation has not proven to be a major disadvantage for telemetry data gathering.

All of the reception systems have preamps mounted in close proximity to the horn or antenna. In terms of G/T, the systems run from a minus 10 for the helix antennas to a positive 4.5 for the phased array. The dish antenna is a negative 3 and the horn has a negative 7.5. The G/T figure for the phased array is only accurate in an angular area of plus/minus 30 degrees in azimuth and plus 2.5 to minus 7.5 degrees in elevation from boresight. The figure falls to about a negative 14 at the extremes of the azimuth angular coverage and to about negative 25 at the elevation extremes.

The receivers used on the P-3’s are Microdynes and Hartmans. We use a mix of Microfyne 1100’s and 1200’s with 3200 and 3300 diversity combiners when dual polarization signals are available. We use both S-band (2200-2300 MHz) and P-band (215-315 MHz) RF front end plug-ins. The P-band front ends are used in conjunction with a downconverter which gives the capability of covering both S- and L-band (1435-1535 MHz) sources with the broad band helix antennas. Several range users still transmit in P-band which is covered with a direct input from a belly mounted omni antenna and preamp. The phased array system operates in S-band only and uses Hartman TMR-74 receivers. The system was originally designed with the signal from each tracking beam being divided between a telemetry receiver and a Miss Distance Indicator (MDI) receiver. We have removed three of the MDI receivers and replaced them with Microdyne 1200’s to increase the IF bandwidth above the 1.0 MHz capability in the Hartman receivers provided in the system. The entire receiver area of the AIS is being redesigned at present to incorporate the Microdynes into the tracking and control loop.

We use a mix of 7 and 14 track magnetic tape recorders onboard the aircraft. At present they are limited to a maximum speed of 120 inches per second. Predetection recording is the method normally used. Each aircraft is equipped with VCO’s and the necessary test equipment to allow for calibrated signal strength recordings using the receiver AGC output as the measurement source. We inject a signal into a test probe or ahead of the preamps and calibrate for IF SNR’s. The phased array antenna presents a problem in this area due to its large angular coverage and the lack of a good place to inject a calibration signal.

A limited decommutation and display capability has been installed in two aircraft. It is used primarily to provide an onboard range safety officer with a strip chart display of parameters that will allow a determination of the flight stability of the source.

Based on this determination, the range safety officer can elect to destruct the missile if required. Two channels of PAM and two channels of PCM are normally installed, but this can be doubled if required. Twelve to twenty individual parameters can be displayed on strip chart recorders.

A retransmission capability exists on several of the aircraft and will be installed on all of them in the near future. A minimum capability of two retransmission frequencies in L-band is desired. The phased array aircraft has the most extensive retransmission system with the capability to retransmit each of the five beams. Each channel is limited to a 1.1 MHz retransmission bandwidth which limits its usefulness to some range users. Each retransmission channel is 60 watts in L-band. All five retransmission frequencies are routed to a single horn antenna which is tied to the internal navigation system and can be programmed to remain pointing to a reception location throughout any aircraft maneuvers. The AIS is unique in this capability; the other aircraft use an omni blade antenna.

Our airborne pod capability can be roughly divided into two types: pods with fixed antennas and pods with tracking antennas. The pods with fixed antennas are built around PMTC designed and fabricated hardware. This includes the forward looking antenna that produces both right and left hand circular polarized signals, receivers, bit synchronizers and four track magnetic tape recorder. A commercial omni antenna is also installed on the of the underside of the pod and an onboard operator can switch between the two antennas. The pods were required to be of small diameter which forced the in-house design and fabrication rather than using commercially available equipment. The systems will handle both S- and L-band telemetry signals, have a receiver for each polarization and use a seven inch reel on the tape recorders. This limits the record time to about seven minutes at 60 inches per second, but this is more than adequate for most air-to-air engagements. Several pods have a retransmission system in place of the magnetic tape recorder. All of the pods are rated for supersonic flight and several which were designed for Fleet use are carrier landing qualified.

The trackable antenna pods are normally flown on our A-3 aircraft. The pods are physically larger and can accomodate a forward looking flat plane antenna of crossed dipoles, giving a pseudo-monopulse system. The antenna has a gain of about 14 db and gives angular coverage in an area bounded by slew limits of 0 to minus 60 degrees in elevation and plus/minus 45 degrees in azimuth down to minus 45 degrees in elevation and plus/minus 25 degrees in azimuth through the remaining 15 degrees of the elevation movement. The systems can be configured in any single polarization and are normally flown in pairs, one right hand and one left hand circular polarization, one under each wing of the A-3. An onboard operator controls antenna pointing for acquisition via a joystick. Either of two preprogrammed S-band frequencies can be selected by the operator as can either of two L-band retransmission frequencies. A pod mounted magnetic tape recorder gives an extended recording capability by using an interleave backward and forward recording scheme.

OPERATIONAL PROBLEMS AND CONSIDERATIONS

We have encountered relatively few hardware problems. Some of the receivers are ruggedized for the shock and vibration environment of the aircraft, but the majority of the equipment is off-the-shelf. We attempt to isolate the hardware as much as possible by vibration isolation of the mounting racks which house the equipment on the planes. RF tuners have been our major source of problems and some off-the-shelf test equipment requires special handling.

The primary problem we have in providing telemetry collection support is getting the aircraft into the proper position at the proper time. In general, the collection aircraft is just one of many players involved in a particular test. There can be a number of aircraft, ships and targets all demanding the attention of the operation conductor at the same time. The operation conductor functions by directing the actions of secondary personnel responsible for one participant or function and this individual may or may not understand the entire operational scenario. One of these secondary functions is the positioning and coordination of all of the aircraft involved and we are dependent on this individual to properly position the telemetry aircraft so that either the nose or port side of the aircraft is directed toward the telemetry source. This is of course a problem of the directional antennas we must use and the limited G/T’s of the systems. The forward looking systems seem to fare better than the side looking. Anticipating the movements needed to insure that an aircraft is lined-up and ready to chase a missile appears to be easier than getting lined-up to fly a parallel course. Keeping the side looking systems directed at a maneuvering source is particularly difficult.

We have been very successful in using the AIS is providing the realtime relay of telemetry data. The system is extremely useful in cases when several telemetry signals may radiate, but the exact ones or their firing order is not known. For example, a number of ships may be ready to launch missiles against an incoming target. Provided there are no more than five potential S-band sources, the AIS can be programmed with one of the potential frequencies on each beam and it will then acquire and track each source as it is fired. In this way, a land based antenna which may not have direct line-of-sight to the launching ships can track a single aircraft and receive the retransmitted telemetry signals from as many as five different sources.

PLANNED IMPROVEMENTS

As indicated above, it is planned to install a retransmission capability on all the P-3 aircraft. It is also desirable to have a decommutation and display capability on all the aircraft to give asset scheduling flexibility in the event that one or more aircraft are down for maintenance. This is also in the planning stage. The operational problems of having the aircraft out of position could be solved with a set of those ever elusive high gain omni antennas. A moderately high gain antenna, say 15 db, with the ability to track a full 360 degrees in azimuth might do the job if we also had the ability to switch between a top mounted and a bottom mounted system to avoid loss of signal while the aircraft turns. This type of a system is also being investigated for future procurement.

An updated specification for a more flexible version of the AIS is being readied for procurement. The system will be installed on P-3 aircraft again and we intend to procure two to three more systems. The major changes for these follow-on systems is the requirement for dual circular polarization capability and an expansion of the flat G/T window in elevation from the present 10 degree window to 20 degrees. A slight improvement for this flat G/T figure to 6.8 vice 4.5 is also specified.

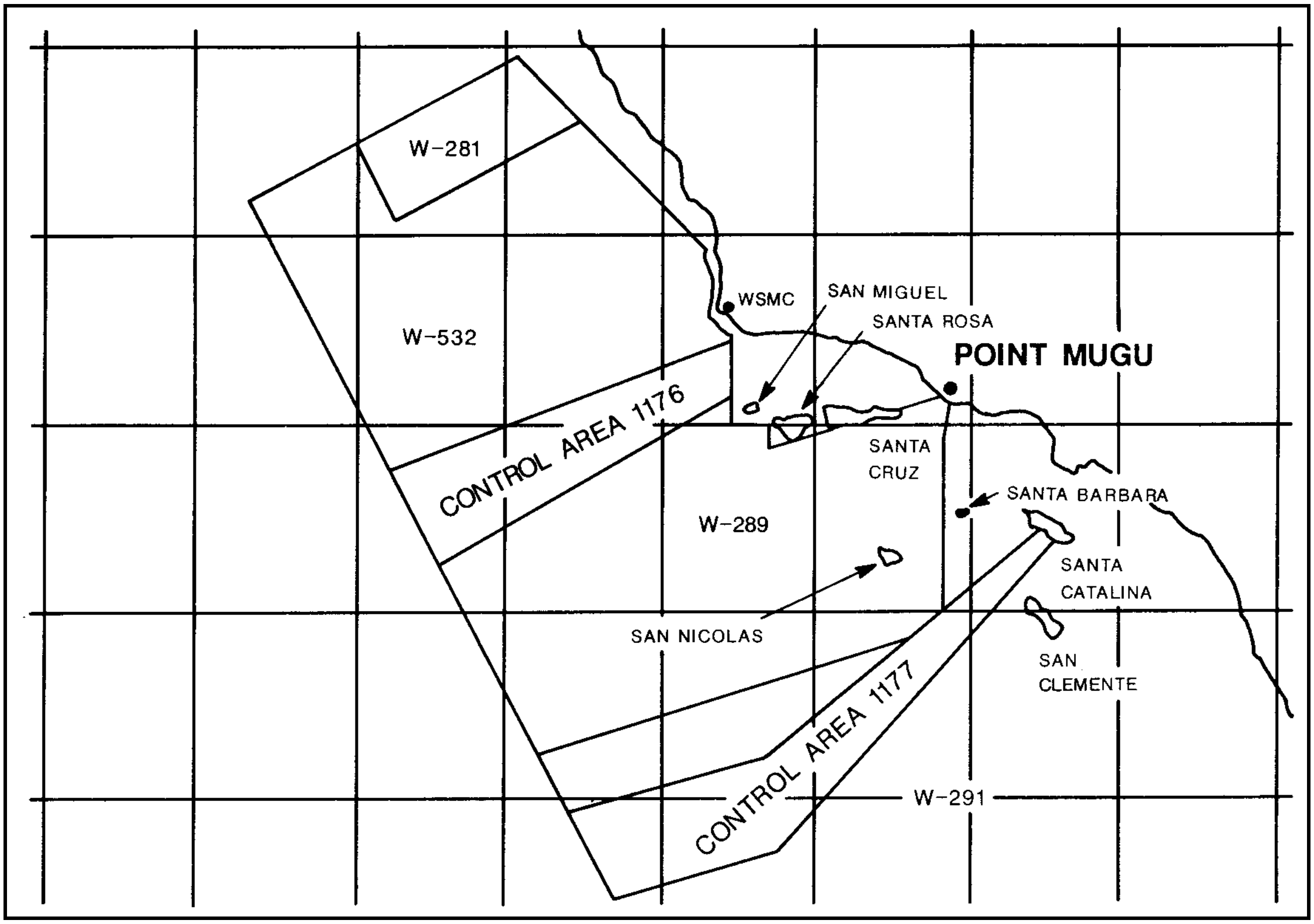

FIGURE 1. PACIFIC MISSILE TEST CENTER SEA TEST RANGE

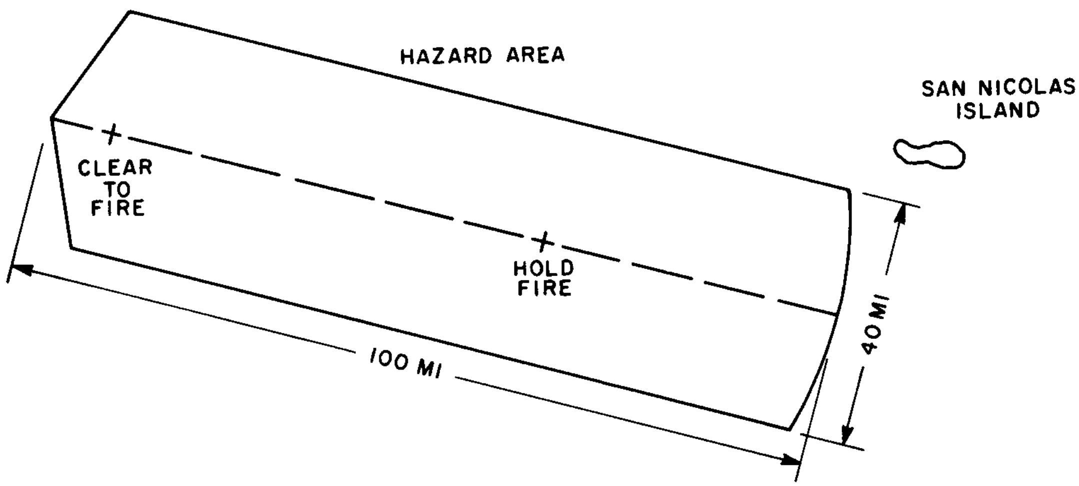

FIGURE 2. TYPICAL AIR-TO-AIR ENGAGEMENT HAZARD AREA

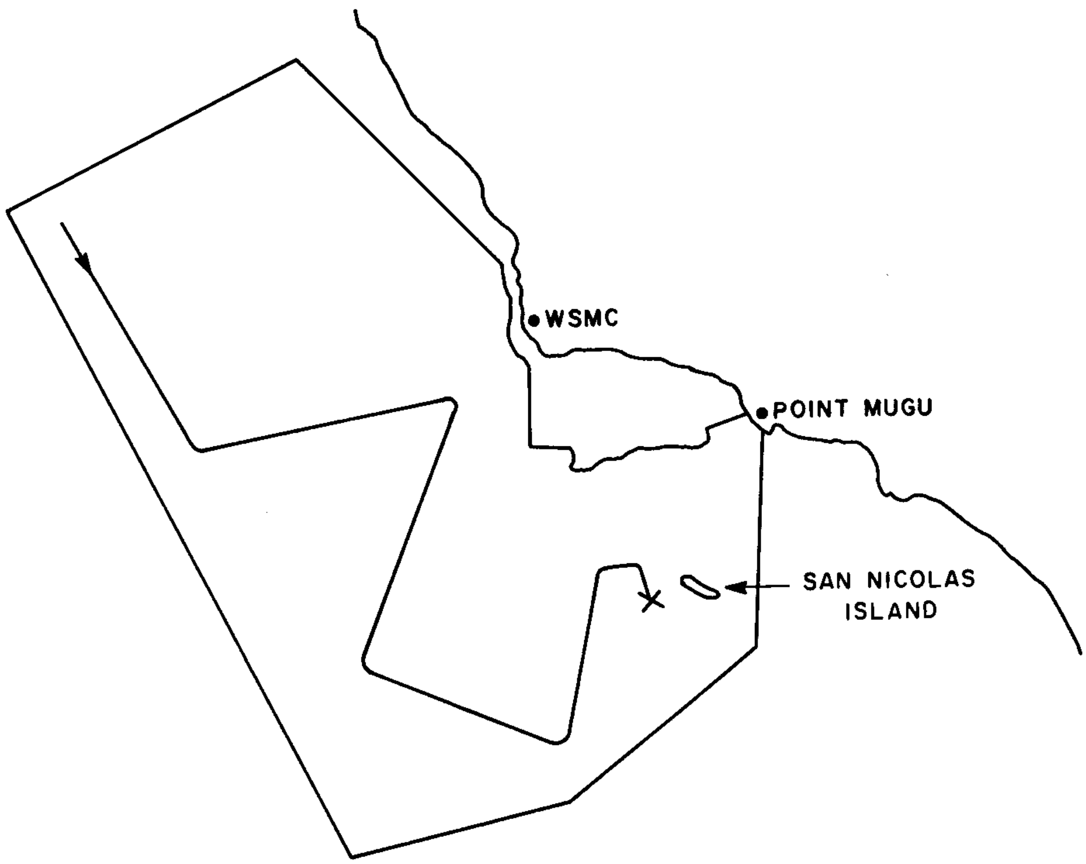

FIGURE 3. TYPICAL LONG RANGE MISSILE GROUND TRACK

ANTENNAS

	BEAMWIDTH	ANGULAR COVERAGE
HELIX	30 DEG AZ & EL	FIXED
HORN	20 DEG AZ & EL	FIXED
DISH	7 DEG AZ/10 DEG EL	+/-20 DEG AZ/+20,-25 DEG EL
PHASED ARRAY	-	+/-66 DEG AZ/+45,-20 DEG EL

SYSTEM G/T's

HELIX	- 10
HORN	- 7.5
DISH	- 3
PHASED ARRAY	+4.5 (Varies as a function of angle)

RECEPTION CAPABILITIES

S-BAND (2200-2300 MHz)
L-BAND (1435-1535 MHz)
P-BAND (215-316 MHz)

TAPE RECORDERS

7 and 14 TRACK
120 IPS MAXIMUM

RETRANSMISSION

S- and L- BAND

DECOMMUTATION AND DISPLAY

PAM and PCM FORMATS
12 - 20 STRIP CHART CHANNELS

TABLE 1. AIRBORNE TELEMETRY EQUIPMENT