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# Eastern Space and Missile Center (ESMC) Capability

S.R. Clark
Directorate of Range
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16 Sept 83

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PREPARED FOR
EASTERN SPACE AND MISSILE
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PATRICK AIR FORCE BASE, FLORIDA 32925



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Discussed are major instrumentation systems for the range and identifies salient instrumentation characteristics importatnt in the support of test programs and the collection of test data. Highlights of many technical enhancements and capital plant improvements.

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# EASTERN SPACE AND MISSILE CENTER CAPABILITY

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## Abstract

The Eastern Space and Missile Center's Eastern Test Range includes all stations, ships, sites, ocean areas, and airspace necessary to conduct missile and space vehicle test and evaluation. This paper discusses the major instrumentation systems for the Range and identifies salient instrumentation characteristics important in the support of test programs and in the collection of test data. Highlights of the many technical enhancements and capital plant improvements planned for the near future are also identified.

## I. Introduction

The Eastern Test Range (ETR) is a Major Range managed by the Air Force Eastern Space and Missile Center (ESMC) for the Department of Defense. Although the Range is used primarily for missile and space vehicle tests, it is also used for some aircraft, drone, helicopter, balloon, and small rocket tests. The ETR extends from the eastern United States through the south Atlantic Ocean eastward into the Indian Ocean at 90°E longitude. The Range comprises a series of stations located at Cape Canaveral Air Force Station (CCAFS) and on the Florida mainland; on the islands of Grand Bahama, Antigua, and Ascension; and at Pretoria, South Africa. (The Air Force station on the island of Grand Turk is being deactivated.) These stations are augmented with two instrumented Range ships. One of the ships, the USNS Vandenberg, is currently in the ready reserve fleet. Since the ship can be reactivated when needed, its common instrumentation characteristics are included in this paper. In addition to these stations, the ETR uses instrumentation operated by the National Aeronautics and Space Administration (NASA) at Bermuda and Wallops Island, and Advanced Range Instrumentation Aircraft (ARIA) from the 4950th Test Wing, Wright-Patterson Air Force Base, Ohio.

The ETR is a service-oriented organization whose basic mission is to collect, process, and deliver test-related data to Range Users. In supporting a typical test, the ETR collects metric, telemetry, photographic, acoustic, and meteorological data. When requested, the ETR also performs processing, reduction, and analysis of the data to the User's specifications.

The technical personnel and the sophisticated instrumentation at the ETR have provided test support to a variety of systems ranging from man-launched anti-tank weapons to the largest intercontinental ballistic missile (ICBM) systems, interplanetary probes, the manned lunar program, and the Space Transportation System (Shuttle).

The Range is fully equipped to serve as a "Lead Range" in a worldwide network, as well as to support other Lead Ranges. This ability is established by using the comprehensive communications, timing, and command systems on the Range, together with the Central Computer Complex (CCC) at Cape Canaveral.

## II. Radar

Precision-tracking pulse radars are located at Merritt Island, CCAFS, Patrick Air Force Base (AFB), Grand Bahama Island, Antigua, and Ascension, and on the USNS Redstone and USNS Vandenberg. These radars are capable of either beacon or echo tracking, and all are able to transmit precision data at 10 samples/second to the CCC. Shipboard radars offer both metric and signature data gathering capability. The significant characteristics of the C-band radar systems are shown in Table 1.

These precision-tracking radars obtain most of the metric data on the Range. They are augmented in the launch area with optical devices to obtain data of higher accuracy at short range and in the terminal area with Missile Impact Location System (MILS) arrays. In the launch and mid-range areas, radar metric data can be augmented with data from the Telemetry Doppler Metric Measurement System.

Seven of the Range tracking radars have been modified to an "on-axis" mode. The on-axis concept grew out of the need to steer telescopes having extremely narrow fields of view with a smoothness and accuracy that permit definitive photography of satellites in orbit. The radar antenna is driven with data that originates in a synthetic orbit generator operating in a computer. The coefficients of the generator's orbital equations can be adjusted in realtime in response to target behavior as sensed by the tracking portion of the radar, thus closing the tracking loop through the computer. These adjustments are made automatically, at intervals and in increments that adapt themselves to optimizing the antenna drive signals for the particular dynamics of the target being tracked. In addition, all deterministic characteristics of the radar antenna are programmed in the computer to compensate the antenna drive signals. As a result, for targets whose accelerations are not large, the "axis" of the antenna is maintained precisely on the target.

To implement the on-axis concept at a radar, a computer is inserted in the antenna servo loops. With its associated software, the computer manages the antenna in realtime. Digital encoders are connected to the antenna azimuth and elevation shafts, and the responses of the mount to the computer-generated drive functions are sampled for processing in the computer. The telescope, encoders, and mount alignment; zero set or bias; mislevel; non-orthogonality; and droop can be accurately established From these, an optical calibration reference can be established on the antenna mount. Availability of targets with both optical and radar visibility then permits determination of the rf axis. This process results in an accurately calibrated radar. The computer and its associated software compensate for the modeled errors and gain coefficients, and point the antenna at the tracked vehicle. The encoders report these angles to the computer, which outputs the corrected data in an Earth-centered (E,F,G) coordinate set.

Table 1 C-Band Radar Characteristics

| | KSC | | CCAFS | | PAFB | | GBI | ANT | ASC | ASC | USNS Redstone | USNS Vandenberg* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MCBR | FPQ-14 | MCBR | FPS-16(M) | FPS-13 | FPQ-14 | FPQ-13 | FPQ-14 | FPQ-15 | TPQ-18(M) | FPS-16(V) | IIR-C |
| Antenna Dia (ft) | 12 | 29 | 12 | 12 | 20 | 29 | 20 | 29 | 28 | 29 | 16 | 30 |
| Gain (dBi) | 44 | 51 | 44 | 44 | 47 | 52 | 47 | 52 | 48 | 51 | 46 | 52.5 |
| RFLG dBm[4] | 232 | 249 | 232 | 224 | 249 | 256 | 249 | 258 | 253 | 253 | 241 | 258 |
| RF Amps | GaAsFET | GaAsFET | GaAsFET | GaAsFET | Paramps | Cryo | Paramps | Paramps | Paramps | Cryo | GaAsFET | GaAsFET |
| Transmitter PW ($\mu$s) | 5 | 5 | 5 | 1 | 10 | 5 | 5 | 5 | 10 | 5 | 10 | 30 |
| Polarization | V | V, C | V | V | V | V, C | V | V, C | V | V, C | V, C | H, V |
| Transmit Power (MW) | 1.0 | 2.8 | 1.0 | 1.0 | 5.0 | 2.8 | 5.0 | 2.8 | 5.0 | 2.8 | 3.0 | 0.8 |

*Also has L/UHF radar

On-axis radars are now at Patrick AFB, Merritt Island, Grand Bahama, Antigua, and Ascension. The ETR is currently working with the Navy to include the Capri-type radars at St. Thomas and St. Croix in the ETR tracking network. The only significant modifications have been for data interface and communications.

Programmed improvements for the radars include rf amplifiers and digital receivers, and replacement of the computer systems.

Telemetry Doppler Metric Measurement System (TDMMS)

The TDMMS is a system that measures and records data that includes the Doppler frequency shift as observed from the telemetry stations. Whenever measurements are available from two or more stations, posttest data processing can obtain both ambiguous range differences and nonambiguous range difference rates. The measurement interval at each station is normally controlled by the transmitted telemetry signal (e.g., the PCM data frame synchronization). Measurements can be obtained from either a modulated or a continuous wave S-band signal. If a convenient synchronizing signal is not transmitted from the missile, then the local stations' timing signals are used to establish the data intervals.

The five telemetry stations with the TDMMS are shown in Figure 1. Any station could be selected as the reference for difference measurements with the other stations. Selection would be based on geometry relative to the missile and could be changed as the

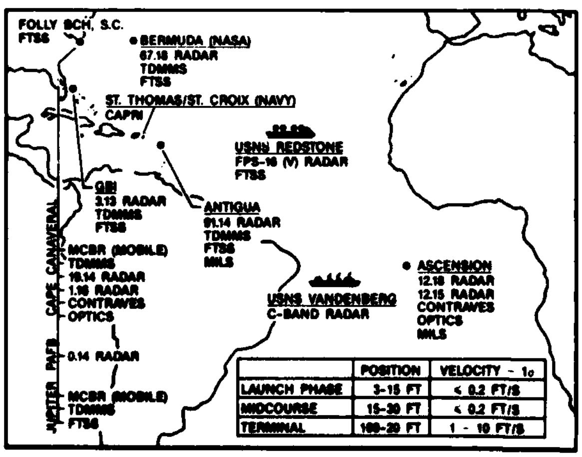


Fig. 1 ESMS Metric Capability

missile proceeds downrange. For example, the reference station might change from Grand Bahama Island to Antigua.

The system improves velocity accuracy for radar trajectory measurements. That is, the ambiguous range differences and the range difference rates are accurate enough to establish position and velocity constraints that complement the radar data. Through TDMMS data, the velocity profile of a radar-only best estimate of trajectory can be improved by approximately one order of magnitude.

Because it depends on another system to furnish an initial trajectory estimate, the TDMMS is not a stand-alone system whose accuracy can be defined in terms of trajectory parameters. Instead, the TDMMS is properly qualified by the 1 $\sigma$ uncertainties in the TDMMS measurement domain given here.

| Error Type | Range Difference | Range Difference Rate |
|---|---|---|
| Bias | Ambiguous | 0.01 ft/s |
| Random | 0.1 ft | 0.02 ft/s |
| Unmodeled systematic | 4 ft | 0.10 ft/s |

The TDMMS has demonstrated stand-alone nonambiguous Range measuring on several missile launches by using the remote ranging signal of the Flight Test Support System. A 500-MHz counter starts when a unique pseudorandom noise Gold Code is generated and stops when the translated signal is received. The resulting count is divided by two to determine one-way travel time, which is then converted to one-way range. This range data is used in conjunction with the azimuth and elevation data from the tracking antenna to develop azimuth, elevation, range, and time (AER&T), which is converted to E,F,G and time.

Missile Tracking Instrumentation System

The Missile Tracking Instrumentation System (MTIS) was developed by the U.S. Navy to gain a tracking capability for extended-range test flights of up to four simultaneous Trident missiles. The system is widely dispersed, with equipment and facilities in ground stations, ships, satellites, and missiles that are separated by hundreds of miles. The MTIS is a combination of new and existing equipment operating as a missile tracking network during powered missile flight.

A translator on board the missile receives the Global Positioning System (GPS) navigation signals, amplifies and frequency shifts them, and retransmits the new signal to a surface-based station. Here, the signals are recorded for postflight determination of missile position and velocity. The system also transmits realtime data to external computers for Range Safety display and decisions. In addition it receives, records, and displays telemetry data.

Basically, the MTIS consists of three major segments: satellite, missile, and surface. These three segments and their major elements are depicted in Figure 2. The satellite segment consists of GPS navigation satellites and the Fleet Satellite Communications (FLTSATCOM) system for communications between the support ship and CCAFS.

The missile segment consists of missiles configured for test launches.

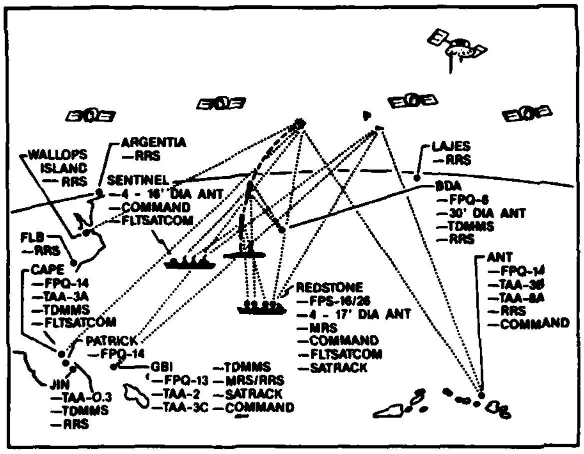


Fig. 2 MTIS/FTSS

The surface segment consists of both new and existing facilities. These facilities include the Flight Test Support System and ETR support systems on ships and land stations; the Loran-C network for time synchronization; and the specialized, User-operated Satrack (satellite tracking) data processing facility for postflight processing and analysis of the trajectory and guidance system data obtained during missile flight.

Flight Test Support System (FTSS)

The FTSS consists of three types of surface stations: Launch Area Support Ship (LASS), Downrange Support Ship (DRSS), and remote ranging station (RRS). Each type performs specific functions for range safety, telemetry, and Satrack data processing from missile broach through equipment-section burnout (ESBO). The FTSS uses multilateration to produce missile position and velocity for the Range Safety computer and display systems. Table 2 summarizes the FTSS locations and the realtime system accuracy (for Range Safety use). The LASS provides range safety, records both telemetry and Satrack data from broach to second-stage ignition, and, as backup, records

Table 2 FTSS Capability

| Locations | Accuracy |
|---|---|
| Master Ranging Stations | Range Sum |
| GBI (1 or 2 missiles | Bias < 600 ft master |
| USNS Redstone (4 missiles) | < 3300 ft remote |
| Remote Ranging Stations | Random < 1000 ft |
| Folly Beach | Range Sum Rate |
| Bermuda | Bias < 3 ft/s |
| Jupiter Inlet | Random < 10 ft/s |
| Wallops Island | |
| Antigua | |
| Lajes, Azores | |
| Argentia, Newfoundland | |

telemetry and Satrack data from second-stage ignition through ESBO. The DRSS accomplishes the range safety, telemetry, and Satrack functions from signal acquisition (nominally 10 seconds before second-stage ignition) through ESBO.

When the missile is in view, the master ranging station (MRS) on the DRSS USNS Redstone, the MRS on Grand Bahama Island (GBI), and the RRS furnish uplink ranging signals for multilateration position and velocity solutions from before second-stage ignition through ESBO. The missile translator receives the ranging signals from the MRS and RRS and the Satrack ranging signals from the GPS satellites and retransmits these signals to the LASS and the DRSS. The DRSS also has a pseudo-satellite uplink to correct for ionospheric refraction.

Launch Area Support Ship (LASS). The LASS is stationed approximately 2,000 yards from the launch point to furnish initial range safety, telemetry, command/control, and Satrack processing. During DASO (Demonstration and Shakedown Operation) and OT (Operational Test) activities, the FTSS on board the USNS Range Sentinel (T-AGM-22) monitors up to four inflight missiles simultaneously.

Downrange Support Ship (DRSS). The DRSS is stationed downrange to monitor missile data during the second-stage through ESBO portions of test flights. During a DASO, the FTSS installation at GBI accomplishes these functions. During an OT, the FTSS equipment on board the USNS Redstone (T-AGM-20) accomplishes the DRSS functions while the GBI installation is backup.

The FTSS on GBI offers master ranging station capabilities for OT support as well as a pseudo-satellite transmitter for Satrack support during DASO's. The FTSS GBI installation interfaces with both the TAA-2 and TAA-3B telemetry antennas. The azimuth and elevation information obtained by these antennas is used in conjunction with ranging information to develop a state vector output. This output forms the FTSS multilateration ranging data, which is transmitted over a modem link to the CCC for computation of instantaneous impact prediction (IIP).

The FTSS on board the USNS Redstone offers flight safety and Satrack support during OT flights, having both master ranging station and pseudo-satellite station capabilities. The USNS Redstone FTSS installation interfaces with the four telemetry antennas. These antennas transfer range safety and Satrack data to the FTSS for display and ranging computation. Multilateration data—both state vector and telemetry backup—is transmitted via SATCOM to the CCC and to the onboard computer for computation of IIP.

Remote Ranging Station (RSS). Each remote ranging station incorporates an uplink transmission system (394 MHz) to transmit a pseudorandom noise (prn) modulated waveform to the missile. These signals are time-division multiplexed with the 394-MHz signal from the MRS and are translated in the missile to a 2.2 to 2.3 GHz S-band downlink. This downlink is used by the downrange tracking site for realtime computation of IIP.

## III. Optics

Metric optics capability is available at CCAFS, at all downrange stations, and aboard ships. These systems include precision theodolites, ballistic cameras, and long-range, large-aperture telescopes. The ballistic cameras and theodolites are mobile, so they can form various configurations of favorable geometry for any flight profile. (Table 3 summarizes the ETR optics capability by type and characteristics.)

The Range has 24 universal camera sites that accommodate any Range vehicle optics systems. Figure 3 identifies these sites at CCAFS and Kennedy Space Center (KSC). Figure 4 identifies the location of ETR tracking telescopes ROTI and IGOR (recording optical tracking instrument and intercept ground optical recorder, respectively).

Table 3 Optics Capability

| | Qty | Aperture (in) | Focal Length (in) | Encoders (bits) | Film (mm) | Accuracy* | Location |
|---|---|---|---|---|---|---|---|
| Contraves | 6 | 7.5 | 60/120 | 17 | 35/Video | 14/5 | Mobile, KSC, CCAFS, ASC |
| ROTI | 2 | 24 | 100/200/300/400/500 | 15 | 35/70/Video | 14/5 | Cocoa Beach, Melbourne Beach |
| IGOR | 3 | 18 | 90/180/350/500 | 15/20 | 35/70/Video | 14/5 | PAFB, 2 Mobile KSC/CCAFS |
| ITEK | 1 | 48 | 120/240/480—7000 | 21 | Video | 1/2 | Malabar |
| Ballistic Cameras | 4 | 5 | 300 mm (3) 450 mm (1) | — | 190 × 215 | 1/2 | CCAFS, ASC |
| IFLOT | 11 | 4/12 | 10—240 | — | 16/35/70 | — | KSC/CCAFS/ USNS Redstone USNS Vandenberg |
| MOTS | 2 | 4/12 | 20—180 | — | 16/35/70 | — | KSC/CCAFS |
| CZR | 4 | 3 | 6/8.25/10 | — | 5.5 in | — | KSC/CCAFS |
| Still Cameras | 160 | 35 mm to 8×10 | Various | — | 35 mm to 10 in | — | KSC/CCAFS/PAFB |
| POPS | 1 | 15/18/ + | 150/180/ + | 18 | 70 | 14/5 | USNS Vandenberg |

*Accuracy = Random/Systematic (arcseconds)

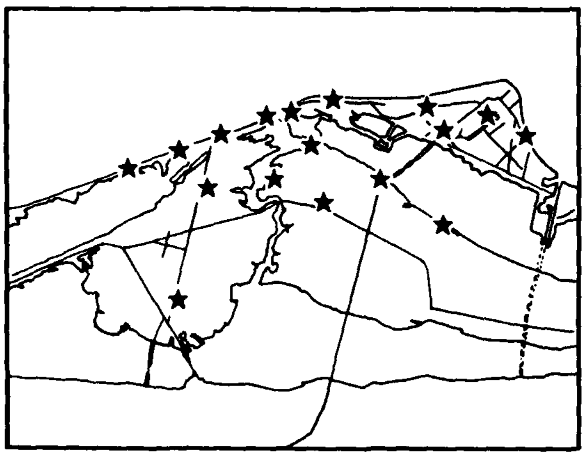

Fig. 3 CCAFS and KSC Universal Camera Sites

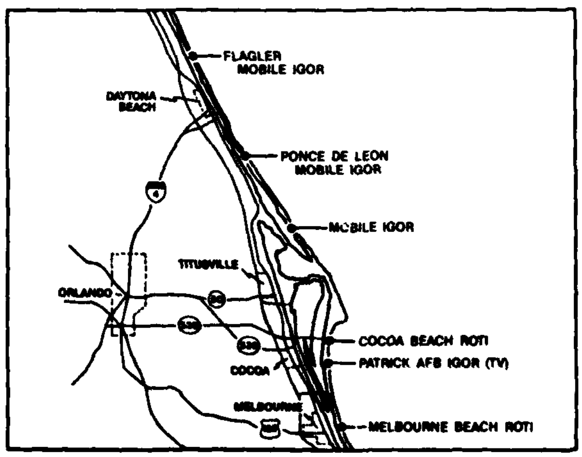


Fig. 4 ETR Tracking Telescopes

A unique feature at the ETR is the ability to compute a multistation optical solution for realtime metric data solutions from an off-the-pad condition using metric optic instruments.

## Contraves

The Contraves Model 151 has a 7.5-inch aperture and a 60/120 inch focal length. It uses a 6800 Intelligent Data System microcomputer and a PDP 11/03 minicomputer in active roles to drive the optical instrument during the data acquisition interval. Modified to use the ESMC precise 2400 b/s acquisition data system, the Contraves computer system conveys time, elevation, and azimuth information in encoded form to the Contraves central computer. It uses data from at least two Contraves to generate both E,F,G and Ė,Ḟ,Ġ solutions plus time for input to the Range Safety system.

The Contraves Model 151 includes a TV camera, a wideband transmitter, a monitor, and a video recorder. When mounted instead of the film camera on the main objective lens, the TV camera allows the operator to view targets through the main objective lens. The wideband transmitter sends video signals from either the main objective TV or the DAGE wide-angle TV system to the remote control console. The TV monitor allows the operator to view video signals from the main objective TV, the DAGE wide-angle TV, or the video recorder. The video recorder records TV data from the main objective plus the time of day to 0.1 second.

The operator at the remote control console can select either the main objective TV or the DAGE wide-angle TV for display and recording. The remote control console also allows the operator to select a manual or a computer-driven mode of control.

ROTI (Recording Optical Tracking Instrument)

The ROTI is a large tracking telescope system that takes time-correlated, high-resolution, long-range photographs of objects in space. It uses a 100-inch focal length Newtonian optical system. Focal length increases are furnished by Biotar Relay lenses in increments of 100 inches to a maximum of 500 inches. The ROTI can obtain up to 500 seconds of coverage (35-mm camera at 32 frames/second).

The telescope is supported by a modified Navy Mk 30, 5-inch gun mount driven by a hydraulic system for azimuth and elevation changes. The angle servo system accepts azimuth and elevation designate data as computed by the data system. The operator's control panel has switches to control the electronics and hydraulics that comprise the angle servos. The panel also has potentiometers and switches that allow the operator to introduce offsetting signals in the servo system.

The ROTI operator can control the system in three modes: aided, computer drive, and computer drive with operator assist/override. The instrumentation can transmit and receive acquisition and present position information in a secure communications mode. The ROTI can also be positioned and focused from an external drive vector in the standard ETR 2400 b/s E,F,G data format.

The data computer and servo positioning systems drive the mount from an external vector so the target is kept within the field-of-view of the primary aperture.

The computer-derived slant range analog causes the focus servo to drive the focus wedges to a position inversely proportional to slant range. This action causes the telescope to be focused to "see" the target at a range equal to the computed slant range.

IGOR (Intercept Ground Optical Recorder)

The IGOR also takes time-correlated, high-resolution, long-range photographs of objects in space, but uses a modified Newtonian optical system, with a 90-inch focal length. Amplifiers (Barlow-type lenses) give added focal lengths of 180, 360, and 500 inches. Either the 70-mm Photosonics or the 35-mm Mitchell camera may be used.

The telescope, mounted on a modified Navy Mk 27 5-inch gun mount, is maneuvered by two operators. Each has a CRT that shows the error (azimuth or elevation) between the telescope aiming and radar target position data. An autofocus unit varies the focusing lens by a servo system. Servo input signals are derived from tracking radar information, corrected by parallax, and converted to slant range by coordinate converters. The coordinate converter takes X, Y, and Z data from a data receiver and converts it to azimuth and elevation voltages. The IGOR at Patrick AFB has an image orthicon TV system for long-range realtime and photo/optical coverage. The realtime television signal is transmitted over landlines to the launch complex blockhouse and the Range Control Center, and is available to Range Users.

Itek 48-Inch Telescope (Meteor II)

The SAMSO OL-AJ Itek telescope is equipped with an f/2.5 solid CerVit paraboloidal primary mirror. A 5-element Wynne-type corrector gives a 35-mm diameter, coma-free flat field at the f/2.5 prime focus. A set of reimaging lenses, supported on an additional spider, can be added in train with the prime focus to give an f/5.0, 35-mm format focal plane. A second attachable support spider holds a 40-mm silicon intensified tube (SIT) TV camera that permits a full field-of-view format at the f/2.5 focal plane. The limiting brightness equivalent value for this system, is 16th to 17th magnitude. Provisions are incorporated for narrow bandpass filters in the f/2.5 and f/5.0 systems.

A remotely controlled reflex mirror can be rotated into position to direct the optical axis through a periscope-relay lens system to a high-angle cube on top of the telescope. This action directs the optical axis back parallel to the primary mirror axis. The relay lens system is designed so that the incoming light is brought to focus at an equivalent f/10 plane.

Mounted on the telescope top surface is a table that can be positioned with a servo torque-motor-driven lead screw to various points along the f/10 optical axis. An attached digital encoder provides a readout of table position with a precision that ensures table positioning to a least-count smaller than the depth-of-focus tolerance of f/10. To maintain accurate focus during mission operation, the table is continuously positioned as a function of range-to-target by the computer.

The translating table carries a reimaging lens with provisions for varying the back conjugate distance to adjust from f/10 to f/15. A double, 5-position filter wheel contains both long-wave, sharp-cut spectral filters and a graded series of neutral density filters for contrast and exposure control.

Video imaging cameras mounted on this table can be standard or infrared vidicon cameras, S-25 photo surface image-orthicon cameras, or extended red S-20, 25-mm or 40-mm SIT cameras. The orthicon cameras and the 40-mm SIT cameras have various options of scan and field rates.

The telescope is carried on an elevation-over-azimuth mount equipped with torque motors and 21-bit shaft angle encoders. Both the main and the TV boresight telescope allow star calibration of mount characteristics. The mount can be driven to keep the telescope pointed at a moving space target to within 1 to 2 arcseconds.

In addition to the imagery, insertion can be made on each TV frame of the last digit of the year, day of year, time of day to 0.1 second, effective focal length, azimuth to 0.1 degree, elevation to 0.1 degree, range, and offset of the f/10 focal plane from infinity. The data is updated 10 times each second.

Ballistic Cameras

Ballistic camera applications include making geodetic survey satellite observations, recording reentry phenomena, and recording continuous flame traces, particularly to obtain points of burnout and ignition of multistage rockets.

The Wild BC-4 ballistic cameras are used on both land stations and the USNS Vandenberg. The camera has a two-axis mount for support and for preset orientation.

IFLOT (Intermediate Focal Length Tracker)

The IFLOT can be configured with appropriate camera lens systems to obtain documentary, engineering sequential attitude, and signature data coverage. Ten IFLOT systems are available as mobile trackers operating in the KSC/CCAFS areas, on board the USNS Redstone, and at Ascension Island. Another IFLOT is on board the USNS Vandenberg. Each IFLOT accommodates up to four camera-lens combinations.

The drive system has two enclosed oil-bath transmissions with preloaded tapered roller bearings. The system is mounted on two-wheeled trailers having precision jacks.

MOTS (Mobile Optical Tracking System)

The MOTS is a remote controlled system for use within the launch danger zones. The system has an infrared tracker for automatic track and a closed-circuit television system for remote track. Each system consists of a pedestal trailer and a remote tracking console. Two camera-lens combinations may be used. The MOTS may be used outside launch danger zones and can be operated at all KSC and most CCAFS optical sites.

### Ribbon-Frame Cameras

The standard, fixed, metric camera system at the ETR is the CZR. The CZR is operated in a fixed orientation to obtain maximum coverage over the desired portion of the trajectory. Triangulation is performed with the two- through four-camera combinations having the best geometry obtainable under field conditions.

The fixed metric camera system records early launch trajectory of missiles for the first thousand feet of missile flight from which position, velocity, and acceleration data can be reduced. Roll, pitch, and yaw data can also be obtained. CZR cameras are mounted on three-axis precision gimbal mounts in an air conditioned astrodome on a four-wheel trailer. An electronic driver unit performs sequencing and start functions, and supplies timing pulses for recording on the edge of the film in response to signals from a central timing source. The cameras may be started remotely from the complex blockhouse sequencer or may be started manually on the site.

### POPS (Precision Optical Pedestal System)

The POPS provides ARIS with reentry data for cold body image photographs, daylight cinespectrograph measurements, and high-speed radiometry measurements.

A modified Nike mount supports the optical sensors. It is suitable for supporting approximately 1,000 pounds of equipment and is capable of accurate designation/slaving to the shipboard tracking radars or computers.

The primary optical system is a high-resolution cinetelescope with a focal length of 180 inches and an f/10 aperture. Automatic exposure and focus controls operate in conjunction with a modified 70-mm Photosonics 10A camera. Pedestal slaving precision is estimated between 10 and 20 arcseconds. Dynamic angular performance has been demonstrated in elevation at 910 mrad/s, 1,200 mrad/s/s; azimuth at 910 mrad/s, 1,100 mrad/s/s. Cold body image photography at sea is possible with a resolution of 1.5 arcseconds.

High-resolution spectrographic measurements are made with a Barnes 18-138 Czerny-Turner cinespectrograph. The lens for this system has a focal length of 150 inches and an f/10 aperture. Spectral response is 0.39 to 0.62 micron. This instrument is capable of daylight cinespectroscopy.

The two short-focal-length Photosonics surveillance cameras operate at 100 frames/second. One camera covers the infrared spectrum of 0.5 to 0.9 micron. The second covers the visible spectrum from 0.4 to 0.7 micron. Knowledge of reentry object tumble, scintillation, and ablation is aided by analysis of the data taken.

### Engineering Sequential and Documentary Optics

The primary purpose of engineering photography is to obtain such test mission event-versus-time data as umbilical disconnect, hold-down release, engine ignition, liftoff, and booster separation. Engineering photography also produces inputs for film reports and record keeping.

Documentary photography is used primarily for historical documentation and public information. Unlike engineering sequential, documentary photography is not necessarily launch related nor time annotated. Its primary purpose is to record the events of transport, assembly, erection, checkout, and launch of missiles and space systems.

The Range uses both tracking mounts and telescopes for engineering photographic coverage. The IFLOT and the MOTS (Mobile Optical Tracking System) are the tracking mounts. Telescopes include the ROTI and the IGOR as well as the Itek 48-inch telescope operated by the SAMSO OL-AJ.

Numerous motion picture and still cameras are available for engineering sequential and documentary photography. Units include 16-mm, 35-mm, and 70-mm motion picture cameras and various types of still cameras. These cameras are used in conjunction with tracking mounts or telescopes, are in fixed positions, or are hand-held to fill a broad range of photographic requirements.

## IV. Telemetry

The ETR land telemetry facilities include the central telemetry station (Tel 4) located on Merritt Island, four essentially similar downrange stations, and a semiactive station at Pretoria, South Africa. The land-based facilities are augmented by both the USNS Redstone, which is specially equipped to serve as a support ship for US Navy underwater-launched missiles, and the USNS Vandenberg.

The central telemetry station at Merritt Island is capable of acquisition, storage, processing, preparation of computer-formatted magnetic tapes, tape copying, tape playback, and interfacing video retransmission. Five separate display areas are equipped with direct-write pen recorders, oscillograph recorders, and digital displays for the convenience of Range Users. Computer-ready magnetic tapes may be formatted in realtime or from recorded data tapes. Facilities exist to produce duplicate predetection or video magnetic tapes. Data handling system interconnection is accomplished by remotely controlled switches rather than through manual patch panels. In addition to switch closures, the Control, Status Display, and Patching System provides equipment status signals and remote operation of the station data recorders. The central telemetry station is undergoing an extensive modernization effort that will include automated rf system, data formatter, tape copy, data controller, data separation, discrimination, receiver, combiner, and rf remote patch subsystems. Three small (3 to 4 foot) nontracking antennas at Ascension receive in the 2.2- to 2.3-GHz range to cover reentry mission from low altitudes to splash down. A 6-foot directed antenna is installed at Jupiter Inlet. (These antennas are not listed in Table 4.)

The autotracking antennas from Grand Bahama Island to Ascension are equipped with a Xerox 530 computer capable of target acquisition and antenna management functions. The TAA-3A and TAA-24 at Tel 4 use an M6800/LSI-11 system for acquisition and management. Programmed improvements include the replacement of the land-based and USNS Redstone computer systems in the next 2 to 3 years.

All shipboard and land-based stations are equipped with multiple receive and record groups with data reception and recording at data rates up to 4 MHz. Additional recorders planned will record data at rates up to 4 MHz with tape speeds of 120 inches/second.

Decommutation equipment for pulse code modulation (PCM), pulse amplitude modulation (PAM), and pulse duration modulation (PDM) is installed at all stations. Frequency modulation (fm) discriminators, digital-to-analog and analog-to-digital converters, and formatters are available for processing this type of modulated signal for presentation on the analog and digital displays and for computer processing. Displays are conventional pen and oscillograph paper recorders, digital and meter readouts, and cathode-ray tube displays.

The Range is equipped with a realtime data selection and reformatting system that outputs selected words at a lower bit rate to accommodate communication channel bandwidth limitations. These are normally 2.4 kb/s on high frequency (hf) radio or satellite relay from Ascension Island, ships, and aircraft; 76.8 kb/s on the Antigua to CCAFS undersea cable; and two 700 kb/s circuits on the Grand Bahama Island to CCAFS cable. Programmed improvements will increase the Antigua data rate to two circuits at 160 kb/s.

Figure 5 and Table 4 identify the location and summarize the characteristics of the ETR telemetry systems.

Table 4 Telemetry System Characteristics

| | KSC (TEL IV) | | GBI | | PRE | ANT | | ASC | | USNS Redstone | USNS Vandenberg | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TAA-24 | TAA-3A | TAA-2 | TAA-3C | AT-36 | TAA-8A | TAA-3A | TAA-3 | TAA-3B | TAA-9(4) | TAA-6 | TAA-10 |
| Diameter (ft) | 24 | 33 | 85 | 33 | 60 | 80 | 33 | 30 | 33 | 17 | 30 | 17 |
| Frequency (band) | S | S-L-UHF | S-L-UHF | S | S | S | S-L-UHF | S | S | S | S | S |
| G/T (dB/K) | 18.7 | 14.2 | 24.5 | 17.5 | 18.0 | 29.5 | 14.5 | 18.3 | 19.6 | 12.5 | 17 | 13 |
| Encoders (bits) | 16 | 15 | 20 | 15 | — | 20 | — | 20 | 15 | 13 | 19 | 13 |
| Computers | PDP-11, LSI-11 | | Xerox 530 | | — | Xerox 530 | | Xerox 530 | | 316R* | AN/UYK-20 | |
| Receivers | | | | | | | | | | | | |
| Dual chan | 10 | | 7 | | — | 6 | | 8 | | 13 | 10 | |
| Single chan | 6 (DEI) | | 12 (SG) | | — | 12 (DEI) | | 18 (DEI) | | 14** | — | |
| Tracking | 5 | | 5 | | — | 5 | | 5 | | 17 | 8 | |
| Recorders (2/1.5 MHz) | 7/8 | | 2/4 | | — | 2/6 | | 2/6 | | 6 | 5 | |
| Decoms (5/.75 (Mb/s) | 3/7 | | 1/3 | | — | 1/3 | | 1/2 | | 1/2 | 2 | |

*Honeywell
**Microdyne

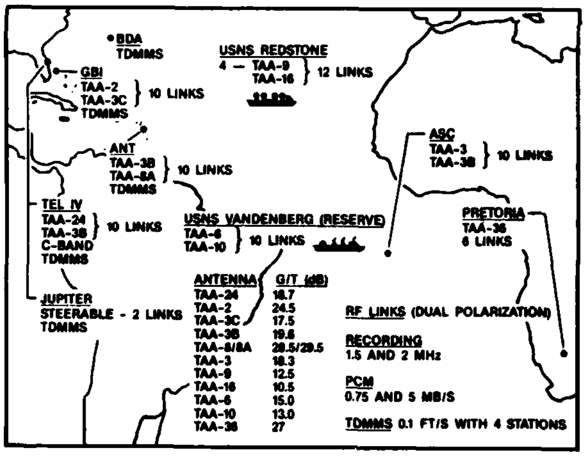


Fig. 5 ESMC Telemetry Capability

## V. Underwater Acoustic Systems

Impact location systems are underwater sound detection systems used to obtain the geographic position of reentry vehicles or other missileborne objects upon impact into the sea. Systems operated on or by the Range can be grouped in two basic types as a function of the technique used for data retrieval.

The first type is the Missile Impact Location System, which uses a cable to relay sound signals detected by the underwater hydrophones to a nearby land station where the signals are recorded. The system is based on: (1) the production of sound generated by the impact of an object on the surface of the water, or by the underwater explosion of a bomb carried by a missile component, and (2) the detection of the sound and the recording of its arrival time at a number of known hydrophone locations. The impact or bomb detonation point can be computed from the hydrophone positions, the velocity of propagation of sound in the ocean, and the arrival times of sounds at the hydrophones.

The second type is the Sonobuoy Missile Impact Location System, which retrieves its data over a radio link in realtime by attendant aircraft. This system consists of an ocean bottom acoustic transponder array plus an array of expendable surface hydrophones (sonobuoys) deployed for each test mission. Specially equipped aircraft sow the sonobuoys and receive and record impact data relayed from them. The transponder array in the impact area supplies the geodetic reference.

Another acoustic system, the Velocity and Position System, has been developed by the US Navy to measure the velocity of any submarine in the launch area during a missile launch. This system consists of an array of specially designed beacons anchored on the ocean floor, interleaved with an array of transponders.

The location and the significant characteristics of the underwater acoustic systems are shown in Table 5 and Figure 6.

Table 5 Underwater Acoustic Systems

| | Distance & Direction (nmi) | Depth | Diameter (nmi) | Impact Scoring Accuracy |
|---|---|---|---|---|
| Target Arrays | | | | |
| Antigua | 150 NE | 3 mi | 25 | 35 ft CSE; 6 ms LSE |
| Ascension | 22 WSW | 2 mi | 12 | 32 ft CSE; 5 ms LSE |
| SMILS (3 rings) | air dropped | surface duct | 14 | |
| | Distance Downrange (nmi) | | | Survey Accuracy (All DOTS rms in ft) |
| Bottom Arrays* | | | | |
| C9E | 1,700 | ocean floor | | 47 |
| C11A | 2,500 | ocean floor | | 28 |
| C12 | 3,000 | ocean floor | | 24 |
| C15W | 1,500 | ocean floor | | 27 |
| C15E | 1,550 | ocean floor | | 27 |
| C16A | 5,400 | ocean floor | | 30 |
| C19 | 4,200 | ocean floor | | 33 |

*10 transponders in pattern

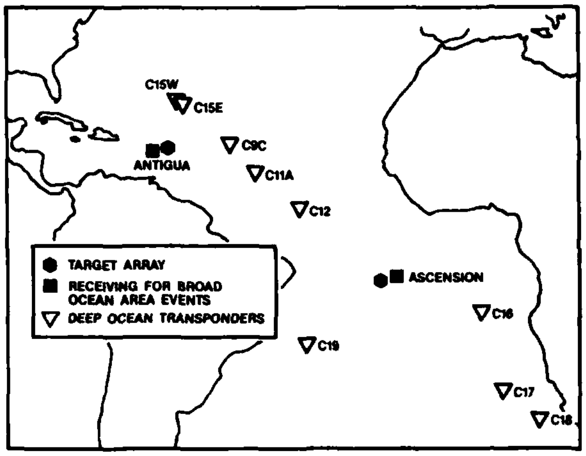


Fig. 6 ETR Underwater Acoustics

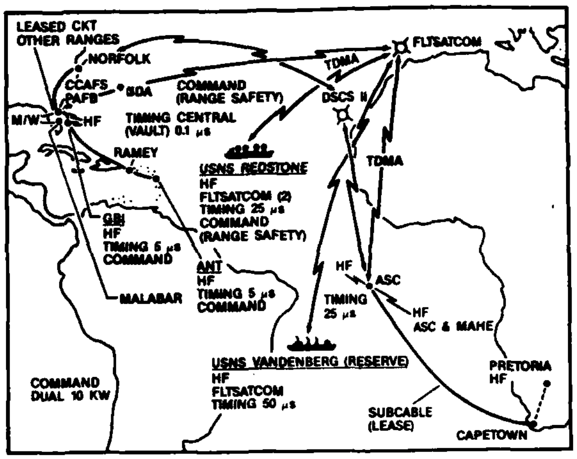


Fig. 7 ESMC Communications, Timing and Command

## VI. Communications

An extensive communication network connects the sites and stations of the Range with each other and with the outside world. To achieve the highest degree of flexibility and reliability, the network uses communications satellites, undersea cables, microwave links, hf radios, and various landline links.

Table 6 lists the mission support communication capabilities on the Range. Figure 7 gives a broad picture, station-by-station, of available communication capabilities. Since circuit alignment is reconfigured daily to meet mission support requirements, the illustration does not indicate the quantity of dedicated circuits support by these facilities. In addition, the Range receives mission support communications services from, or furnishes them to, other test agencies such as NASA at Bermuda and Wallops Island, the Navy's USNS Range Sentinel, the Satellite Control Facility at Mahe, and the 4950 Test Wing (ARIA). Due to the flexibility and capability of its communications network, the Range also offers nonmission communications services, on both a temporary and a continuing basis, to the US Army, US Navy, other Air Force and DOD agencies, other NASA offices, the State Department, and other Government agencies.

Interstation communications includes cables, high-frequency and ultra-high frequency radio, satellites, microwaves, data, teletype, and voice transmission.

Operations control of Range communications is exercised by communication control centers at each major station. These centers allocate, monitor, and maintain transmission quality on all on- and off-base circuits and technical operations nets for their station. Equipment and capabilities are limited to manual and semiautomatic operation.

Table 6 ESMC Communications Capability

| ETR Communications Systems | CCAFS | PAFB | MAL | JUP | GBI/ Cays | P.R. | ANT | ASC | PRE | Redstone | Vanden-berg (Reserve) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Comm Security (COMSEC) | X | X | X | X | X | | X | X | | X | X |
| Telephone Exchanges | X | X | | | X | | X | X | | X | X |
| Radio Sys: HF/VHF/UHF/ Mobile | X | X | X | | X | | X | X | X | X | X |
| Microwave | X | X | X | | X | | X | | | | |
| Closed Circuit TV | X | X | X | | X | | X | | | | |
| Satellite Ground Terminal | X | | | | | | | X | | X | X |
| Teletype System | X | X | X | X | X | X | X | X | X | X | X |
| Data Modems | X | X | X | X | X | | X | X | X | X | X |
| TDM's | X | X | X | X | X | X | X | X | | X | X |
| Submarine Cable System | X | | | | X | X | X | | | | |
| Technical Control | X | | | | X | X | X | X | X | X | X |
| Intercom/PA | X | X | X | X | X | X | X | X | X | X | X |
| Audio Recording | X | X | | | X | | X | X | X | | |
| Outside Cable Plant | X | X | X | X | X | X | X | X | X | | |
| Aeronautical Radio | | | | | | | | X | | | |
| Navigational Aids | [illegible] | X | | | X | | * | X | | | |
| Control Towers | X | X | | | X | | * | X | | | |
| Meteorological Systems | X | X | | | X | | X | X | | | |

*Operated by locals

CCAFS is the communications focal point for all Range circuits, Range User nets, and commercial carrier interconnections to all Government agencies. Antigua is the nodal point for the Caribbean area. Ascension is the net control station for ship and aircraft operation in the Atlantic, Africa, and Indian Ocean areas. Antigua and Ascension have complete manual and semiautomatic Range communication control center capabilities.

Closed-circuit television on the Range, managed through ETR communication systems, is generally limited to Patrick AFB and CCAFS except for boresight TV cameras on precision radars and optical instrumentation. CCTV systems are used for management and test operations support. TV systems for test operations support include cameras for launch pad area coverage, spin test facilities, and display information distribution.

## VII. Command, Control, and Range Safety

The Range command and control system consists of a network of radio transmitters at CCAFS, Grand Bahama, and Antigua, and on board the USNS Redstone (plus one mobile van system). These sites, linked to the CCAFS Range Safety Display System (RSDS), are used by Range Safety Officers to transmit arm-and-destruct commands to missiles and spacecraft. Range User applications include the transmission of such commands as command safe, engine cutoff, and retrofire, as well as the transmission of tones for vehicle control.

When additional coverage is needed for northerly launch azimuths, Range Safety uses the NASA Bermuda and Wallops Island stations. The Bermuda station is a prime support station for NASA manned launches, but is considered as backup support for DOD launches.

The command destruct system on the USNS Redstone primarily supports the USN fleet ballistic missile programs in conjunction with the LASS.

NASA's Bermuda station, the USNS Redstone, and all but one of the other transmitter sites have high-power 10-kW transmitters. The exception is Wallops Island, which is limited to 600 watts. The CCAFS site can also transmit low-power 1-kW signals for the launch area.

A summary of the ETR command capability is given in Table 7. Commands initiated by the Range Safety Officer (RSO) are routed through the command remoting system to the remote command transmitting sites at CCAFS, Grand Bahama, Antigua, USNS Redstone, Wallops Island, and Bermuda. Commands are simultaneously transmitted to the vehicle and recorded on strip chart recorders. The commands are relayed back to the RSO to verify the transmitted command. Signal strength received by the vehicle is reported by telemetry.

Table 7 ESMC Command Capability

| Capability | Cape A | Cape B | GBI | ANT | Trans-Portable | USNS Redstone |
|---|---|---|---|---|---|---|
| 10 kW Transmission | Dual | — | Dual | Dual | Single | Dual |
| 800 W Transmission | — | Single | — | — | — | — |
| Steerable Directional Antenna | 2 | — | 2 | 2 | — | 1 |
| Fixed Directional Antenna | — | — | — | — | 1 | 2 |
| Omnidirectional Antenna | 1 | 1 | — | — | — | — |
| Standard Range Safety Tone Sequence | X | X | X | X | X | — |
| Variable Format Tone Sequence | X | X | X | X | X | X |
| Digital Secure Coded Message | X | — | X | X | X | — |
| Monitor and Recording | X | X | X | X | — | — |
| Centrally Controlled and Status Reporting | X | X | X | X | X | X |
| Local Station Controlled | — | — | X | X | — | X |
| Multitarget Command | X | X | X | X | — | X |

The USNS Redstone command destruct system is designed to terminate the flight of up to four errant sea-launched missiles. Arm-and-destruct command functions are frequency modulated onto a 10-kW rf carrier and transmitted at the request of the LASS Flight Safety Officer, the RSO at CCAFS, or the DRSS RSO on the USNS Redstone.

Programmed improvements in the command area include a new Range Safety Display System at CCAFS, new transmitters/exciters, modulation subsystems, automatic checkout subsystems, monitor receivers, and a digital command terminal at Bermuda. New Range safety sea surveillance radar, surveillance control display, and display generators are also planned.

## VIII. Range Count Control

Range Count Control at CCAFS provides:

1. Off-on sequential control of vehicle and instrument functions on a universal time coordinated (UTC) base.
2. Hold-fire controls for Range Safety and Range User instrumention control
3. Direct reading display of countdown time
4. Dissemination of liftoff time

The system includes a countdown generator in the RCC, which may be used before the vehicle countdown starts; a sequencer in the blockhouse, which automatically controls operations during countdown and firing; a realtime programmer in the RCC for programming events according to UTC; countdown indicators throughout CCAFS to show progress of the count; and a distribution system of three nets. Switching blockhouse and RCC equipment into these nets is controlled from an RCC console.

## IX. Range Timing System

Timing at CCAFS is accomplished with three cesium-beam frequency standards operating 24 hours a day. Three independent time and frequency outputs are produced for Range Users. The time signal generators are synchronized to UTC with the aid of the East Coast Loran-C Chain, operated by the US Coast Guard, and closely synchronized to the US Naval Observatory and radio station WWV operated by the National Bureau of Standards.

The time signal generators in the RCC produce 24 different time codes (presence-absence, pulse width, and pulse position), with frame rates ranging from 1 frame/hour to 10 frames/second and element rates ranging from 1 pulse/minute to 1,000 pulses/second.

A Time-Division Multiplexed Timing Distribution System (TDMTDS) operates at CCAFS. At Central Timing, an encoder time-multiplexes early signals from the generators and distributes the composite signal by wideband cables or uhf radio. Propagation delay is compensated for in the receiving system.

All downrange stations contain dual time-signal generators and a signal comparator. The signal generators at Grand Bahama and Antigua Central Timing are identical to those at CCAFS. The signal generators are synchronized to the DOD master clock via WWV and Loran-C with periodic verification by portable cesium clocks.

A timing terminal unit consists of a power supply chassis that accepts modular subassemblies. The outputs of the timing terminal units are used for data clocking, neon light timing for metric camera operation, and timing records on magnetic tape and oscillograph charts. Timing signal accuracy deteriorates from transmission delays, the delay of the timing terminal unit, and the response time of the customer instruments. When correlation accuracy better than 1 millisecond is needed, these delays can be measured and incorporated in the data reduction process.

Subcentral timing systems at satellite instrumentation sites on the Florida mainland accept and detect a signal from the central timing system; generate pulse rates, coded timing signals, and position identifiers; and transmit standard signals to instrumentation equipment and timing terminal units. The transmission delays are periodically measured and compensated for so that the subcentral sites are within 5 microseconds of synchronization with the central timing system.

Improvements programmed for the timing system include additional cesium standards, new GPS receivers, uhf timing systems, and most parts of synchronization, distribution, and display systems.

## X. Designate/Tracking Data Handling

The Range is capable of collecting, processing, and distributing information for radar, optics, command, and telemetry systems. This data contains correlated time, identifier, and status information.

Typically, data extracted from the radar at a rate of 160 and 100 samples/second is simultaneously recorded with correlated timing and processed by an on-site digital computer. In processing, correction factors remove systematic errors to produce highly accurate data. Earth-centered coordinates (E,F,G) and their rates $(\dot{E},\dot{F},\dot{G})$ are generated from the range, azimuth, and elevation angles and added to each sample. The composite samples are formatted as required and readied for transmission at 10 samples/second. Data from tracking telemetry systems may be added.

Realtime data has three primary uses. First, it forms the basis for computing the predicted impact point and for plotting present position displays. Second, it is used as designate messages to enable other instruments to find and track the same target. Third, it is transmitted in several formats to such Range User facilities as blockhouse and hangar displays.

When requested, realtime metric data is formatted, scaled, and transmitted, during both manned and unmanned space operations, to off-Range facilities such as Goddard Space Flight Center, Johnson Space Center, and Jet Propulsion Laboratory.

The Range network supplies realtime distribution of data from any source to any or all other locations, both on and off the Range. KG-13 type cryptographic equipment protects the confidentiality of all data. Figure 8 shows a typical ESMC Designate/Tracking Data System configuration.

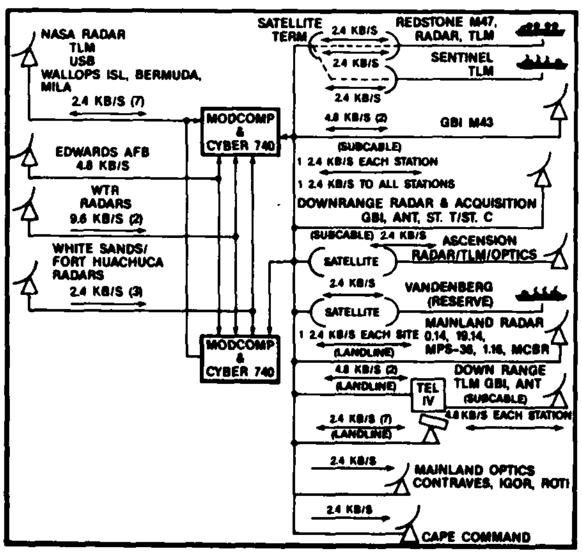


Fig. 8 Designate/Tracking Data Systems

## XI. Acquisition and Processing Control

The data acquisition, processing, and control of data and the support of mission requirements demand an extensive computer network. Figure 9 indicates the current computer capacity on the ETR. As mentioned previously in this paper, many of these computers will be replaced with more modern versions with additional capacity and greater reliability. For example, SEL Model 32/27 computers have been procured to replace all the Xerox Sigma 5 and 530 computers.

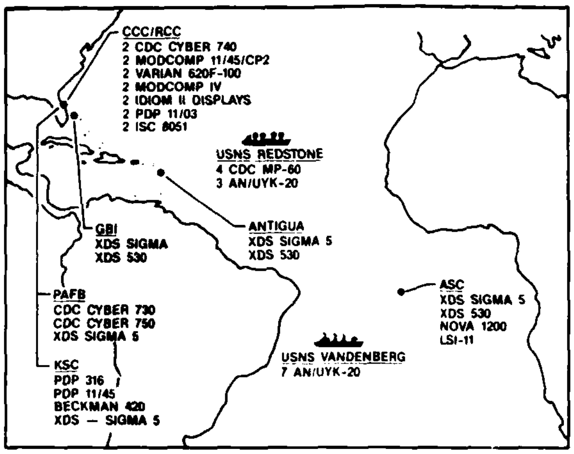


Fig 9. Acquisition, Procssing, and Control

## XII. Lorac

Lorac (LOng Range ACcuracy) is a radio-positioning system operating in the 1.7—2.5 MHz portion of the radio spectrum. Lorac produces position information for ships and submarines engaged in launch, tracking, and recovery operations. It also provides a standard of comparison for calibration of a ship's inertial navigation systems and associated equipment. The two Lorac networks on the Range cover CCAFS to Eleuthera.

A Lorac network consists of three base stations and one reference station. The three base stations are arranged in a triad (one center and two end stations) to supply coverage in the area of interest.

The three base stations operate in the continuous wave mode to generate two families of hyperbolas for position information. The reference station operates in the amplitude-modulated mode to transmit the reference signal against which the phase measurements are made.

Each Lorac station has automatic failover from the primary to the secondary transmitter. The reference station uses remote control equipment to activate the network stations. Backup power is also available at each site.

The ESMC Lorac system configuration and accuracy is given in Figure 10 on the next page.

## XIII. Meteorology

An integrated meteorological system is used to obtain surface and upper-air weather data at several points along the Range. The GOES (east and west) satellite data received from Miami via telephone lines in near-realtime is used to prepare forecasts.

### AN/FPS-77 Storm Detection Meteorological Radar Set

The AN/FPS-77 radar system at CCAFS displays the horizontal and vertical cross sections and intensity measurements of precipitation areas with a 120-nmi radius. Antenna controls permit

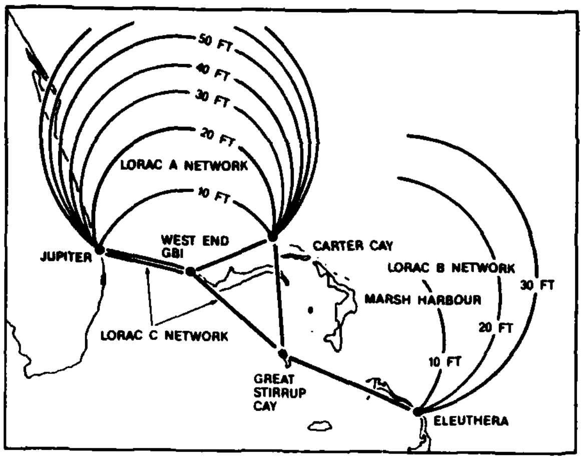


Fig. 10 Lorac

continuous scan, manual positioning, and elevation sector scan. A scan-converted monitor scope is available for video distribution of sweep data. In 1984, programmed improvements will replace the AN/FPS-77 with a new meteorological radar system.

Launch Pad Lightning Warning System

The Launch Pad Lightning Warning System gives the duty forecaster at the Cape Canaveral Forecast Facility (CCFF) the capability of detecting and monitoring lightning activity over the CCAFS/KSC complex. The system consists of 34 electrostatic field sensors, the Cyber 740 computer system for data acquisition and analysis, and a Tektronix terminal to output contours of the field mill network. Twenty-four of the 34 field mills can be output to strip chart recorders; all 34 are analyzed and contoured by the computer. This data gives the forecaster information on trends in the electric field potential and on the location of highly charged clouds and charge centers associated with lightning discharges.

Lightning Location Positioning (LLP)

The LLP is a lighting ground stroke location system. It consists of three remote direction-finding antenna sites and a position analyzer at CCAFS. The antenna configuration covers the KSC and CCAFS launch and industrial areas as well as a considerable area beyond. The stroke data is displayed at the CCFF as an aid in the decisionmaking processes that protect ETR resources and personnel.

Weather Information Network Display System (WINDS)

The WINDS consists of 16 stationary towers located throughout the CCAFS/KSC complex that are from 54 to 500 feet high with wind, temperature, and dewpoint sensors attached to the towers at various heights. The data is transmitted to a central computer that receives and processes the sensor measurements and displays data on a 30-, 15-, or 5-minute readout rate.

Meteorological Sounding System (MSS)

The MSS is a radio direction finder used for automatic tracking of a balloon- or rocket-borne instrumentation package. Instrument slant range, altitude, and elevation and azimuth angles versus time are recorded on punched tape and magnetic tape. Temperature and humidity versus time are displayed on a CRT and printed as a hard copy at a 10-second rate with the instrument position data.

Table 8 locates the ETR weather systems by station.

Table 8 Weather Systems

| | STATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Service | CCAFS | KSC | PAFB | GBI | ANT | ASC | USNS Redstone | USNS Vandenberg |
| MET Balloon Observations | X | — | — | — | X | X | X | X |
| Surface Observations | X | X | X | X | — | X | X | X |
| Rocketsonde | X | — | — | — | X | X | — | — |
| Automatic Weather Station | — | — | — | X | X | X | — | — |
| Test Support | X | X | X | — | X | X | X | X |
| MET Sounding System | 2 | — | — | — | — | X | — | — |
| OMEGA | — | — | — | — | — | — | X | X |
| GMD-4 | — | — | — | — | X | X | — | — |
| WINDS | X | — | — | — | — | — | — | — |
| LPLWS | X | — | — | — | — | — | — | — |

## XIV. Summary

The ESMC is an ever-changing national test and evaluation center. As programs and projects are received, a constant effort is expended to ensure each Range User can obtain the data and data accuracy required.

Two projects of major significance recently initiated by the Air Force are worthy of note. As a result of a Range utilization study, a new station is being implemented at Florida's Jonathan Dickinson State Park. This station will be our first integrated Range instrumentation facility containing radar, telemetry, command and control, precision timing, and communication as a single manager-controlled operation.

In the second project, RCC modernization will provide a consolidated command control, centralizing the Range Safety, data display, status control and Range control functions.

As we move into our planning for future program implementations, our major thrust over the next 3 years will be to make the ESMC ready to support the Trident D-5 program.

By continually planning for the future, by taking advantage of advancements in technologies, and by making additional capital investments in technical equipment, the ESMC can be expected to remain a high technology test and evaluation center for the US Air Force and its many Range Users.

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