Twenty-First Century Telemetry

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ABSTRACT

This paper addresses several areas of Telemetry instrumentation for the future. The possible 21st Century data formats and using the means made possible by technological advances to receive, record, and process telemetry data will be discussed.

We will review the past, present and future systems and the changes to expect in the areas of Higher Data Rates, Greater RF Bandwidths, Multiple Object Test Scenarios, Telemetry Multiplex, Digital Microwave Radio Links, Lightwave Fiber Systems, Optical Disc Telemetry Data Recording, Data Security, and Global Telemetry via Satellite.

INTRODUCTION

Telemetry Past

- Trackers -- Twoscore and five years ago Telemetry tracking was accomplished by a helix antenna. The helix antenna systems were improved by creating bifilar helixes which were pointed manually. To “Track” a missile the operator used a signal strength meter indication to peak up on the signal.

One of the first motorized antennas was a four helix array called a “Radi-Quad” which used a converted searchlight mount as the antenna pedestal and the operator used a joy stick to point the antenna. A signal strength meter indication served as a tracking aid. The next step was to a large, high gain antenna that needed a pedestal to move a large dish - typically a 15 foot parabola. These antennas could be “slaved” to an optical tracker. The operator used binoculars to see and track the object. The antenna pedestal could also be slaved to a coordinate converter system that provided pointing data from the range radars. One of the first automatic tracking antennas for telemetry was made by modifying a T-9 Radar System. A specially designed antenna for telemetry was a conical scan feed system called a TELTRAC. The TELTRAC S-band RF output was down-converted to P-band.

Receiving, Relaying, and Recording

The Telemetry data bandwidths were very narrow. The modular receivers had plug-in IF filters of 10KHz to 500KHz. The highest telemetry subcarrier was 70KHz and the most used digital Telemetry formats were PAM and PDM. Relay links operating at 600 MHZ were established in order to provide launch to impact coverage of long-range missile tests. Launch are in Utah and Ft. Wingate, New Mexico for the Athena and Pershing programs required that launch to impact telemetry data be processed in “Real-time at White Sands Missile Range (WSMR). During the Hound Dog program of the early 1960’s, White Sands Missile Range used a 600 MHZ microwave relay link to relay the telemetry from Del Rio, Texas into WSMR. Tape recording was accomplished by Ampex Model 309 and Model 500 magnetic tape recorder. Oscillograph recordings were made on photographic paper or film.

TELEMETRY PRESENT

Telemetry acquisition on WSMR is accomplished by the use of two 24 foot Telemetry Acquisition System (TAS) located at Jig-10 and Jig-67 and a later model Telemetry Acquisition System (TAS II) located at Jig-56. These three systems are used to support the Space Transportation System (Space Shuttle) missions. Telemetry and television data is transmitted via SATCOM II to the Goddard Space Flight Center in Greenbelt, Maryland and to the Johnson Space Control Center in Houston, Texas. There are seven transportable Telemetry Acquisition Systems that are deployed throughout the range and off-range for mission support.

The Telemetry data received by these systems is relayed to Jig-56 where it is demultiplexed and tape recorded. The Telemetry signals are then relayed to the Telemetry Data Center on the Telemetry Acquistion and Relay System (TARS) Microwave and the lightwave systems. (Figure 1).

The Telemetry Receiving Systems

The microprocessor controlled Telemetry Receivers are configured to operate in a polarization diversity mode. Both RF polarizations are connected to an optimal ratio diversity combiner to provide a combined video composite signal, a combined Pre-detection record carrier signal and a combined 10 MHZ IF signal. The IF signal is used as the input to the analog microwave radio. (Figure 2).

Recording and Relaying

PCM data from the receivers is conditioned by a PCM Bit Synchronizer. The bit Synchronizer output is distributed through an isolation amplifier to the magnetic tape recorder, to the intelligent multiplexer for relaying over the Digital Microwave Radio or for using the Lightwave fiber system. Typical mission data rates that are presently supported are 1.8 mega-bits per second, and 3.2 mega-bits per second. The highest rate is 9.86 mega-bits per second.

Data and Link validation is accomplished using the Automatic System Calibration (ASC) to simulate each missions Telemetry carrier frequency and deviation using a Psuedo Random Bit Stream (PRBS) at the mission bit rate to perform a Bit Error Rate Test (BERT).

TWENTY-FIRST CENTURY TELEMETRY

The Telemetry acquisition systems of the future must be capable of tracking several objects at the same time. They must be able to provide precision position information and be able to operate remotely and unattended. Multiple beam acquisition systems, such as the existing Multiple Object Tracking Radar (MOTR), can be the models for futuristic telemetry beam tracking systems. A network of four such systems could support the most complex test scenarios involving multiple missiles, aircraft and warheads. Use of broad beam antenna arrays can also provide excellent coverage of multiple object tests.

The existing telemetry receiving systems can provide good service well into the future by making use of a centralized demodulation and recording facility. The diversity antenna RF outputs from remote unattended sites can be “block converted” (such as cable TV) and carried over an analog lightwave fiber to the central demodulation facility. This central facility can record clear and encrypted data in their secure form. This data can be routed to the Telemetry Data Center over the lightwave fiber for further demultiplexing, decryption and reduction. Analog fiber drivers on the market today are capable of carrying data bandwidths up to 12 giga hertz. Future technology will easily achieve tera hertz data bandwidths.

Future telemetry data formats will require data rates of 100 to 200 mega bits per second. These rates are necessary because of increased resolution requirements and the need for data security. PCM encryption rates for a typical infra-red imagery system can easily approach 200 mega-bits per second. Digital data rates of 12 giga-bits per second are possible with equipment that is on the market now.

Recording

Optical discs are available now for many high density and high rate digital recording needs. Future telemetry data will be recorded on optical discs.

Analog to Digital/Digital to Analog Conversion

Many signals are in analog form and need to be digitized in order to relay them over a digital microwave or lightwave system. Television signals and FM/FM composites that have been digitized can be processed in digital form or converted to analog signals for display on monitors or chart recorders.

Muldems

Multiplexers and demultiplexers are commonly used to increase the data capacity of digital microwave and lightwave systems. Higher order multiplexers with capacities of up to 550 mega bits per second can be used on existing fibers. Multiple input fiber transmitters can also be used to increase the data capacity of the lightwave systems.

Analog Drivers

Analog drivers are needed to carry wideband video and telemetry data on the existing fibers. Analog drivers with tera hertz bandwidth capability can be used to carry telemetry RF outputs from remote antennas to a central processing facility - Block conversion (such as cable television) can be used to carry several telemetry signals on one fiber.

Data Automation and Security

All designs for future telemetry instrumentation systems must make extensive use of automated control. All systems must be identical to simplify software requirements. All sites must be linked via a duplex microwave or lightwave system.

Impenetrable fibers are ideal for relaying classified analog and digital telemetry data. Encrypted PCM Signal handling is simplified because the data remains encrypted until it is ready to be demultiplexed.

Global Telemetry

An earth station is presently being used to relay telemetry and TV signals to Goddard Space Flight Center and to the Johnson Space Center to support space shuttle missions. A permanent Earth Station can also provide intra-range telemetry data exchange with other National Ranges.

CONCLUSION

Replacement of obsolete equipment with state-of-the-art Telemetry equipment is made possible by technological advances in Microstrip Antenna Arrays, Analog and Digital Fiber Drivers, Multiplexers, and Optical Recording Discs.

Applying these technical innovations to future telemetry instrumentation systems will result in: greater reliability, redundant capabilities, greater data storage capacity, and most important; cost effectiveness, because of reduced manpower requirements. Fewer systems can collect more data in better ways than the methods now being used.

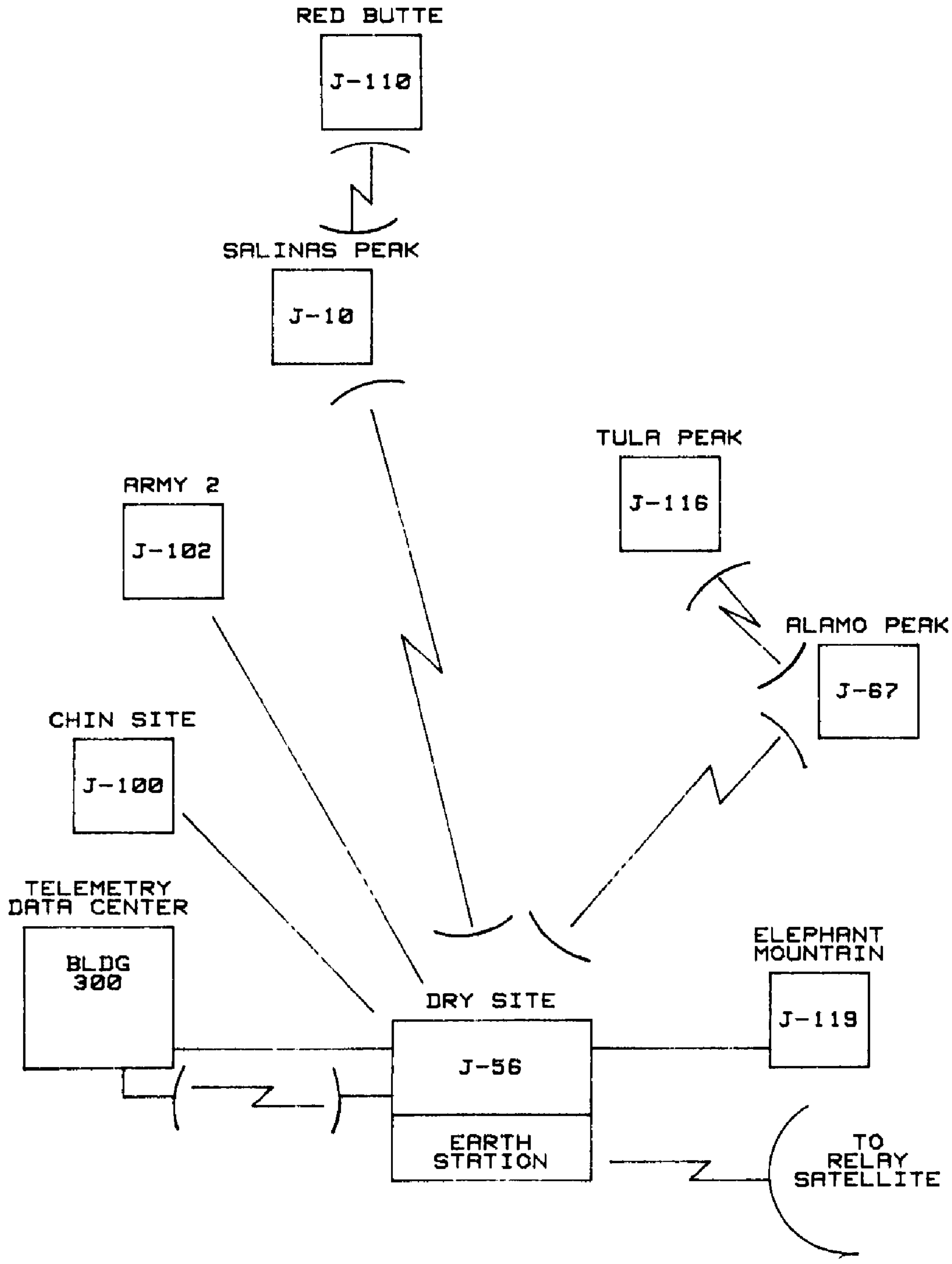
RED BUTTE
J-110
SALINAS PEAK
J-10
TULA PEAK
J-116
ARMY 2
J-102
ALAMO PEAK
J-67
CHIN SITE
J-100
TELEMETRY
DATA CENTER
BLDG
300
ELEPHANT
MOUNTAIN
J-119
DRY SITE
J-56
EARTH
STATION
TO
RELAY
SATELLITE

Figure 1

TELEMETRY RECEIVER/COMBINER

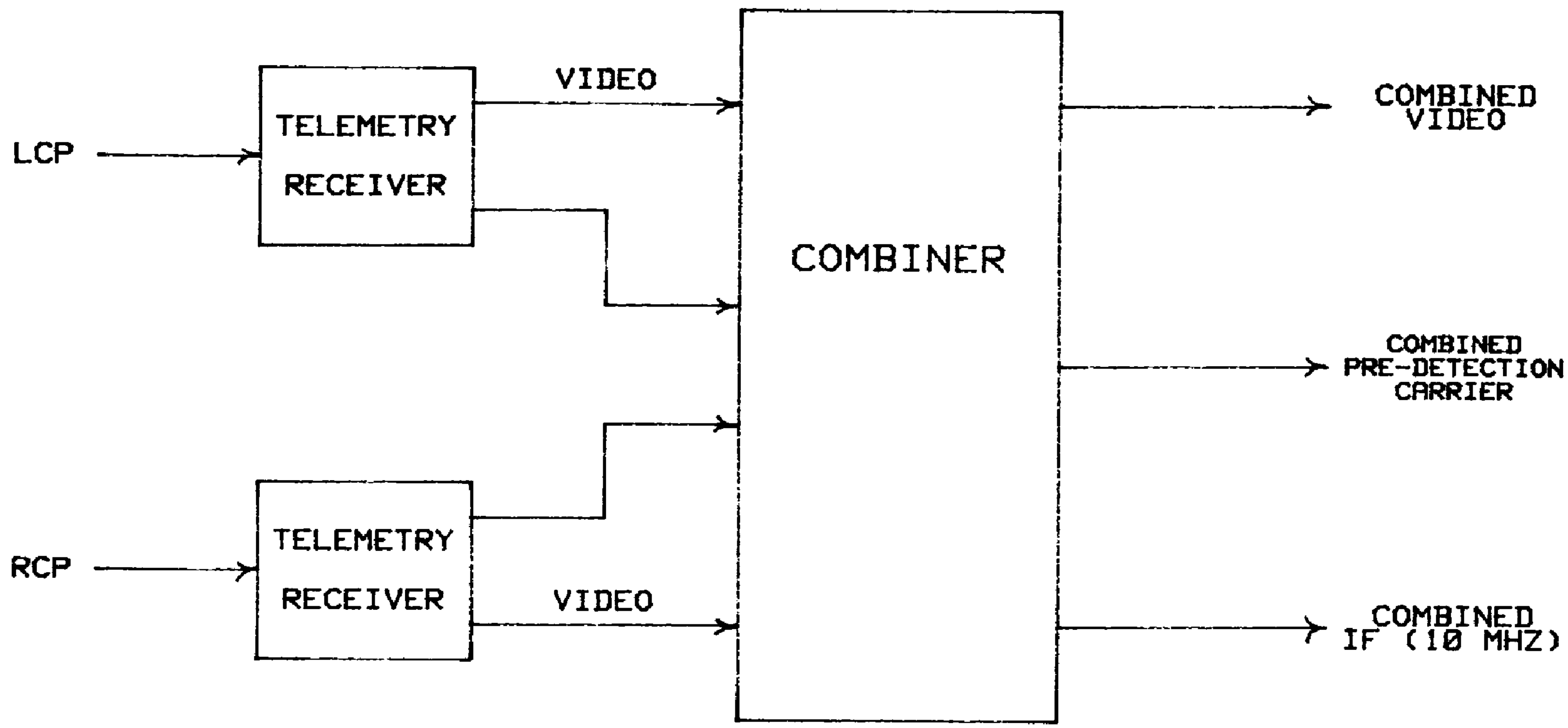

FIGURE 2