REMOTE CONTROL OF TWO AXIS AUTO-TRACKING TELEMETRY ANTENNAS

Tom Cronauer
Air Force Flight Test Center
Range Division

Brian Eslinger
TYBRIN Corporation

ABSTRACT

Due to Cost and Safety considerations the Range Division of the 412th Test Wing is upgrading remote telemetry (TM) antenna sites to be operated and monitored remotely. This is possible, in part, due to the installation of fiber optic cable, and the use of ATM communications protocol. Both of these applications significantly reduce signal latency from the remote control station located at Ridley Mission Control Center (RMCC) and the Antenna site. This paper discusses the challenges associated with controlling these sophisticated systems remotely. We will also describe the decisions and how they were made, the concerns over system performance, and the impact to other systems. This paper also addresses the technologies chosen to support the requirements and overcome the challenges. The benefits of remote range sensors are also discussed. We will provide top-level block diagrams of the system architecture.

KEY WORDS

Auto-Tracking, Antenna Control Unit (ACU), Positioner, Fiber Optics, Asynchronous Transfer Mode (ATM), Communications

INTRODUCTION

The 412th Test Wing, Range Division at Edwards AFB is currently upgrading the telemetry tracking capability at three of its remote sites. The upgraded capability involves upgrading the antenna, positioner and remote controlling the tracking operations to the Ridley Mission Control Center (RMCC) located at Edwards Air Force Base Base. The three sites are: Leuhman Ridge, 16 statute miles from main base; Shadow Mountain tracking facility, 31 statute miles; and a mobile system that will be located as needed at the Goldstone Deep Space Tracking Network (Ft. Irwin) property approx. 65 statute miles away. The concept of remote control is not new nor is it difficult. Most commercial off the shelf (COTS) telemetry tracking equipment available today has software routines available to allow remote control. The difficulty with antenna tracking systems is the real-time need to (re)acquire targets and the inherent latency with command and response of the antenna positioner. The latency over the physical communication media (copper, fiber, or microwave) is negligible. Delays have historically been encountered in the transmission and reception equipment linking the tracking facility with the remote facility or the fact that only low speed transmission resources were available.

REMOTE CONTROL REQUIREMENTS

Three areas must be considered when remoting a telemetry tracking facility:

- Front-end set-up and pre-mission test
- Operations
- Data Retrieval

Each of these three functions demands their own set of requirements. Front-end set-up and pre-mission tests are typically performed on a boresight tower that is not moving and is completed with little or no time constraint. The same is true of closed loop system and direct injection tests. Solar calibrations are also performed with no time constraints, however high latency due to manual positioning inputs could make these calibrations more time consuming and frustrating. But again, Solar Calibrations are performed without any strict time requirement and can be performed at almost any time.

There is also a requirement to interact with a many different and individual pieces of equipment need for specific mission support. The telemetry support equipment is usually set-up 1-2 hours prior to the actual mission. This equipment includes but is not limited to:

- Positioners
- Bit Synchronizes
- Receivers
- Combiners
- Test Pattern Generators
- Link Analyzer
- Boresight Transmitters
- Power control units

The software and more importantly the time required sending commands could greatly exceed the maximum allotted latency.

Real-time operations of the antenna positioner are highly interactive and require low delays, on the order of 50 milliseconds (msec). When an operator moves the joystick or the thumb-wheels the positioner must move with no perceived delay.

Another consideration is the coherency of the tracking aid data (tracker video and error signal) that the operator is using to acquire a signal. The feedback from the remote antenna system most also be minimized to ensure the target is where the operator perceives it to be. While the operator is acquiring the target signal they will switch between tracking aids. Therefore, the error data and the video must be synchronized. In this system design the real-time equipment being controlled is only the antenna control unit (ACU). Also, the end equipment in place has been minimized to reduce cumulative latency. The communication protocol used for this interface will play a large role in the total delay experienced in the remote command function.

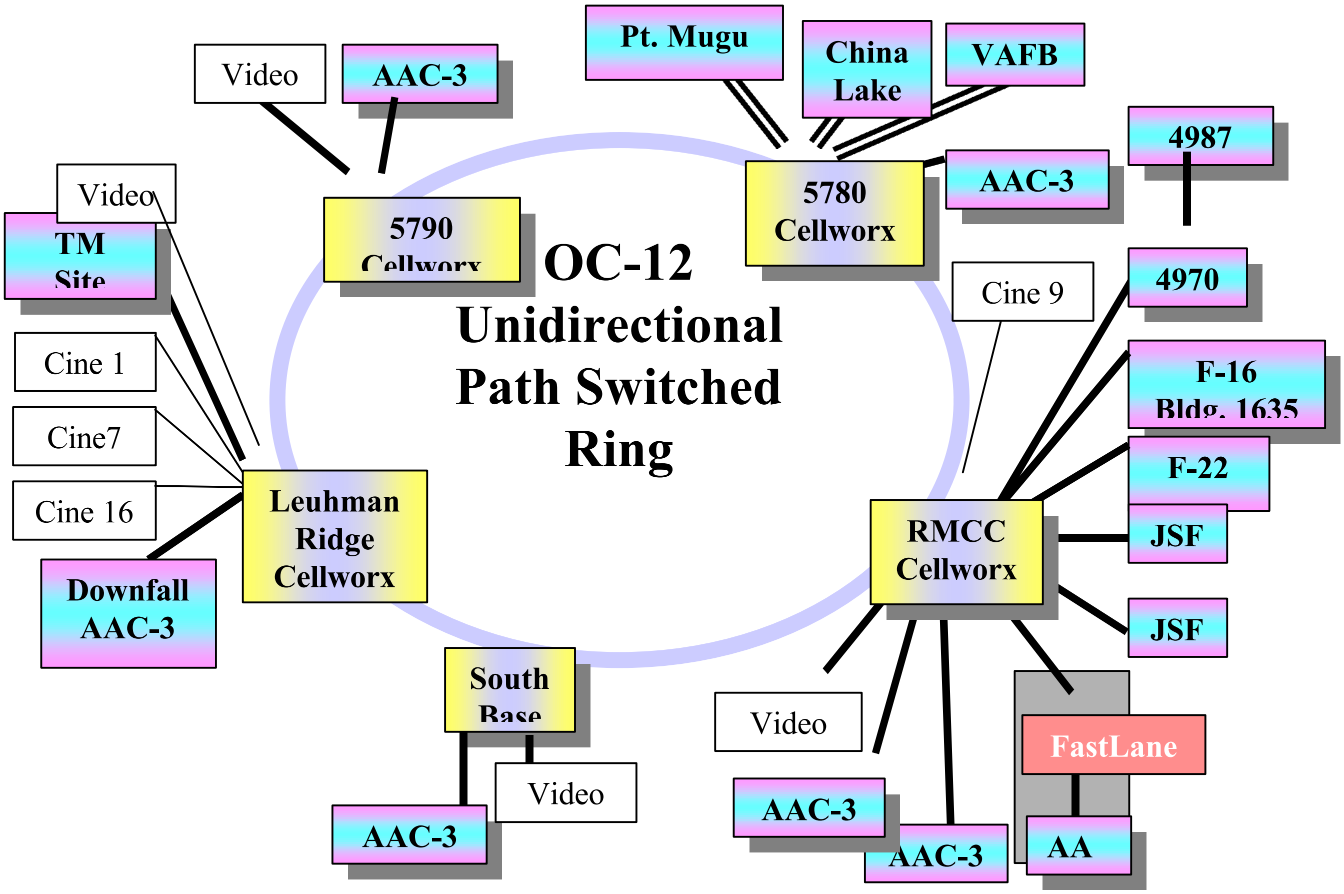
Providing error free data is the mission of the telemetry tracking facility. The information from the target must be linked to the mission control facilities in real-time, providing low latency and high reliability. The telemetry data stream is typically a PCM serial data stream that is isochronous to the communications system. Reliable data is possible with delays of a few to a few dozen milliseconds, depending on the data rate.

COMMUNICATIONS

To satisfy the above requirements we will be using the Asynchronous Transfer Mode (ATM) communications protocol and associated end equipment.

The AFFTC Range Division is upgrading its data communications systems (Figure 1). The upgrade incorporates an ATM/Synchronous Optical Network (SONET) hybrid backbone system running at OC-12c, 622 Mb/s. This provides connectivity between the tracking and mission control facilities as well as the main range communication hubs at Edwards. The ATM edge switches, that is the switches deployed in user facilities, support various communications rates and protocols. The edge switch converts the user data into ATM cells for transport and reassembles the data at the output end in the same format.

The use of ATM and SONET provides very efficient high speed/low latency communications. The ATM cells give us the ability to prioritize and therefore ensure the immediate transfer of data with minimum delay. In the ATM network, most of the delay is in the Segmentation and Reassembly (SAR) process of the transport. Therefore, larger Ethernet packets will take longer to ingress and egress the network. The delay experienced in this type of connection is expected to be between 4 and 20 msec roundtrip. As a design consideration of the remote control software, all Ethernet messages should be kept as small as possible. The second set of circuits required for remote controls are the hand



Edwards AFB ATM/SONET Communications Ring
FIGURE 1

wheel and joystick inputs into the remote site antenna positioner. These circuits will have input from the antenna controller as analog signals, then into an analog to digital converter for minimum rates of 56 kilobits per second (kb/s). The delay of a 56 kb/s serial data stream will be between 10 and 20 msec across the network. These delays are expected to be tolerable to the antenna system operator.

FRONT-END SET-UP AND PRE-MISSION TEST

The Prototype remote control telemetry site the Range is upgrading is the system located on the peak of Leuhman Ridge. The system is composed of a 14-foot dual axis auto-tracking antenna with dual opposed drives. We use 5 receiver sets with dedicated bit synchronizers for each set. A Signal simulator and Link analyzer will also be used for pre-mission checks and antenna calibrations.

The Receivers, Bit Syncs and test/calibration equipment will all be controlled/monitored-using IEEE-488 communications using the local control PC. The Antenna Control Unit, Bore sight camera and power controllers will be controlled using RS-232. The ATM Concentrator does not accommodate RS-232 communications directly. This requires the use of a Channel Bank that will bring the rate to a T-1 level, which will then be sent to the Concentrator.

A dedicated communications circuit will be provided across the range communications network for each tracking facility. By assigning a dedicated circuit to each facility, two things can be assured. First, the bandwidth is available on the network to support any setup activities required. Second, no other activities will interfere with operations at a particular site. Another benefit of using the Ethernet network is that all equipment interfaced through Ethernet, or via terminal servers, serial interfaced equipment can be commanded and controlled over this circuit.

The equipment controls are displayed on the computer monitor in the equipment vendor's format, using their software. For equipment that uses less sophisticated software a Graphical User Interface (GUI) was created for the ease of the operator. The GUI software utilized is Visual Basic 6.0.

Since test aircraft typically keep the same instrumentation package for many missions our telemetry ground equipment setup are stored in files tagged to the aircraft to be tested. These files make it quicker and less risky when configuring the equipment for mission support.

For pre-mission tests a signal simulator and link analyzer are used to verify our ground equipment operation. The signal can be transmitted from a bore sight antenna or through direct injection using directional couplers. The test results are then returned via the Ethernet and ATM to the operators console (Remote Control PC) for evaluation and recording.

The antenna system is equipped with warning lights and horn to prevent injury to personnel from inadvertent operation from the remote control PC.

OPERATIONS

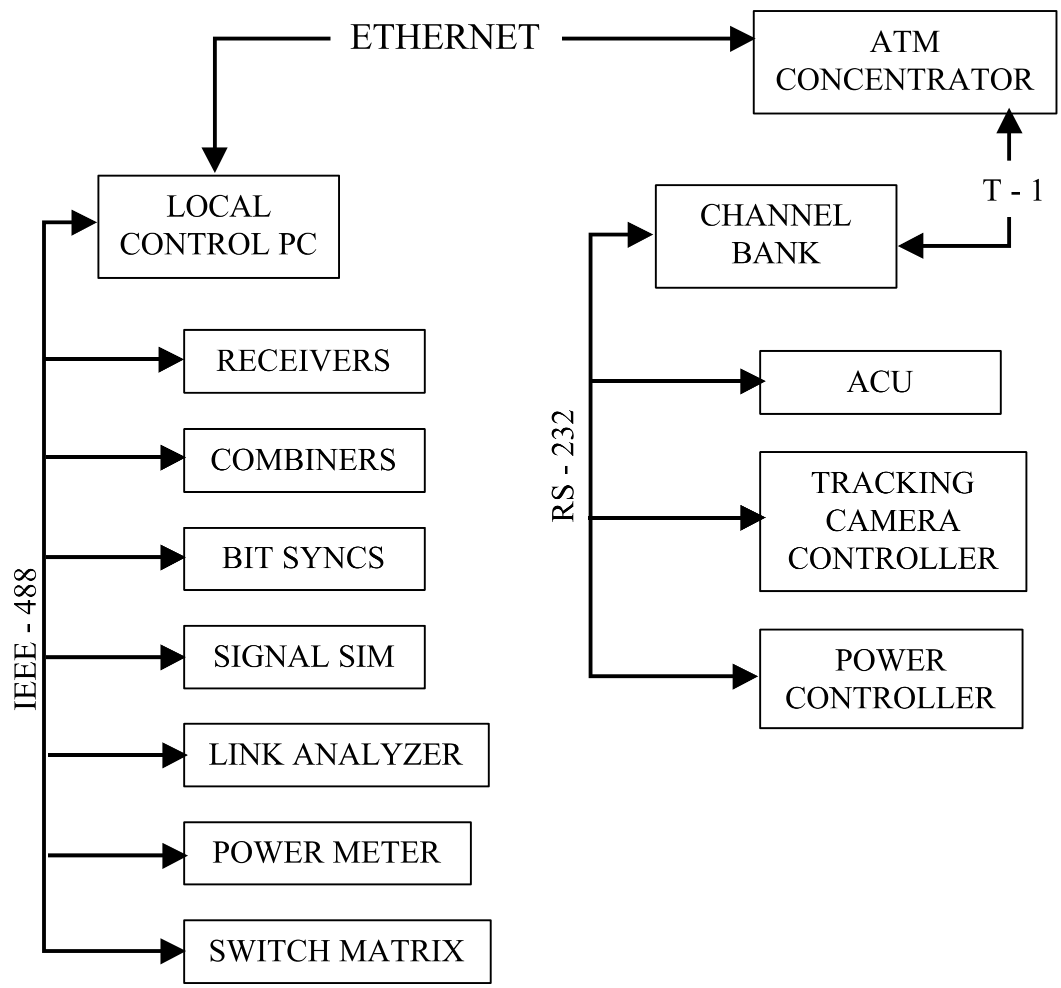
Several circuits may be required to support the operations of the remote tracking facility. A dedicated Ethernet connection will be used to interface the controller computer with the remote control computer located in Ridley Mission Control. The Ethernet communications will be used for front-end equipment setup, calibrations and maintenance. The local control computer will also poll the equipment for status and return that information to the remote control PC. Upon power-up the local computer at the tracking site waits for communications with the computer located at Ridley to be established. Control of the antenna site equipment can be transferred between either site at any time from either side.

In the event of a communications failure the local computer will assume control until communications have been reestablished.

The antenna tracker video image, used by operators to track the aircraft, is displayed on the operator's PC display using a video insertion card. Also, on the operator's display are the telemetry receiver AGC levels. The AGC levels can be displayed in user configurable graphics (bar graphs, numeric values, etc.). Above the Remote Control PC and below the operators PC monitor is the tracking error indicator, or meatball.

Below the Remote and Local control PCs are the thumb-wheels used for manual position inputs to the antenna positioner. The joystick is mounted in a enclosure enabling the operator to move it to a comfortable position.

Should the communications fail, technicians at the antenna site can operate all the systems.



Remote Site Control Interfaces
FIGURE 2

DATA RETRIEVAL

When the target signal has been acquired and the data received it is returned to Ridley Mission Control for decryption, processing and display in one of the mission control rooms. This is accomplished using the same concentrator equipped with an adaptive rate telemetry interface card. The adaptive rate card takes as input the PCM telemetry data from the bit synchronizers at rates from 500Kb/s to 5 Mb/s. Testing is underway to increase the maximum rate to 25 Mb/s.

Video data from the antenna-mounted camera is also returned via the concentrator. The video is first digitized using a video adapter, which has the capacity for a maximum of 7 video streams without compression.

The telemetry equipment status is also returned over the fiber-optic network from the concentrator. The Ethernet connection passes all the equipment status to the operators console. The operator can then verify system set-up. The antenna site calibrations are also recorded at the operator’s console along with system performance.

CONCLUSION

Remote site operations by remote control can greatly reduce costs to customers as well as make working conditions safer for the operators. Being able to bring a site on-line without requiring a 2-hour drive greatly increases our flexibility and readiness.

Because of the vast improvement in communications technologies and the high reliability of modern telemetry equipment, remote control is an attainable goal.