Range Communications System Using Asynchronous Transfer Mode (ATM)

Brian Eslinger
TYBRIN Corp.
307 E. Popson
Edwards AFB 93524
Phone: 805-277-5376
brian.eslinger@edwards.af.mil

Joleen McCombe
412 TW/ TSRE
306 E. Popson
Edwards AFB 93524
Phone: 805-277-3955
mccombej@tsr.edwards.af.mil

As aircraft become more complex and require more resources over larger areas, the challenge of the test ranges is to provide economical solutions to move telemetry data from the test article to the data processing facility. Edwards AFB is in the process of upgrading the ground transmission facilities to transport data including telemetry using Asynchronous Transfer Mode (ATM). This paper documents the challenge of supporting telemetry over ATM, different approaches that are available, the benefits of using ATM, and discussion of candidate hardware options.

The effort at Edwards include the linking of the major range facilities over a fiber optic backbone and links to other major test ranges in the Southwest Range Complex via microwave. The fiber optic backbone is expected to be OC-12c (622 Mbps) ATM supporting new capabilities as well as all of the legacy systems. The backbone system will be designed so that migration to OC-48 is possible without service disruption. The microwave links are multiple DS-3 capable. Some of these DS-3s may support legacy systems, but the ability to link ranges using ATM is expected simultaneously.

Keywords

Asynchronous Transfer Mode (ATM), Telemetry, Communications, Flight Test

Introduction

The Range Division at Edwards Air Force Base (AFB) is in the process of a major communications system upgrade that will affect several test facilities in the southwest United States. Two separate tasks comprise the upgrade: 1) A microwave upgrade that installs new capability between Edwards AFB, Naval Air Warfare Center – Weapons Division (NAWC-WD) China Lake, NAWC-WD Point Mugu, and Vandenberg AFB (VAFB); and 2) A technology insertion to upgrade the method of transport from time division multiplexers and/or proprietary encoders/multiplexers to transport telemetry and video. The technology being investigated is Asynchronous Transfer Mode (ATM). The technology insertion will begin with the upgrade of the intra-range communications system at Edwards and then extend to the other bases via the microwave systems.

The timing for this upgrade meets the need of changing testing requirements. The face of testing is changing to include virtual, constructive, and open air testing. Testing will include both standalone testing of the System Under Test (SUT) and interactive testing with other virtual or real players. The data communications requirements are exploding to include higher bandwidths and more diverse types of data streams.

This paper addresses the insertion of ATM as a new technology as an alternative to continuing business as usual. This paper discusses the requirements for the data transmission system, research that has been conducted, the architecture being implemented, and the benefits that may be realized.

Requirements

The primary requirement for the upgrade to the transmission system is to meet current and upcoming test program requirements at the southwest test ranges. SUTs are now requiring larger areas of coverage by range facilities to perform Developmental Test & Evaluation (DT&E). Larger areas are required due to faster vehicles (i.e. X-33, X-34, F-22) and long duration capabilities (i.e. Tier II+). In addition, the types of data are growing in number; the types of data may include:

- Telemetry
- Voice
- DGPS uplink
- Command and control uplink
- Flight termination information
- Radar position information
- GPS downlink information
- Local Area Networks /Wide Area Networks (LAN/WAN)
- Ground based video
- Downlinked video (Compressed digital)
- Remote range system command and control and status monitoring

Other requirements that must be considered in the development of the transmission system include:

- Supporting legacy systems
- Broadcasting to multiple locations
- Encryption
- Sensitivity to Delay
- Reliance on Commercial-Off-The-Shelf (COTS)
- System supportability
- Network Management

The new transmission system must also interface the existing voice and video switches in the range. The voice switch is a Digital Access Cross Connect Switch at the DS-1/DS-0 levels. The video switch is a wideband analog switch, which switches National Television Standards Committee (NTSC) video.

Other uses envisioned for this system include a standalone "Red" system for secure communications. Once the capability to switch telemetry is established, it will be possible to switch both the encrypted and clear signals. The ability to switch both "Red" and "Black" (unsecure) telemetry data will be possible using separate "Red" and "Black" switching systems through a common network management system. Another use is as a DS-3 switch at the microwave site to provide for switching of trunk lines between the different ranges.

Deploying mobile range assets at the required locations will satisfy many of the missions with large geographic coverage requirements. It must be possible to transmit the required data between the fixed range transmission system and the remote site. The mobile sites may be linked back to the range through either dedicated microwave at various standard telecom data rates or through commercial leased lines. For higher telemetry data rates and commercial lines, it must be possible to use inverse multiplexing to link the remote sites.

Architecture

The architecture for this transmission system includes the microwave system and the range communications upgrade. The system is a hybrid of transmission rates using both North American standard circuits and Synchronous Optical Network (SONET) circuits. The circuits that may be included in this system are:

- DS-3 (44.736 Mbps) (North American Standard)
- STS-1 (Synchronous Transport Signal Level –1 (51.840 Mbps) (SONET)
- OC-1 (Optical Carrier Level 1 (51.84 Mbps) (SONET)
- OC-3 (Optical Carrier Level 3 (155.52 Mbps) (SONET)
- OC-12 (Optical Carrier Level 12 (622.08 Mbps) (SONET)
- OC-48 (Optical Carrier Level 48 (2488.32 Mbps) (SONET)

The architecture of the microwave system includes dedicated three DS-3 microwaves between Edwards and China Lake and Edwards and Vandenberg. In addition, a dedicated three STS-1 microwave capability is being planned from Pt. Mugu through Edwards to China Lake. Figure 1 shows the proposed implementation.

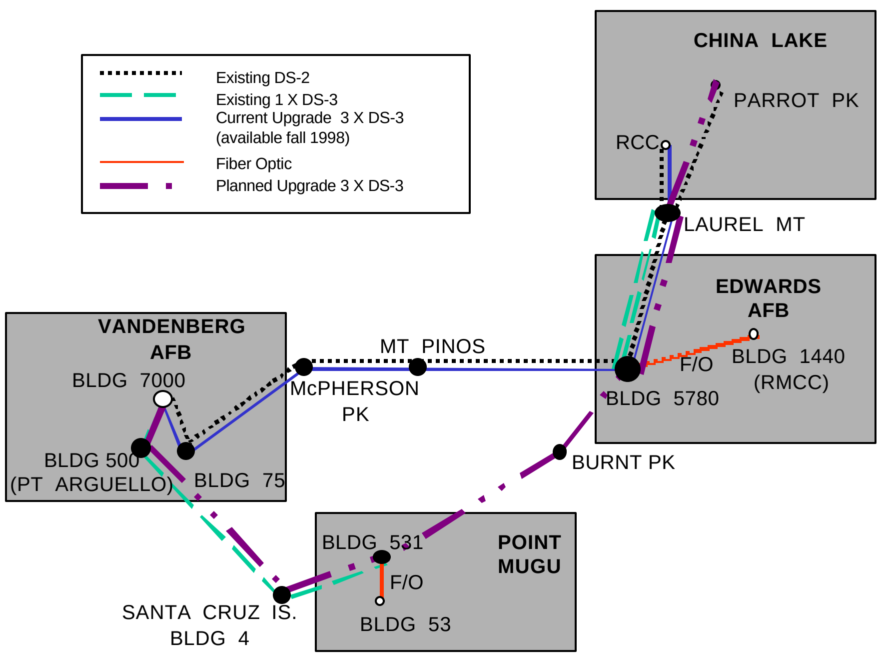

Figure 1. Inter-Range Microwave Communications Architecture.

Notice in Figure 1 that it is possible to setup a ring, a star, or mesh architecture using the microwave links. The possible architectures are illustrated in Figure 2. When operational, the microwave system will likely be a hybrid of all of these architectures. Each architecture has its own drawbacks and benefits, but the types of data being transmitted may determine the architecture that is implemented. For instance, a modeling and simulation scenario with interactive components at different facilities might demand the shortest delays possible, which implies a point-to-point mesh connection. However, a high risk test at a VAFB location with the data required at China Lake might demand a ring configuration to ensure the data are collected and displayed real-time. In the modeling and simulation scenario the time critical nature of the data might be offset by the low risk and the ability to redo the test. In the second scenario, the high-risk nature of the test demands that all precautions possible be taken to ensure that good data are presented to the engineers.

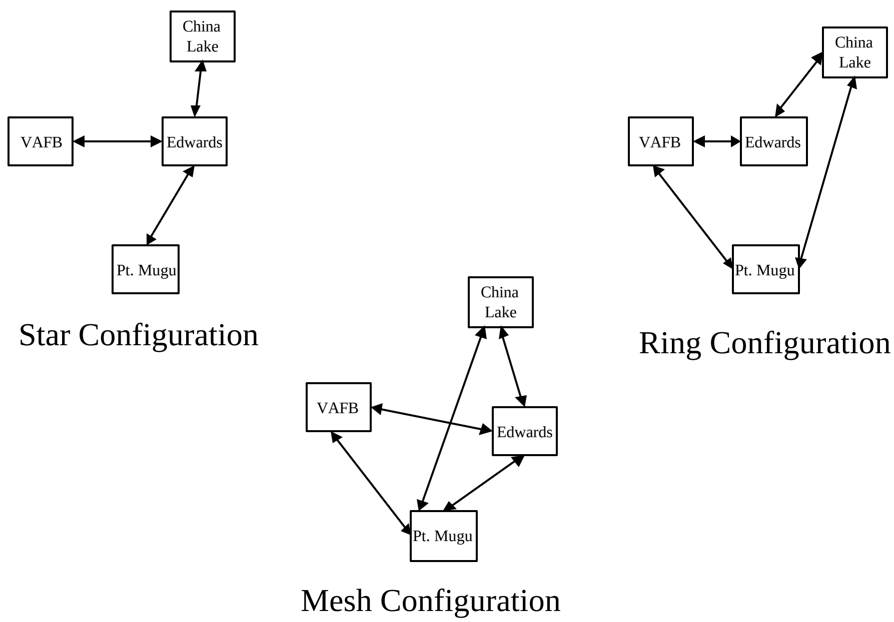

Figure 2. Possible Network Architectures for Inter-Range Microwave System.

The ATM network on the Edwards Range is being implemented in a ring architecture with ATM access concentrators feeding the nodes of the ring. The ATM access concentrators are not just multiplexers; they are ATM switches. The distinguishing factor between a mux and a switch is that a mux takes many low speed interfaces into a single high-speed circuit, where a switch can connect any high or low speed port to any other high or low speed port.

The network at Edwards is being implemented primarily with two products: a backbone switch and an access concentrator. The Range Division at Edwards will be conducting beta tests of the ADC Telecommunication's Cellworx Service Transport Node (STN) during the summer of 1998. The Cellworx combines the advantages of both ATM and SONET technologies in a hybrid add/drop multiplexer. The Cellworx STN uses ATM for transmission as well as switching. While providing transport for ATM traffic classes such as constant bit rate (CBR) and variable bit rate (VBR), the Cellworx STN provides the reliability of a path-protected SONET ring in an environmentally hardened package. The Cellworx STN provides a 10 Gigabit per second (Gbps) cell switching capacity on an OC-12c or OC-48c SONET ring. The access concentrator being proposed is the ADC Kentrox AAC-3. The advantage expected from the AAC-3 is the implementation of the adaptive clocking capability and the ability to transport telemetry directly over ATM.

Figure 3 shows the architecture of the new transmission system at the Edwards Range. The system will begin by connecting the Ridley Mission Control Center (RMCC), the Birk Flight Test Facility (BFTF), Building 5790 (the primary telemetry receiving site), and Building 5780 (the primary microwave relay site). The interfaces to be supported at the four sites include:

- T1 Circuit Emulation (CE)
- DS-3 CE
- Ethernet (10 BaseT)
- Telemetry
- RS-530 nX56/64 kbps
- OC-3c User Network Interface (UNI)
- DS-3 UNI
- Video (Digital compressed)

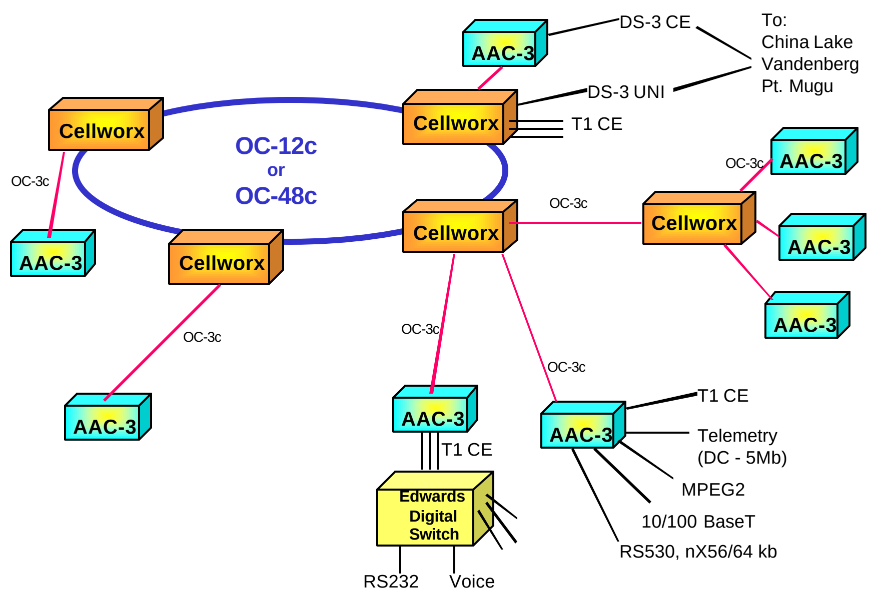

Figure 3. Edwards Range Communications ATM Architecture

The interfaces provided at the Edwards Range sites will support all of the current range functions. Some existing range systems will be decommissioned when this system is implemented, in other cases the legacy systems will be supported. The systems to be decommissioned include analog microwave systems and telemetry multiplexers operating at DS-2 rates (6.312 Mbps). Some of the legacy systems that must be supported include DS-3 multiplexers carrying telemetry and video.

The ability to transport telemetry directly over ATM provides the capability to develop efficient networks and allocate bandwidth as needed. Past research into candidate methods to transport telemetry over ATM is documented in Reference 1. The available COTS solution is to multiplex to North American standard telecom data rates (DS-1, DS-3, etc.), then transport the standard telecom data rates via Constant Bit Rate (CBR) over ATM. This results in very inefficient transmission systems.

The difficulties of implementing an efficient telemetry-to-ATM interface are also documented in Reference 1. The most significant difficulty is the isochronous nature of the telemetry stream and the amount of frequency instability in the signal due to Radio Frequency (RF) artifacts (e.g., Doppler, multipath, etc) and instrumentation oscillator offset. Some of the approaches that have been proposed for the telemetry-to-ATM interface are proprietary in nature on both the transmit and receive end. Several additional approaches are being investigated. One of the candidate approaches allows for the data to be input through any system that supports external clocking and only relies on the data being reliably received to reconstruct the clock and output.

Benefits

Many benefits will be realized from this upgrade. Benefits are both technical and logistical in nature.

The technical benefits from this upgrade include the technology insertion and a move away from proprietary solutions. Although the implementation of this approach has proprietary processes embedded within, there is no proprietary manipulation of the data within the ATM cell to prevent other vendors from receiving the input and recovering the data. The upgrade provides automatic redundancy that has not been previously implemented at Edwards. By the nature of ATM, the links that are supported become more efficient through the statistical nature of the technology. In the extended range scenario, efficiency is also gained through the use of a standards based implementation of inverse multiplexing.

A benefit of a less technical nature is the higher reliance on COTS. Instead of the government developing specialized product and suffering high costs to maintain equipment, the use of COTS equipment allows the government to share costs with industry.

By extending ATM to the receiver site, this upgrade supports some of the next generation programs that are underway or being proposed. Programs that are proposing networks in the sky, or instrumentation through ATM, can be supported through this upgrade without major infrastructure changes.

Conclusion

The upgrade program currently underway at Edwards AFB introduces ATM into the flight test range environment. One major innovation is the introduction of ATM into the range environment not only as a switching technology but also as a transport facility. The proposed upgrade provides increased efficiency and reliability over existing systems with a higher reliance on COTS.

During this upgrade program, the interconnection of several of the major test ranges in the Southwest United States will be linked using high capacity microwave links and ATM data transport protocols. The increased interconnectivity provides for distribution of open-air test data and networking of other test articles, whether simulated or hardware-in-the-loop. This capability meets the needs of today and the anticipated needs of tomorrow.

References

Eslinger, Brian and McCombe, Joleen,” Telemetry Transmission Using Inverse Multiplexing and Asynchronous Transfer Mode (ATM),” Proceedings of the International Telemetry Conference (ITC), Volume XXXIII, October 1997.