NETWORK CONFIGURATION FOR RANGE INTERCONNECTIVITY

STEVEN R. DOUGLAS
Naval Warfare Assessment Division
Telemetry/Telecommunications Engineering
P.O. Box 5000
Corona, CA 91718-5000
Commercial: 909-273-5189, DSN: 933-5189

ABSTRACT

A demonstration of near real-time performance assessment for the Program Executive Officer for Cruise Missiles Project and Unmanned Aerial Vehicles, Cruise Test Directorate, PEO(CU)-CT, was conducted between 22 March 1994 through 4 May 1994. The demonstration involved the temporary installation of a portable TOMAHAWK telemetry recording and telecommunications capability at the Air Force Development Test Center range at Eglin Air Force Base, Florida and a receiving telecommunications capability at the Naval Warfare Assessment Division (NWAD), Corona, California. The system was successfully used on 4 May 1994 to record TOMAHAWK missile telemetry data in real-time in support of Operational Test Launch (OTL)-163 and to transfer that data to the weapons system performance analysts at NWAD in near real-time.

The one hour and three minutes of flight data was compressed in real-time as it was recorded, then, after completion of the flight, the data was transferred to NWAD in about 12 minutes using the switched 56 kbps network. Additional transfers using the Defense Commercial Telecommunications Network (DCTN) were also conducted. All transfers were secured using ethernet encryptors. The data was processed by both the NWAD telemetry ground station and the TOMAHAWK workstation complex.

This paper quantifies the results and documents the lessons learned from this demonstration and proposes a standardized system design for possible implementation at TOMAHAWK test range sites in the future. A position is taken that for situations where the remote site (e.g. other range or data analysis site) does not exercise direct operational control over the test/host range, near real-time data relay solutions are not only as adequate, but in many cases are preferable to real-time solutions.

KEYWORDS

Telemetry, Telecommunications, Network, Near Real-Time, Demonstration, TOMAHAWK, Naval Warfare Assessment Division, Eglin Air Force Base

INTRODUCTION

BACKGROUND

In October 1993, the PEO(CU)-CT Data Quality Management Board (DQMB) chairman requested that the Naval Warfare Assessment Division (NWAD) investigate the feasibility of providing a mechanism to reduce the time and effort required to accomplish performance assessment for future TOMAHAWK missile tests. This request was directed to the Cruise Missile Analysis branch within NWAD (PA-52). A preliminary briefing was prepared by the Telemetry/Telecommunications Engineering Branch (PA-11) and then presented during a DQMB meeting at NWAD on 2 November 93. Based on previous experience with the AEGIS Performance Assessment Network (APAN), the preliminary briefing affirmed the feasibility of using an all electronic media to relay the telemetry data necessary to accomplish the performance assessment in as close to real-time as possible (i.e. near real-time). As a result of that meeting, DQMB representatives asked NWAD to prepare a demonstration proposal.

PROPOSAL

During the mid-year program review for the PEO(CU)-CT at NWAD on 8 March 94, PA-11 proposed that a demonstration be conducted. Operational Test Launch (OTL)-163 which was scheduled to take place in the first week of May 1994 on the Air Force Development Test Center (AFDTC) range at Eglin Air Force Base (EAFB), Florida was then selected as a candidate test case. The location of OTL-163 would provide the remoteness necessary for a proper demonstration of the technology. On 22 March 94, go-ahead for the demonstration was authorized by the PEO(CU)-CT.

OBJECTIVES

Two sets of objectives were established for this demonstration. The primary technical objectives were: (a) acquire OTL-163 telemetry data in real-time at EAFB, (b) securely transfer the data to NWAD in near real-time, and (c) perform the initial quick-look performance assessment and report the results to the TOMAHAWK community in less than 24 hours after the completion of the test flight. The programmatic objectives were: (a) evaluate the technical results with respect to timeliness and effectiveness, (b) develop a standardized design for use during future tests, and (c) develop an estimate of the costs and time frame that would be required for possible implementation of the demonstrated technology at other sites.

PURPOSE

This report is intended to document the approach used to conduct the demonstration, as well as the technical and programmatic results achieved. Finally, recommendations will be made, based on the results, for the benefit of the PEO(CU)-CT, and the TOMAHAWK technical community.

APPROACH

SCOPE

As will be seen in the design and implementation sections of this report, this demonstration involved many areas of project engineering and execution in a very short time period (i.e. six weeks). During this time, final design, remote test site planning/ coordination, security, equipment and telecommunications acquisition, integration/ testing, modifications/repairs, shipment, travel, installation and check-out all had to be accomplished.

OTHER INITIATIVES

APAN. An important step in approaching this demonstration was to take full advantage of the experience gained from other similar initiatives. One such initiative, APAN, had shown that use of modern telecommunication techniques was not only feasible, but practical and effective in rapidly transferring large quantities of data over great distances in support of Combat System Sea Qualification Trials (CSSQTs). The NWAD team chosen to perform the demonstration was previously responsible for the successful implementation of APAN (from concept to initial Operational Capability (IOC) at six sites) in the 12 month period of January-December 1992. This experience would prove crucial to the successful completion of this demonstration.

TERIS. Another initiative of similar nature (since canceled by OSD) was the Test & Evaluation Range Internet System (TERIS). NWAD was the development agent for training and weapons assessment for the Navy on the TERIS Integration Working Group (TIWG). TERIS had planned to network many key T&E ranges and training complexes, including the AFDTC at EAFB and the Southern California Range at Point Mugu, CA (both principal TOMAHAWK flight test ranges) and NWAD at Corona, CA. A key provision in the system was the ability to relay telemetry data in real-time to one or all nodes in support of a test event or training exercise. During a TIWG meeting at Edwards AFB, CA in February 1994, the preliminary design for this demonstration (based on the APAN concept) was discussed and revised by the EAFB telemetry station head and the NWAD PA-11 lead engineer. After several additional phone calls were made, the required planning and coordination between NWAD and EAFB was nearly completed prior to the demonstration even being approved by the PEO(CU)-CT.

DESIGN

Concept. As mentioned above, the initial design was similar to that used by the APAN. Namely, instead of attempting to relay test data (e.g. telemetry) in real-time, a store-and-forward method is used. In this method, data is collected at the source in real-time and archived as a data file on a high capacity disk drive. Then, immediately after the flight is completed, the file is telecommunicated to the remote site using standard Wide Area Network (WAN) communication techniques.

Rationale. Several advantages are realized with this approach. First, the need to maintain disciplined synchronous telemetry clock sources from end-to-end is eliminated. Second, standard network communications techniques such as Transport Control Protocol/Internet Protocol (TCP/IP) over ethernet Local Area Network (LAN) interfaces can be used. This can be achieved using low-cost commercial-off-the-shelf technology that is both user-friendly (reducing operator training requirements) and proven. Third, TCP/IP communication protocols assure that all the telemetry data will be received errorlessly at the remote site (something very difficult to achieve in real-time). Fourth, store-and-forward allows for off-line compression prior to transmission and a reduction in peak long-haul bandwidth requirements. For example, data from existing 2.4Mbps (and future 5Mbps, 10Mbps, and 20Mbps) telemeter packages (telepacs) can be transferred to remote sites over affordable T1 circuits (as opposed to T3 circuits) if end users can wait a few minutes for the data rather than having it in real-time (i.e. while in flight). It also allows for the incorporation of ancillary capabilities such as multi-media audio and video. Fifth, ethernet encryptors can be used to greatly simplify the Communications Security (COMSEC) effort. The encryptor used in this demo, the Network Encryption System from Motorola is a Controlled COMSEC Item (CCI) and remains unclassified when unkeyed. It can also be shipped by any commercial overnight carrier that can provide constant surveillance service. Because the Keying Material (KEYMAT) is like that used in the STU-III (unclassified when not loaded into the CCI encryptor), key management is simplified by eliminating the need for Two-Person Integrity (TPI) during operations. Finally, switched 56 kbps and Defense Commercial Telecommunications Network (DCTN) circuits were used to achieve long-haul connectivity. The only drawback to this approach is that data is not received in real-time. However, since it is unlikely that any remote site (NWAD or otherwise) would be granted operational range control, real-time data is unnecessary. In light of this fact, near real-time data is completely satisfactory and was utilized.

Design Details. A set of block diagrams which depict the design that was demonstrated is provided in Figures 1-4. In order to improve the probability of success for this mission, a back-up system was used for each of the three subsystems in the design: (a) telemetry data acquisition, (b) data transmission, and (c) data processing.

Telemetry Data Acquisition. The primary means of acquiring telemetry data was a Portable Telemetry Data Processor (TDP) manufactured by Acroamatics. This subsystem is based on a VME bus architecture and provides a compact (7 inch high rack mount enclosure), reliable method of acquiring, time-tagging, decommutating, and archiving telemetry data as a file on its large capacity disk drive. The portable TDP file record format is compatible with the NWAD telemetry ground station. The back-up system was a traditional one based on analog tape archiving followed by data storage on digital ½ inch magnetic tape media. The digitized tape could then be placed on a VAX workstation for subsequent network transmission to NWAD. Both systems tapped into the existing telemetry data sources at the EAFB telemetry receiving station and provided first-order data compression. This type of compression involved a cull of unused words within the telemetry frame, and a cull of all words whose value had changed less than 0.5% from a previously recorded sample. The 0.5% "compression window" is within the error tolerance of the missile telepac. This type of compression has successfully been used for many years by the NWAD telemetry field stations and the ground station at Corona. Use of this compression technique resulted in significant reductions of the telemetry file sizes involved in this demonstration.

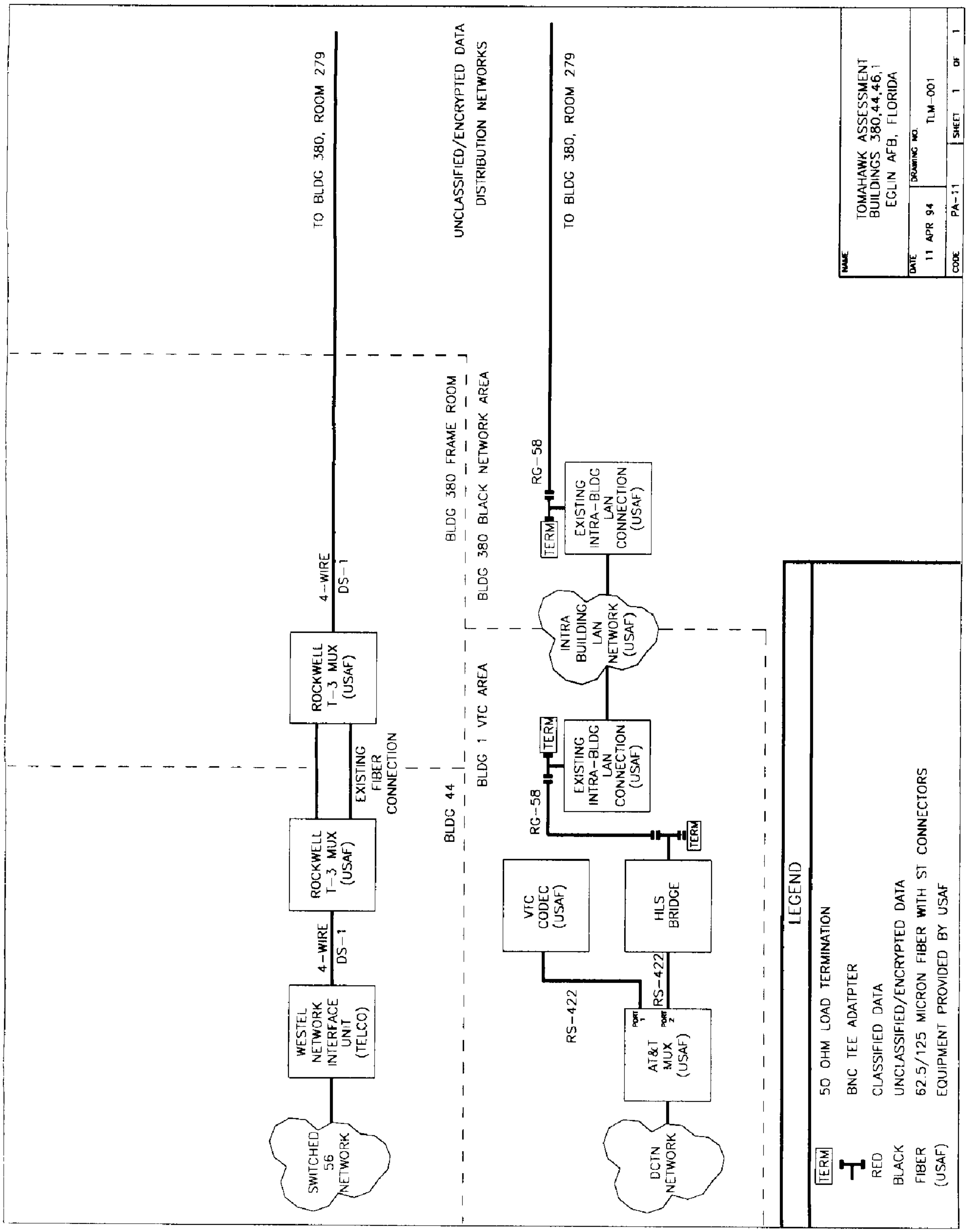

FIGURE 1. EAFB WIDE AREA INTERFACE BLOCK DIAGRAM

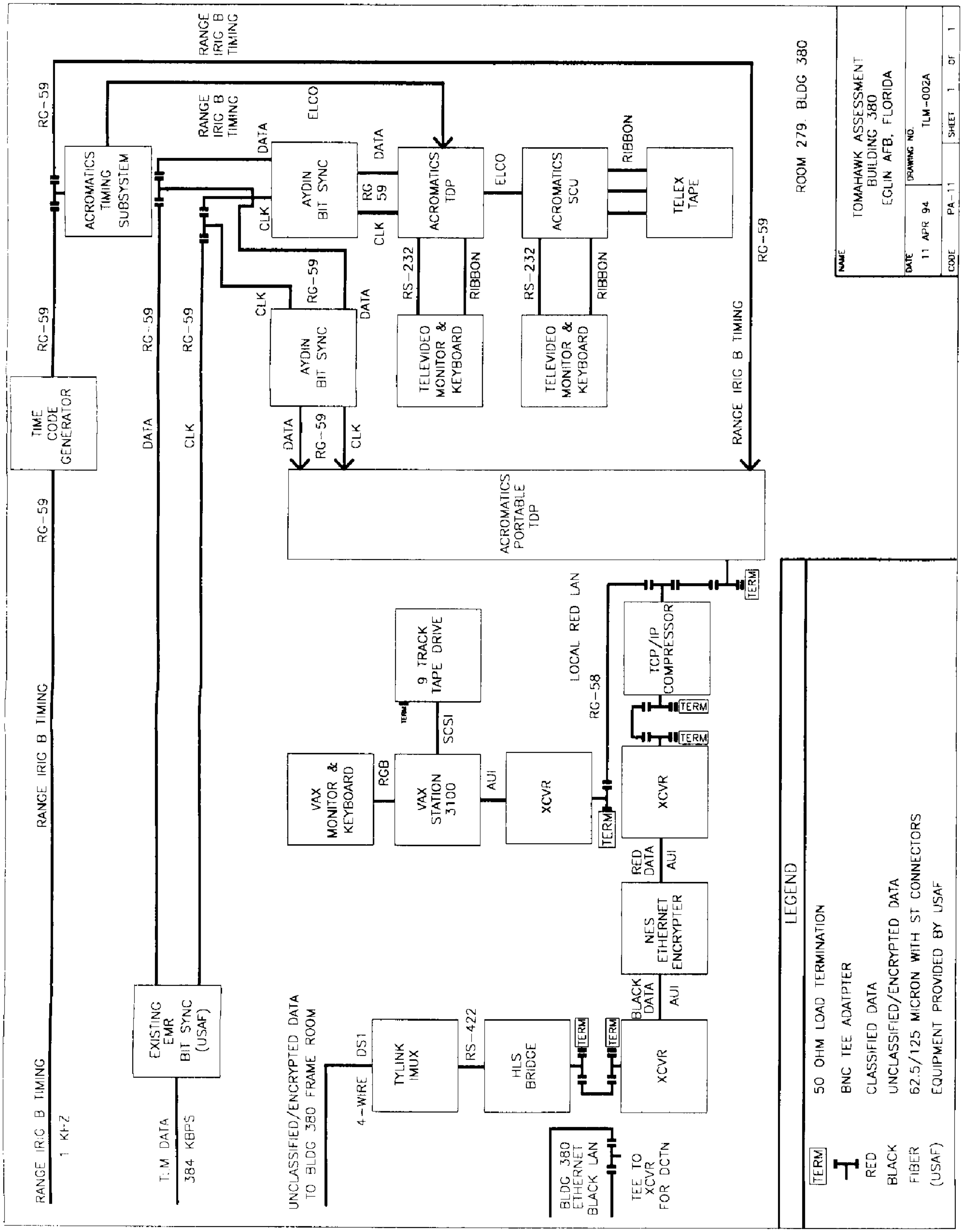

FIGURE 2. EAFB TELEMETRY INTERFACE BLOCK DIAGRAM

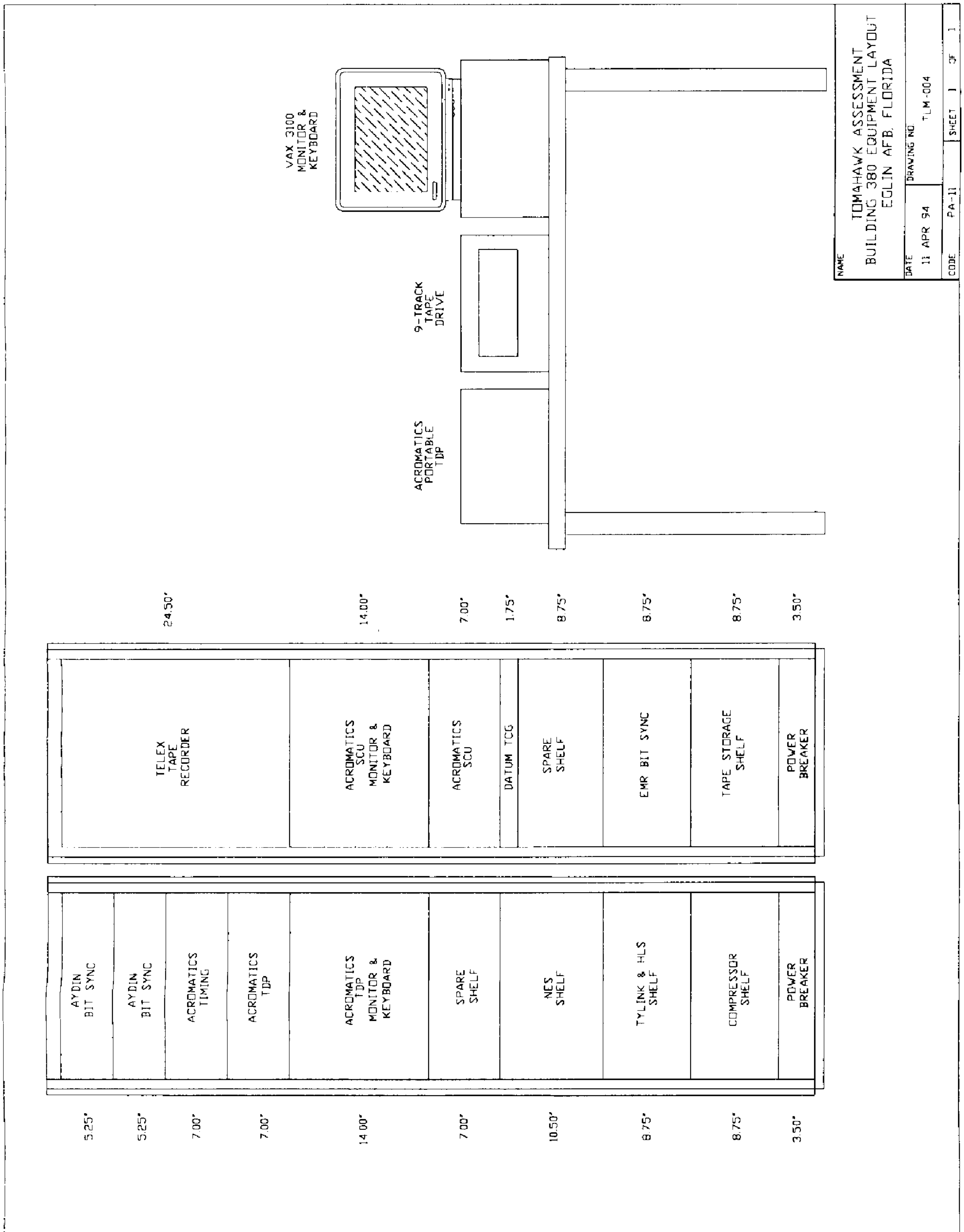

FIGURE 3. EAFB TELEMETRY RACK ELEVATION BLOCK DIAGRAM

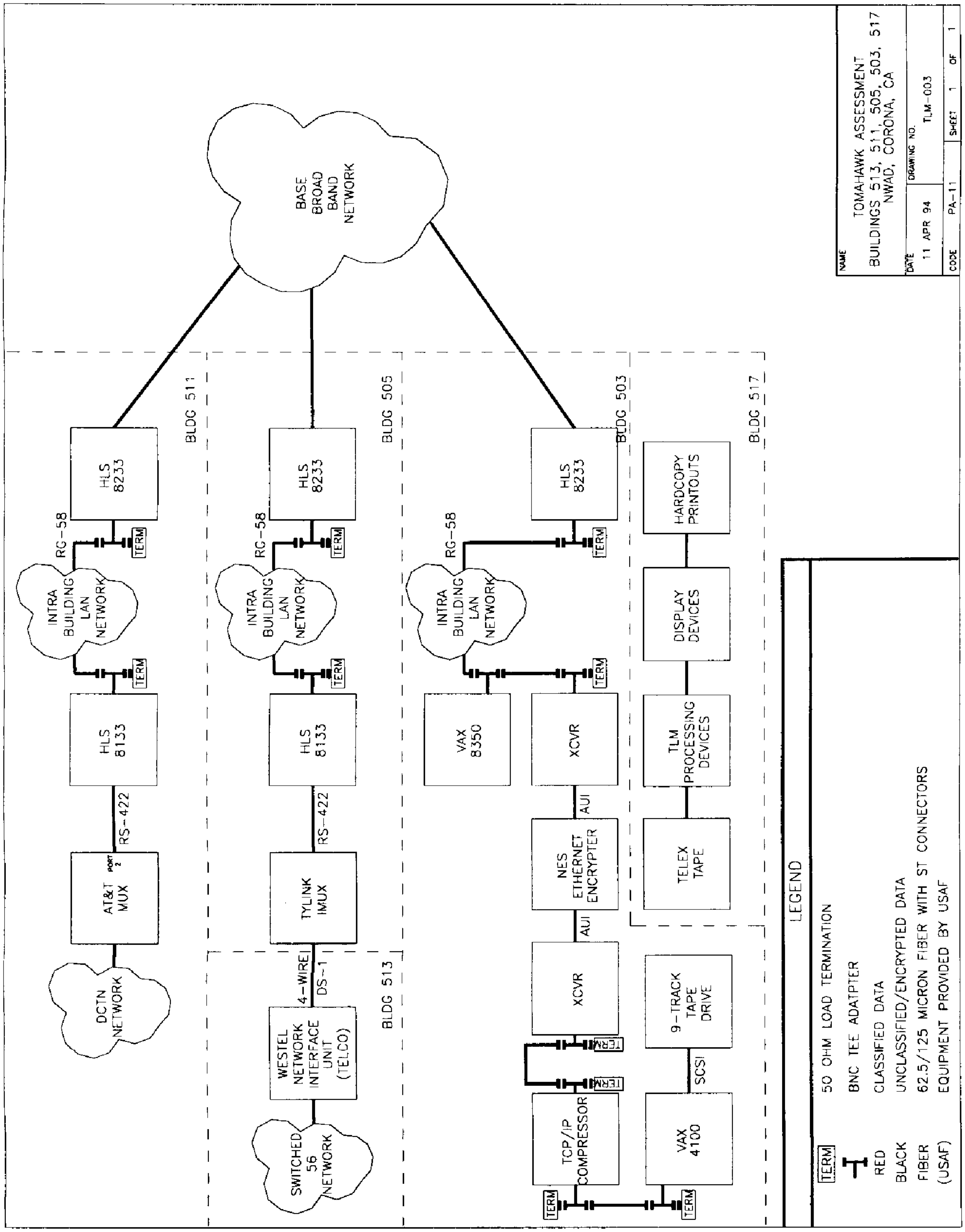

FIGURE 4. NWAD SYSTEM INTERFACE BLOCK DIAGRAM

Data Processing. The primary data processing subsystem at NWAD was the telemetry ground station in building 517. Since this system did not have direct network capability, telemetry data files from the primary and back-up systems at EAFB were sent to the VAX at the NWAD Telemetry Station Development (TSD) laboratory in building 503. Once there, the TSD VAX converted the files onto digital ½ inch magnetic tapes using record formats that were compatible with the NWAD telemetry ground station. The ground station then used standard processing procedures to provide analysts with hard copy telemetry data records. For data processing, the TSD lab served as a back-up system, as did analyst SGI Unix based workstations which had been programmed to accept the ground station tape file formats.

IMPLEMENTATION

This section will review the preparatory efforts required during the six week period from demonstration authorization to the OTL-163 launch date.

Final Design. The system design was finalized within a matter of days after receiving demonstration authorization. In view of the extremely short lead-time, only equipment which was available on-hand, or via loan was included in the design. Besides the physical equipment design which has been diagrammed in Figure 1, the design effort required that addresses be assigned to the various network equipment used in the demonstration. This information is provided in Figure 5 and was used to generate the KEYMAT required for the NES encryptors to function properly.

Acquisition. Once the design was finalized, identified equipment was shipped or hand carried from the various projects and locations where they function as additional units to meet peak capacities, or as spares. Besides equipment, a digitized telemetry data tape of a previous TOMAHAWK missile test was obtained from the NWAD ground station to use during check-out of the portable TDP. The portable TDP was obtained for evaluation purposes from Acroamatics. This unit was actually their development test bed model since the three units in their production line were already committed to other customers and could not be diverted. Because of this, NWAD had to arrange for compatible TCP/IP communication software to be acquired and configured for use with the portable TDP VME single board computer ethernet port. Finally, a dedicated T1 access line from EAFB to a local SW 56 point-of-presence was leased for a one month period to provide the primary long-haul circuit connectivity.

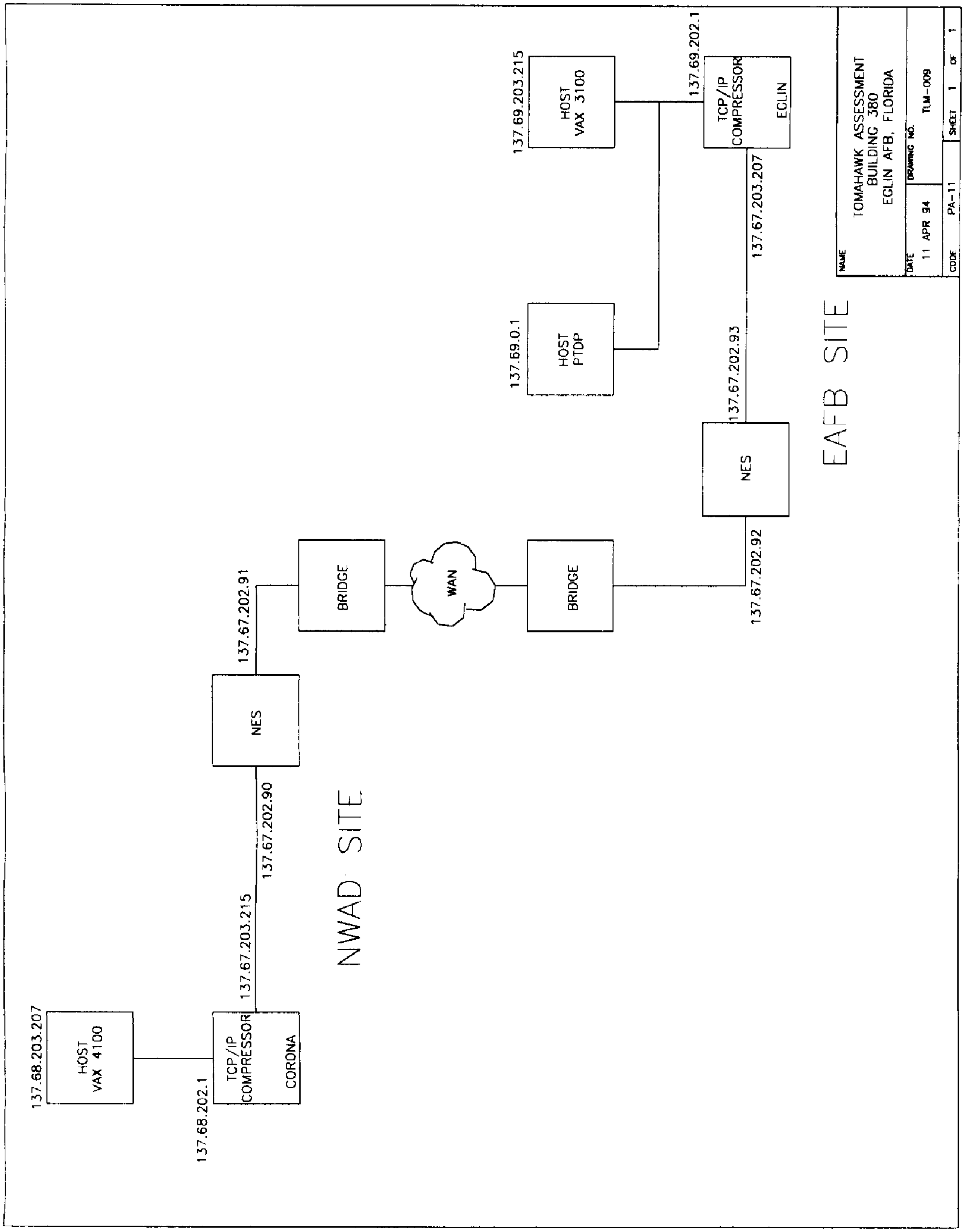

FIGURE 5. DEMONSTRATION NETWORK ADDRESS ASSIGNMENTS

Remote Site Coordination. Although informal coordination began during a TIWG meeting (Feb 94) at Edwards AFB, formal coordination efforts began immediately after the demonstration was authorized. Since a single point of failure could not be tolerated in view of the short time-frame, all coordination efforts were accomplished via telephone/fax, and culminated in a written Memorandum of Agreement (MOA). The MOA provided the necessary blueprint for the NWAD and EAFB teams to successfully conduct the demonstration including; equipment block diagrams, building layouts for equipment placement, use of DCTN data access, on-base routing of T1 circuit for SW56 access, and a responsibility matrix in order to achieve IOC.

Security. Security issues revolved around the use and protection of COMSEC equipment and KEYMAT and NWAD personnel access to restricted areas at EAFB. Although APAN uses another type of ethernet encryptor that provides slightly higher throughput rates than the NES, it requires TPI KEYMAT for operation. Due to the short time-frame involved in this demonstration, and the fact that the encryptor was needed for bench testing of both systems up until they were shipped in late April, standard Defense Courier Service shipment of TPI KEYMAT was impossible. Therefore, the NES encryptor was selected for use. The hardware was shipped by commercial overnight service under constant surveillance. KEYMAT was then generated at NWAD and hand carried by operations team personnel. Security clearances for all operations team members were arranged as were "out-of-hours" access authorizations so that testing of the systems could continue during the last weekend in April just prior to the OTL-163 launch date. All these arrangements proved valuable and successful.

Integration & Testing. One of the most demanding efforts required in preparing for the demonstration involved integrating the primary and back-up systems at NWAD for bench testing prior to shipment to EAFB. This process continued at EAFB during and after initial on-site installation. Several all-day (and late-night) sessions were required by the design and operations team to completely check-out the systems.

Modification & Repairs. As a result of bench testing at NWAD and field testing upon installation at EAFB, it was apparent that modifications (or repairs) were required on many of the equipment items. The next paragraphs detail these efforts.

Portable TDP. The first item to require attention was to use the example TOMAHAWK data tape to check file format compatibility between the portable TDP and the NWAD VAX 4100 which would receive the file transfers. Although the portable TDP and NWAD ground station both use 32 bit (4 byte) words, the portable TDP records the bytes in a 1-2-3-4 sequence, while the VAX 4100 used a 4-3-2-1 sequence. The second item involved the file record length. The portable TDP uses a fixed 8192 byte record block length while the VAX 4100 used a variable record block length approach. Both of these items were overcome by modifying the output record routines used by the VAX 4100. The third item involved the creation of two different CONFIG.SYS files for the portable TDP single board computer due to a conflict in "high memory" allocation for the newly added TCP/IP software driver. Thus, one configuration was used for data acquisition, another was used for TCP/IP file transfers. A fourth item involved the repair of a failed bit-slice processor (and swap-out of a disk drive that worked intermittently) due to excessive heat. Apparently, this development test bed unit from Acroamatics had not received a dual-fan upgrade to reduce heat build-up and prevent such failures. After the repairs were made and a second fan was installed, no further failures were experienced. A fifth item required the portable TDP timing card to be reprogrammed to "Translate Time Code" mode instead of "Generate Time Code" mode. The last item was a bug in the microcode of the portable TDP that produces the time tick for hard copy printouts. Instead of counting 1-1000 in milliseconds on the printout every second, the time tick for millisecond 10 was skipped (the data for millisecond 10 was still there). Since this last item wasn't discovered until the unit was at EAFB where the operations team had no access to compilers or Acroamatics software experts, a microcode patch routine was developed by Acroamatics and sent via fax to the operations team in the field. The patch directed the output print file to produce a "double tick" at millisecond 9 (note: the presence or absence of this patch did not have any effect on the integrity of the actual recorded data file, just the output time tick step routine for the print file).

Back-Up TDP. The back-up system was comprised of traditional components that were borrowed from other telemetry resources. However, although all equipment necessary for a back-up system was available, some equipment components would not operate individually or as a system and needed repair or adjustment. The first item to be addressed was the Timing Subsystem. Bench testing revealed that it would not properly lock onto modulated IRIG-B range timing signals of the type expected at EAFB. This was overcome by using a spare Time Code Generator to, in effect, "regenerate" the modulated IRIG-B timing signal to a sufficient level for the TDP Timing Subsystem to accept. This was successful. The second and third items involved the System Control Unit (SCU): (a) a failed Data Storage Control card had to be swapped-out, and (b) a failed floppy disk drive had to be replaced. The fourth item involved file compatibility between the VAX 3100 at EAFB (used to network data back to a VAX 4100 at NWAD) and the digitized ½ inch magnetic tape files produced by the back-up TDP. A RECORD STRUCTURE command had to be used to allow the VAX to maintain proper record file lengths during TCP/IP file transfers using native DFC/UCX communication software, and, the standard CR/LF that is added to each record block under the WRITE command had to be disabled by using a QIO command instead. The integration cable set was not complete and included some cables that were previously damaged. This was overcome by repairing all damaged cables and fabricating all missing cables at NWAD. Finally, the TELEX ½ inch magnetic tape drive proved very troublesome: (a) a hinge door was damaged during shipment which prevented tapes from loading properly , (b) a pre-amp board for the record head had failed, (c) a ribbon-cable was found to be frayed due to an intermittent power supply problem that required the power supply to be frequently removed and replaced. The known problems were repaired at NWAD by a TELEX service rep. However, the power supply still operated intermittently (which, in turn, caused the tape drive to pass internal diagnostic tests yet not operate with the SCU) until it was removed and replaced once more just before the OTL-163 launch date. Thereafter, including the entire OTL-163 test period, the tape drive operated flawlessly.

On-Base T1. After initial installation was made and the dedicated T1 access line to the SW56 point-of-presence was activated, attention was directed to the on-base system at EAFB which routes the T1 from the TELCO demarcation point to telemetry building 380. End-to-end bit error rate testing revealed an inability of older style Alternate Mark Inversion (AMI) cards in the EAFB T3 mux to properly pass 2047 test pattern data. This test pattern is used because it contains long strings of zeros that are prevalent in encrypted links. The older cards would not tolerate a low one's density pattern. That being the case, the problem was readily solved by using newer generation cards.

Miscellaneous. Travel, shipment, and installation were also accomplished for the most part without major incident. The NWAD omnibus support contractor arranged for shipment by commercial air carrier and completed the delivery of equipment from the air terminal in Atlanta to EAFB by truck since the size of the palletized equipment racks exceeded that allowed for direct commercial air delivery to EAFB. The support provided by the telemetry branch at EAFB was outstanding. They provided excellent support and stopped at nothing to overcome any last minute difficulties or unforeseen obstacles.

Summary. Although at times during the preparation phase the problem list seemed insurmountable, by the time a full-up telemetry check was performed on Sunday 1 May 94, all systems were operational.

RESULTS

The results for this demonstration are divided in the following sections into technical and programmatic categories. All technical objectives were successfully achieved. All programmatic objectives are included at the end of this document.

TECHNICAL

Overview. On the morning of Wednesday 4 May 1994, OTL-163 was conducted. The flight was 1 hour and three minutes in duration and used a block III telepac at a data rate of 384 kbps. Both systems acquired the entire flight telemetry without incident. Immediately after the flight was completed, the resulting data tape from the back-up system was placed on the VAX 3100 and the 28.6 Mbyte file was transferred to NWAD in approximately 12 minutes. The file from the portable TDP (PTDP) was then transferred to NWAD in approximately 45 minutes. At NWAD, the files were received on the TSD VAX 4100. Within 45 minutes of receipt, all files were converted to NWAD ground station compatible ½ inch magnetic tape media for production processing. Within 2 hours, standard telemetry records and data products, along with the digitized telemetry tapes, were provided to PA-52 TOMAHAWK analysts. Within 6 hours of receipt of the data from the ground station, a preliminary anomaly report memo was issued by PA-52.

Details. Once the telemetry data was transferred to the NWAD ground station for processing, further data file transfers were conducted to gain a better understanding of the capabilities of the demonstrated systems and to improve subsequent designs.

Data Acquisition. One result was of the data acquisition effort was a clear finding that the first order compression by both TDP systems resulted in dramatic reductions in the size of files that were involved. For example, the TOMAHAWK 384 kbps data rate is equivalent to 48 kbytes per second. However, the data is actually constructed in PCM frames with sub-channels of sampled data. On average, a channel is one byte (some are 1 bit events, others are 10-24 bit words). This results in a 48 kchannels per second data rate. The TDP records each channel as a 2 byte word and appends a 2 byte channel ID/precise time header for a total of four bytes of file data for each channel. Thus, the uncompressed rate of a Tomahawk telemetry file as recorded by the TDP is approximately 192 kbytes per second. Therefore, the 63 minute flight should have resulted in a 725 Mbyte file. The actual file size of 28.6 Mbytes represents a compression ratio of 25:1.

Data Transmission. Once the files were ready for transmission, both SW56 and DCTN pathways were used. Because the SW56 circuit was under direct user control via the IMUX front panel (instead of via advanced reservation as with DCTN), this was the preferred pathway for the operations team. Table 1 summarizes the data transmission results. As can be seen from the results, increasing the WAN data rate above 448 kbps had no noticeable effect on transfer times for the back-up TDP/VAX system. This is due to the "throttling" effect that the NES has as it reaches the maximum number of packets per second it can process. Also note that the portable

TDP transfer times were much slower than those of the backup TDP/VAX combination. The primary difference can be attributed to lack of optimization of the native TCP/IP software used with the portable TDP single board computer ethernet port. Such factors as window size (for the IP component) and segment size (for the ethernet component) could not be optimized and hurt performance considerably. It is recommended that a different TCP/IP software package be used in future implementations. Even with these setbacks, the file was transferred in less time than it took to record it.

Table 1. Data Transmission Summary

Configuration		WAN Details		Transfer Details[2]	
Test No.[1]	Telemetry System	Circuit Path	Data Rate (kbps)	Duration[3] (seconds)	Data Rate[4] (kbps)
1	Back-Up	SW56	784	664	344.8
2	Back-Up	SW56	784	728	314.4
3	Back-Up	SW56	784	678	337.6
4	Back-Up	SW56	784	684	334.7
5	Back-Up	SW56	448	680	336.6
6	Back-Up	SW56	336	743	308.1
7	Back-Up	SW56	336	739	309.8
8	Back-Up	SW56	224	962	238.0
9	Back-Up	DCTN	1408	775	295.4
10	PTDP	SW56	784	2385	96.0
11	PTDP	DCTN	1408	2333	98.1

Notes:
1) Test numbers are not in chronological order.
2) All transfers are based on actual file size of 28,614,282 bytes.
3) Actual duration.
4) Includes lossless TCP/IP compression ratio of 1.5:1 on average.

Data Processing. Data processing took place first in the NWAD ground station. Processing time was approximately 2 hours. Then, records and digitized tapes were provided to the TOMAHAWK flight analysts. A preliminary anomaly report memo was then issued and released within six hours of receipt of the data products from the ground station.

PROGRAMMATIC

The programmatic objectives were: (a) evaluate the technical results with respect to timeliness and effectiveness, (b) develop a standardized design for use during future tests, and (c) develop an estimate of the costs and time frame that would be required for possible implementation of the demonstrated technology at other sites.

Timeliness & Effectiveness. Timeliness objectives for this demonstration were definitely met since the data products were provided to the analysts in less than four hours after the flight was completed. Effectiveness assessment objectives were also met since an in-depth comparison between the telemetry data sent via the telecommunications network and the telemetry data recorded on the primary and backup systems at the host range showed no substantive variation.

Standardized Design. A standardized design which reflects the lessons learned from this demonstration is shown in Figure 6. The use of centralized spares is preferred to a complete back-up system. This system can be implemented at any TOMAHAWK telemetry source site. The initial cost to implement the system at each site is estimated to be $ 150K as listed in table 2. The life cycle costs are estimated to be $35K per year.

Table 2. Standardized System Cost Estimate

Item	Description	Amount ($)
1.0	Initial Costs	
1.1	Labor (Gov't)	30,000
1.2	Travel (Gov't)	5,000
1.3	Equipment (Including Central Spares)	90,000
1.4	Site Support	10,000
1.5	Support Contract Task	
1.5.1	Labor	10,000
1.5.2	Travel (Including Truck Rental)	2,500
1.5.3	Materials/Air Shipment	2,500
	Total Initial Costs	**150,000**
2.0	Life Cycle Costs (Annual)	
2.1	Operations & Troubleshooting	20,000
2.2	Equipment Repair	5,000
2.3	Telecomm Lease (ISDN/DCTN)	10,000
	Annual Life Cycle Costs	**35,000**

Implementation Time Frame. Based on experience from this demonstration, the time frame for implementing this technology at other sites is estimated to be nine months after go-ahead authorization.

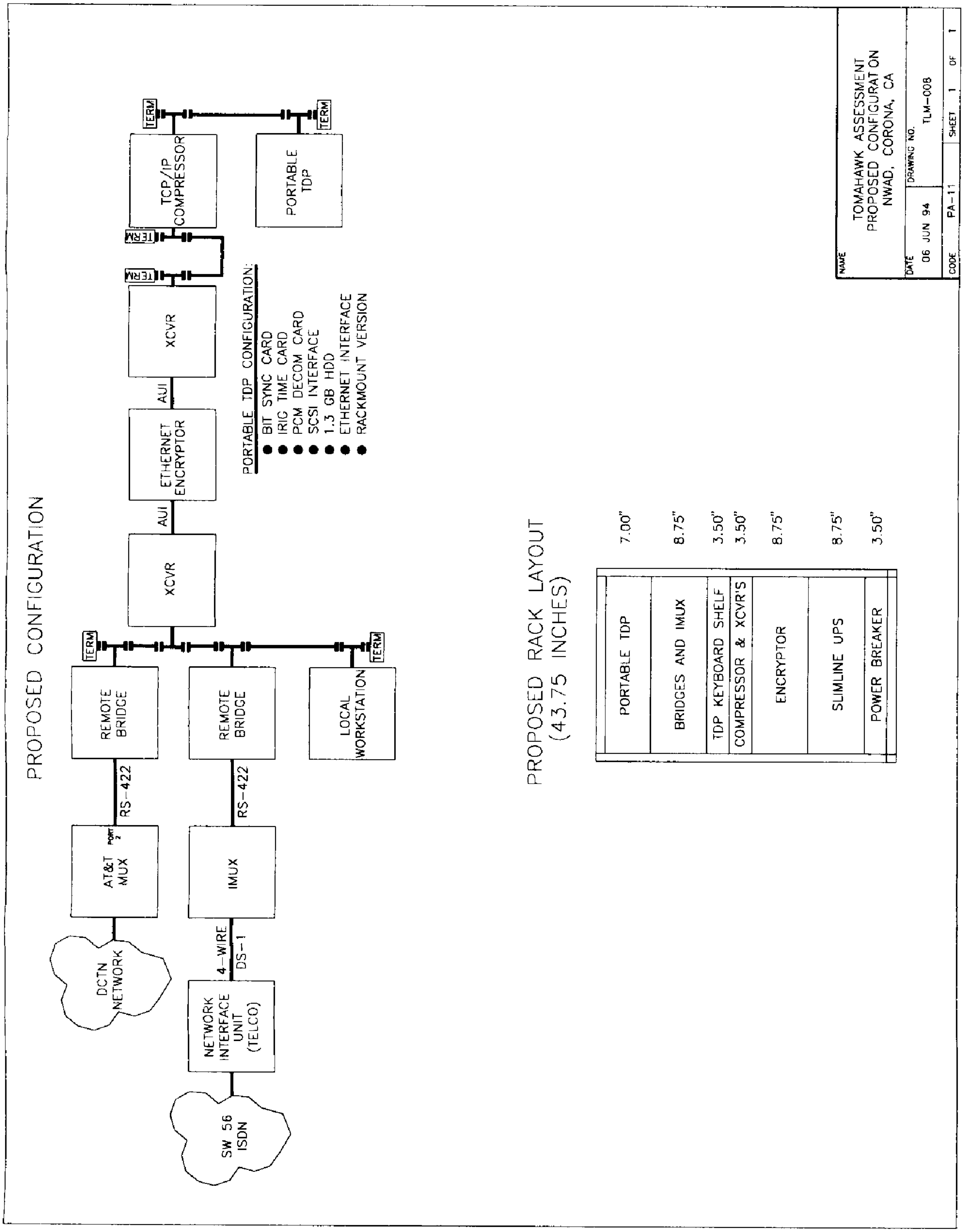

FIGURE 5. STANDARDIZED SYSTEM BLOCK DIAGRAM

CONCLUSION

The temporary installation of a portable TOMAHAWK telemetry recording and telecommunications capability at the Air Force Development Test Center range at Eglin Air Force Base, Florida and a receiving telecommunications capability at the Naval Warfare Assessment Division (NWAD), Corona, California was successfully used on 4 May 1994 to record TOMAHAWK missile telemetry data in real-time in support of Operational Test Launch (OTL)-163 and to transfer that data to the weapons system performance analysts at NWAD in near real-time.

The one hour and three minutes of flight data was compressed in real-time as it was recorded, then, after completion of the flight, the data was transferred to NWAD in about 12 minutes using the switched 56 kbps network. Additional transfers using the Defense Commercial Telecommunications Network (DCTN) were also conducted. All transfers were secured using ethernet encryptors. The data was processed by both the NWAD telemetry ground station and the TOMAHAWK workstation complex.

The near real-time data relay solution employed during this demonstration was found to be totally adequate and a standardized system design for possible implementation at TOMAHAWK test range sites in the future was proposed. Possible use of the standardized design for the near real-time telemetry relay requirements of other projects is warranted.

ACKNOWLEDGMENTS

The following individuals were responsible in one way or another for the actual execution of this demonstration project and are hereby acknowledged for their tireless efforts: Johnny Pappas and Jim Moneymaker at EAFB; Kevin Banning, Bill Willoughby, Roberto Javier, Russ Cryder, and Charlie Pettinger, at NWAD; Eric Baumgardner, Gerry Pitts, and George Arruda at Dyncorp; and Geoffrey Johnson at Acroamatics.