OFF-RANGE CORRIDOR SUPPORT

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ABSTRACT

White Sands Missile Range is supporting Ballistic Missile Defense Organization (BMDO) target firings from Ft. Wingate, NM. This two Off-Range Corridor allows BMDO to conduct long range testing within the continental U.S. The Transportable Range Augmentation and Control System (TRACS), consisting of a control van and one of two Mobile Telemetry Systems (MTS), provide the necessary on-site telemetry support. The Dual Remote Interferometer System (DRDAS) that tracks the telemetry RF carrier in support of Missile Flight Safety (MFS) is also included in this paper. This paper describes the telemetry support scenario in terms of preliminary simulations followed by real-time support. Real-time support consists of data distribution from the MTS to the Telemetry Distribution Center, TRACS Control van, Missile Flight Safety display van, Project Support vans, on-site data processing, as well as relaying raw data to the main WSMR Telemetry Data Center (TDC) for real-time analysis. As soon as telemetry data arrives at the TDC, it is converted into information. This information is used by MFS during real-time monitoring of vehicle performance. This paper includes the methods used for the conversion of data into information on-site and at TDC. Real-time data processing involves multiple independent systems performing their respective tasks on a particular segment of data.

KEY WORDS

Off-Range Corridor (ORC), Transportable Range Augmentation Control System (TRACS), Mobile Telemetry System (MTS), Data Processing, Dual Remote Interferometer System (DRDAS), Data Conversion.

Introduction

White Sands Missile Range, Off-Range Corridor (OFC) consists of a fully instrumented real-time range support at Ft. Wingate, NM, and real-time relay to the main Range Control Center at WSMR. The OFC supports Ballistic Missile Defense Organization (BMDO) target firings from Ft. Wingate, NM. The Off-Range Corridor allows BMDO to conduct long range testing within the continental U.S. The Transportable Range Augmentation and Control System (TRACS), consisting of a Control van and one of two Mobile Telemetry Systems (MTS) provide the necessary on-site telemetry support. Telemetry support consists of two phases. The first phase consists of simulating expected Signal Level, Antenna Tracking Dynamics, Third Order Intermodulation Product Analysis, and the expected time On-Range telemetry systems will acquire the signal. Phase two is the real-time support. Real-time support consists of receiving the data via auto-track and distributing data from the MTS to the TRACS Control Van, Missile Flight Safety Display Van, Project Support Vans, On-Site Data Processing, as well as relaying raw data to the main WSMR Telemetry Data Center. Raw telemetry data is sent via T1 fiber optics links. In addition to the real-time telemetry data support, the Telemetry Branch uses an Interferometer System known as the Dual Remote Data Acquisition System (DRDAS), to track the telemetry RF carrier signal in support of Missile Flight Safety (MFS) early launch. The DRDAS consists of two systems (DRDAS-X and DRDAS-Y). These systems track the missile from lift-off to T+50 seconds and reports if the missile is on course during this critical time.

Discussion

Simulations: Telemetry

Telemetry engineers use the method described in the ITC/USA 96 paper titled “Antenna Pattern Evaluation For Link Analysis“[1], to do a one-per-second trajectory link analysis of the target for the expected trajectory. A post flight analysis is made after the firing to compare the simulation values and the actual flight values for any unexpected events. The computer program also does an analysis of the missile dynamics for the proposed trajectory with respect to the telemetry tracking system location and servo parameters. If the missile expects to radiate more than two frequencies, a Third Order Intermodulation Product Analysis and a Sum and Difference Products Analysis is made. An expected-time-of-acquisition for on-range telemetry systems is also calculated based on the proposed trajectory, terrain, and earth curvature.

Simulations: DRDAS

A simulation of the expected azimuth and elevation angles from the center of the DRDAS antenna fields to the missile along the trajectory is plotted. A 10^0 azimuth and elevation angles cone of the nominal trajectory is also plotted. The simulations become real-time plots to assist the Missile Flight Safety Officer determine if the missile is on course. For multiple frequencies the Third Order Intermodulation Product Analysis is very helpful for the DRDAS-X and DRDAS-Y systems because of their proximity to the launcher. DRDAS-X is located one mile behind the launcher and DRDAS-Y one mile west of the launcher. Due to their proximity to the Launcher, the antennas receive a very strong signal with harmonics that can interfere with tracking. Once the signal level is known, the received signals at the antennas can be attenuated to prevent interference.

Real-time Support

The MTS is located 3.5 miles northeast of the launcher at Ft. Wingate, NM. Each data link is fed to two Data Receivers, one Diversity Combiner, a Bit Synchronizer, and finally to a Distribution Amplifier. The video data is distributed to analog and digital recorders plus an output to the Data Distribution Center. Signal strength recording for each data receiver is done on a strip chart recorder. One output of the Data Distribution Amplifier is sent to the Data Distribution Center approximately 400 feet away via four (4) RG/59 cables (See Figure 1.0). The current setup uses four sets of cables to include redundancy. Cable tests of the RG/59 cable determined that equipment may be separated up to 1000 feet without increasing the BER. At the Data Distribution Center, the data is fed to a Bit Synchronizer and a Multiplexer then distributed to the required destinations. Two sets of cables are fed to the Communications Van where they are mated to two T1 fiber optics links. (Only one is needed but two are sent for redundancy).

Results

This data is received at the main Telemetry Data Center at WSMR where it is decommutated and displayed in real-time. On site, the data is decommutated and relayed via RG/59 cables to the Display Van where MFS monitors the Health and Status link plus the IMU data. MFS also monitors the DRDAS angular data for any indications of the missile deviating from the nominal trajectory during the first 50 seconds of flight. The data monitored on-site is also monitored at WSMR in real-time. The MTS on-site has tracked the target to the intercept point or up to within one second of impacting on range. At a T+x seconds, additional range telemetry stations acquire the missile carrier. For T+x, x is a function of the spatial xyz position and time. The on-range systems track the target, and relay the signal to TDC via fiber optics and or microwave systems. This gives TDC a "best source selection" and displays the best data for MFS. Some missions require a more complicated setup. The setup depends on the number of data links, bit rates, TV links, and data formats.

Mobile Telemetry Data Processing Operations

Once telemetry data is acquired by the MTS, the data must be processed and presented to the telemetry customer. At White Sands, the internal customer of the system is the Missile Flight Safety Officer (MFSO) and the external customer is the missile system developer. The Telemetry Data Center (TDC) developed a Mobile Telemetry Data Processing System (MTDPS) to interface to the MTS. Thus satisfying both the external and internal customer mission support requirements. This new capability provides real-time telemetry data processing, archival and display services for WSMR customers at remote testing sites. In an effort to achieve such a goal, an operations strategy was incorporated into the planning of a new mobile support system. This strategy is based on the following three factors:

a) Customer analysis

b) Process-focused Strategy

c) Implementation

Customer Analysis

An analysis to identify the customer, their needs and categorize them was the initial step during the development of the MTDPS. The functionality of the mobile system is based on a customer-driven operations strategy. The design of the MTDPS began with an analysis and assessment of our customer requirements. A process chart (see figure 2.) was developed illustrating all known processes the system is to satisfy. This includes customer interaction through all phases of mission support (e.g. pre-mission checkouts, dress rehearsals etc.). Subsequently, this analysis proved to be the critical first step in the creation of the MTDPS. Therefore, the process chart allowed us to determine the utility of the system, what type of systems would be needed and even how the system is used. Without such an assessment, then the possibility of scarce funds being wasted on capability no one will use becomes a definite reality. The basic MTDPS configuration would have to satisfy the following customer requirements:

- Mission support displays
- Data archival capability
- Communications (data, voice and status)
- Improved customer support environments
- Improved system responsiveness
- Reduced operational and maintenance cost

Process-focused Strategy

The goal of the MTDPS is to provide a self-contained transportable system to support mission preparation, execution, real-time data collection and processing, mission control/flight safety, and quick-look post mission data analysis. This system is used in two configurations:

- Augmentation Configuration: to augment existing range capabilities
- Standalone Configuration: provide complete autonomous support at remote locations

The development of the MTDPS is based on a process-focused strategy. This strategy is incorporated into the planning of not only the mobile system but also all of the TDC's systems.

The ability to satisfy operational requirements in a mobile environment is dependent on two factors, desired capability and availability. In a mobile environment, simple concerns such as space availability have a direct impact on desired capability. System compatibility was also an important factor to consider. If the mobile processor were designed such that it was totally compatible in both software and hardware then it could be used at the main facility when not at a remote testing environment. Furthermore, all of TDC's processors are identical, and are referred to as Telemetry Data Handling Systems or TDHS. Other considerations implemented in the design are as follows:

- **Equipment and work force organized around processes**- the system must be able to process, display, archive and relay data back to a central ground station.
- **Equipment is general purpose-** System should incorporate Commercial-Off-The Shelf (COTS) products to facilitate the operation and maintenance of the system.
- **Engineering Staff must have multiple skills-** In a mobile configuration, a large staff cannot be easily accommodated, and therefore, the staff must be able to satisfy multiple tasks.

All TDHS are stand-alone systems capable of performing distribution, decommutation, tagging, merging, processing, archiving and finally displaying of the data. The TDHS can support operations in any of four possible modes such as preflight, real-time, post-flight and mission simulation exercises. The MTDPS processor is designated as system-D. Whenever the system is not in a mobile configuration, it is resident in the TDC supporting real-time operations; augmenting the other systems. All of the processors are both functionally and physically the same, therefore all software and hardware configurations are the same. Software databases from one system are easily transferred to another.

Implementation

The actual implementation of the MTDPS took into consideration the framework of the goals identified earlier. As part of TDC's modernization plans, new technological trends were analyzed and selected as having a high probability of successful implementation into the real-time environment, both in a mobile or fixed configuration. New support capabilities were accomplished by removing older technologies, and replacing them with newer ones wherever possible.

Modern communications standards and Open Systems (OS) technology were selected for implementation. Commercial off–the–shelf (COTS) products (software and hardware) were identified for integration into the system or modified for use in the MTDPS. The intent was to be able to use new technology to improve the process and arrive at the desired capability as shown by the following:

A. Telemetry Processors

- Front-end equipment for bit and frame synchronization, simulation, time stamping, and high-speed processing.

- A host processor and data storage peripherals.
- Ethernet- 10/100 based network of workstations, terminals, PCs, and other peripheral devices integrated to meet specific application requirements.
- Multiprocessing and multitasking.

B. Improved data storage and access

- All processing systems are capable of digitizing telemetry data in real-time. The direct benefit to MTDPS customers is greater recording capacity at lower cost.

C. Improved display capability

- Real-time telemetry data presentation capability includes interactive displays and improved display environments, which provide accurate dynamic data visualization tool to aid real-time decision making.

The Implementation Schedule for the mobile system is shown as follows:

Implementation Schedule Milestones and Deliverables

EVENT	DESCRIPTION	OBJECTIVE
1	Introduction of Open System Processors	Multi-processing, parallel processing, interoperability, and cost effective.
2	Display Hardware and Software Upgrades	Current systems are non-portable; most software is platform dependent. New displays will install an efficient suite of Windows NT/UNIX displays. Hardware independent. Eventual project will explore the possibility of moving to JAVA based applications.
3	Data Archival	Improve data archival methodologies to provide TDC customers with a greater variety of data products.
4	Networks	Improve TDC LAN 10-Base to 100-Base, with 1GB backbone. This will allow TDC to transfer greater volumes of data in real-time
5	Simulations (Virtual Tools)	Augment real-time displays with simulated data and virtual tools.

CONCLUSION

The White Sands Telemetry Branch has consistently shown it is capable of supporting off-range missions in real-time analysis or for post-flight analysis using only one MTS and the MTDPS. The DRDAS has proven to be an inexpensive and reliable tool for MFS during the first 50 seconds of flight.

REFERENCES

1.0 Pedroza, Moises, "Antenna Pattern Evaluation for Link Analysis", Volume XXXII, page 111, Proceedings of International Telemetering Conference, San Diego, CA, October 1996.

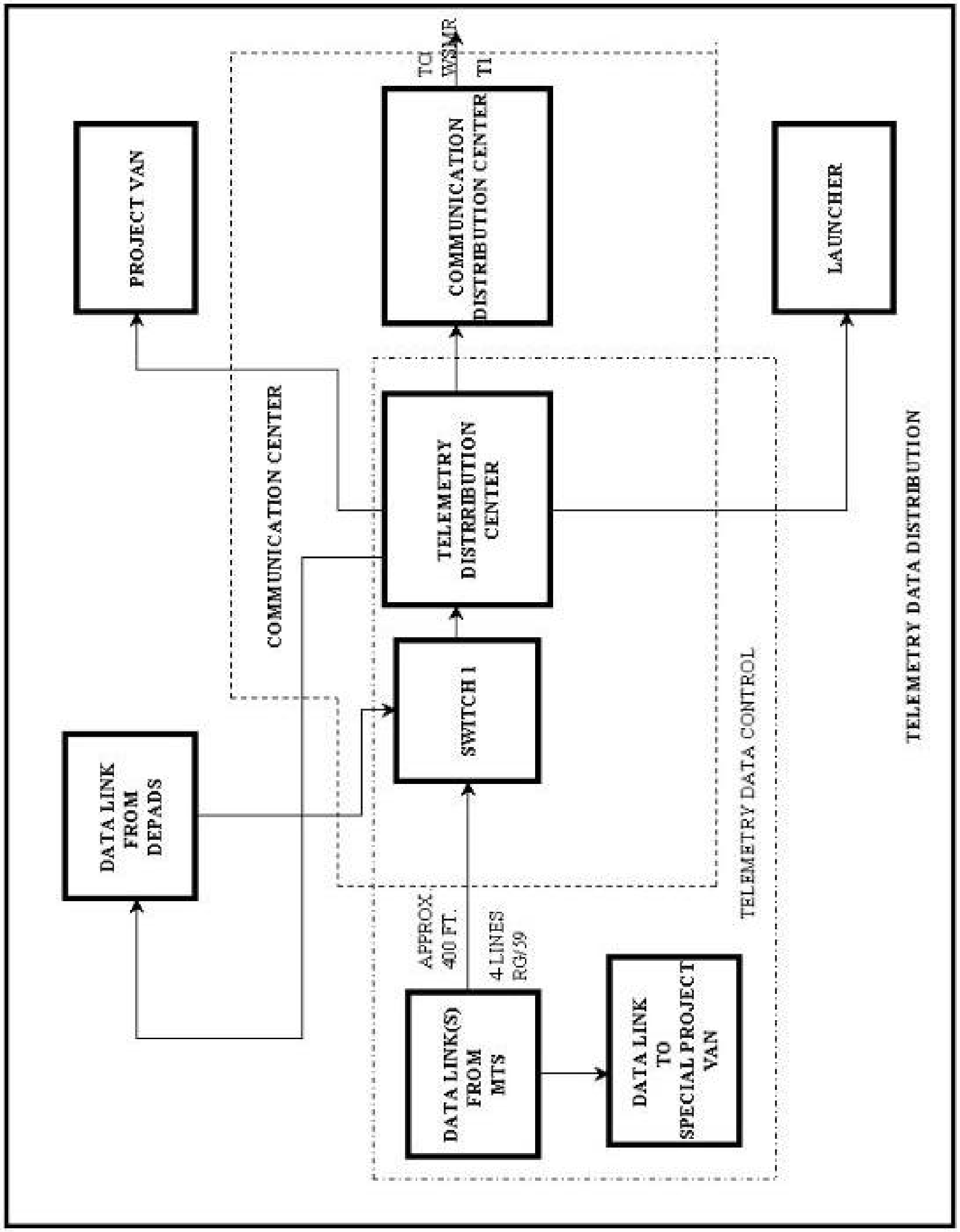

Figure 1. Telemetry Data Process Flow

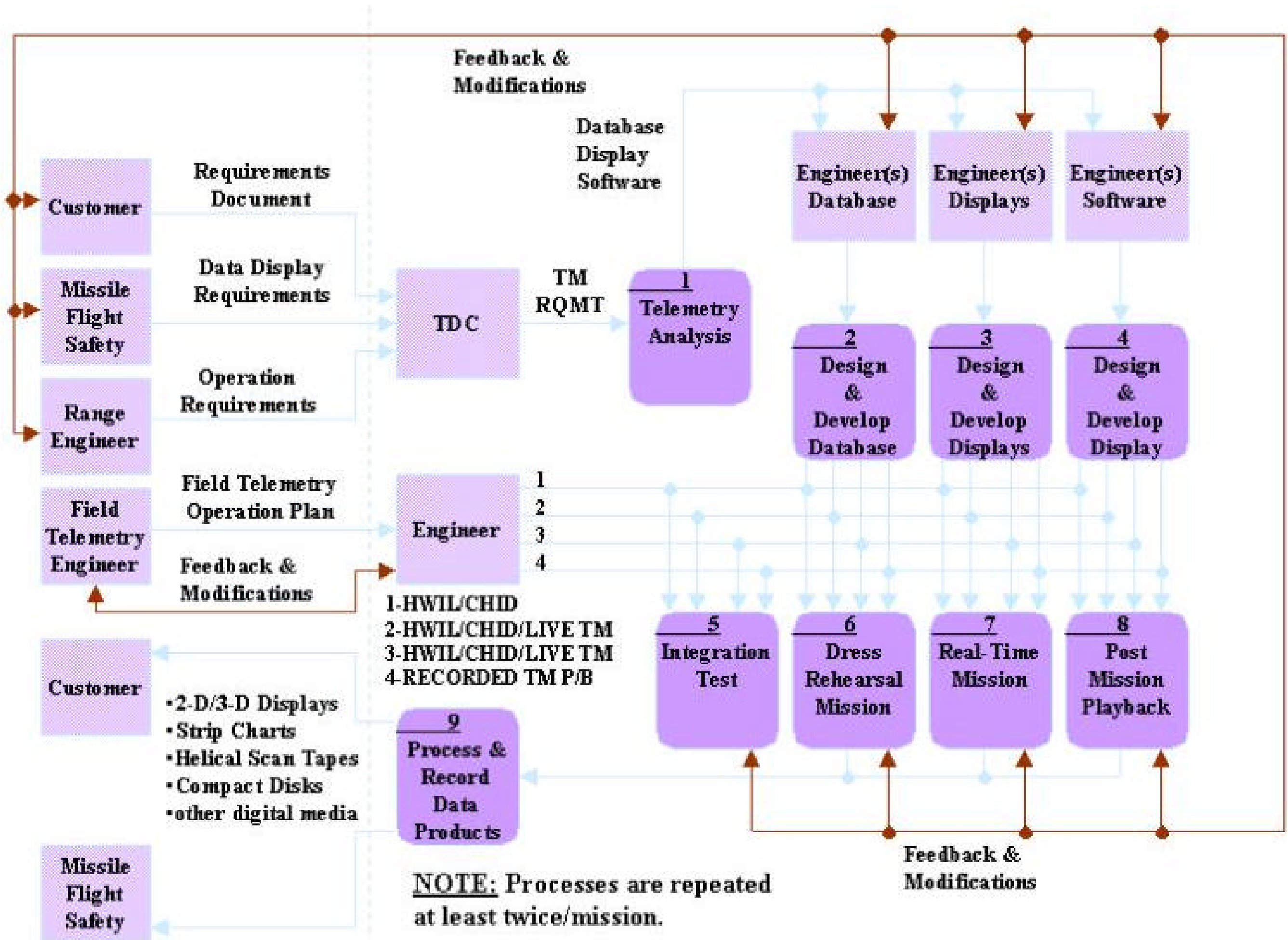

Figure 2. MTDPS Process Flow Diagram