AIR FORCE FLIGHT TEST CENTER
RANGE SAFETY SYSTEM

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ABSTRACT

The Range Division of the 412th Test Wing has recently had to incorporate high power RF transmission, remote monitoring and remote operation of systems to support the new Range Safety function incorporated within the Range. The sub-systems that make-up the Range Safety System are:

Command Transmitter System (CTS)
Command Panel System (CPS)
Instantaneous Impact Prediction (IIP) (modified TECCS)
Range Safety Data Display (ADAPS)
Range Safety Data Recording (RaSDR)
Flight Termination Test Set

Being aware of the increasing importance of cost associated with ground and flight testing, the Range has structured its systems around Commercial Off The Shelf (COTS) hardware and software and remote operations where ever and when ever possible. This paper will outline the Ranges approach to Range safety addressing the rational behind the system design and making the customer happy. We will also discuss typical operations and how the Range maintains redundancy and RCC compliance.

INTRODUCTION

The Range Division of the 412th TW/TSRE is in the process of supporting various Unmanned Air Vehicles (UAV) programs. This support by the range has required the design and implementation of a Flight Termination System (FTS) to maintain the safety of the sparsely located inhabited areas in the flight test area. The FTS, ground segment, is

made-up of the Command Transmitter System (CTS), Command Panel System (CPS) and the Range Safety Console located in Range Operations Center in room 282 of Bldg. 1440.

COMMAND TRANSMITTER SYSTEM (CTS)

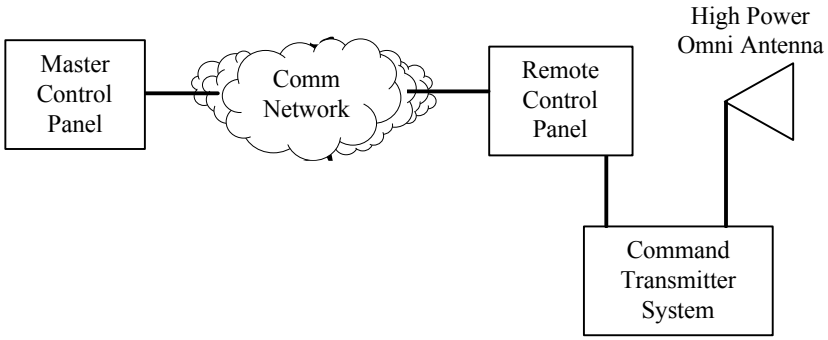
The heart of the FTS ground segment are the redundant 1-Kilowatt transmitters (Figure 1). The CTS #1 is installed in a refurbished Ground Launch Cruise Missile (GLCM) Launch Control Center (LCC) trailer. CTS # 2 is located on the Ranges A-7 site, Bldg. 8022, on the north west side of Rogers Dry Lake. Both CTSs use a 0-dB gain Omni antenna with hemispherical patterns. Both systems are equipped to use a directional helical antenna for longer-range requirements. CTS # 2 was modified so it can be operated and monitored remotely from Ridley Mission Control Center (RMCC).

Command Transmitter System
Figure 1

COMMAND PANEL SYSTEM (CPS)

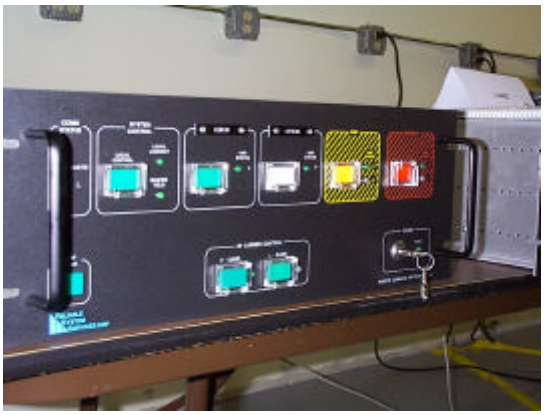
The CPS (Figures 2 & 3) allows remote control of the CTS equipment from the Range Safety Console in Ridley Mission Control Center (RMCC). The CPS is comprised of the Master Control Panel (MCP) and the Remote Control Panel (RCP) (Fig. XX). The MCP and RCP communicate via an RS 232 Asynchronous communications link. The communications between the MCP and RCP are constantly monitored and status displayed on the CPS front panel. The CPS was a joint design effort between the ExTRA - X-33

team and Range Safety personnel. The CPS will be used to support the X-33 launches from Edwards AFB



CPS to CTS Interface Block Diagram
Figure 2

Master Control Panel
Figure 3



Remote Control panel
Figure 4

MASTER CONTROL PANEL

The MCP (Figure 2) is capable of controlling as many as five transmitter systems and the L-Band up-link system, specific to X-33. The MCP is comprised of a CPU, Serial interface and a digital I/O. The programming software for the MCP simply designates control functions for the Monitor, Option, Arm and Destruct push buttons.

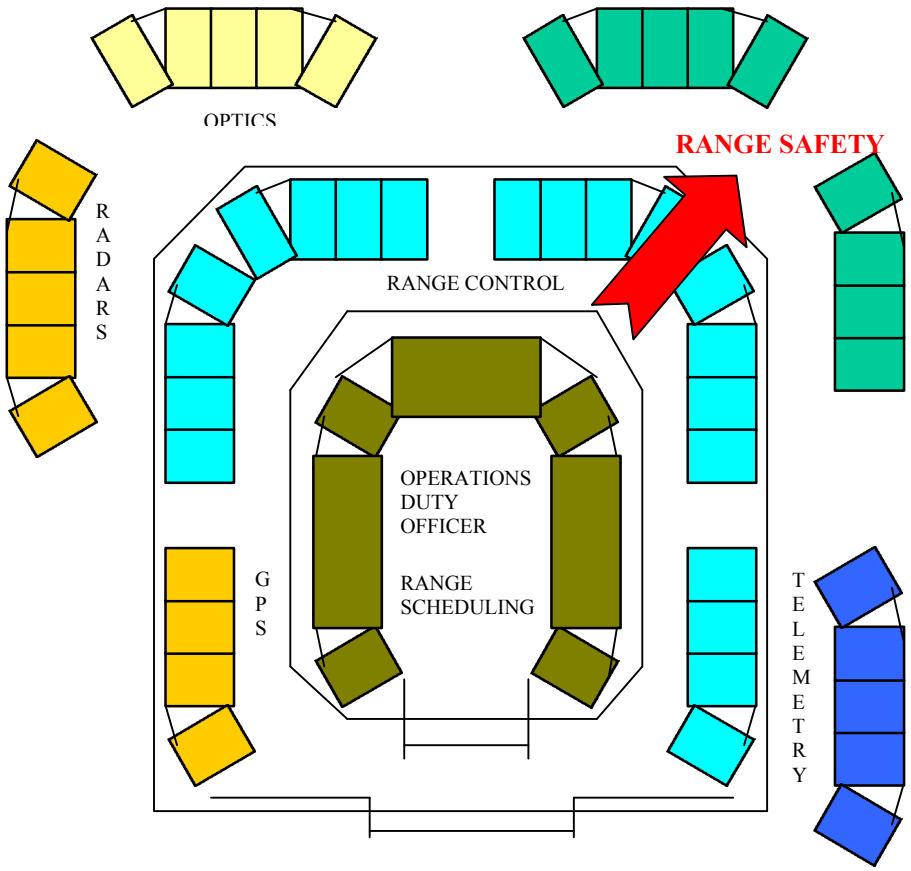
REMOTE CONTROL PANEL

The RCP (Figure 3) receives the commands sent from the MCP and provides the TTL levels necessary for the CTS activation. The RCP may also be used to command the CTS should communications between the MCP and RCP be interrupted. The L-Band function

of the CPS causes the RCP to output a command word data stream, which is up-linked to the X-33 vehicle, initiating the destruct sequence.

RANGE SAFETY CONSOLE

The Range Safety Console (Figure 5) is located in the Range Operations Center of Ridley Mission Control Center (RMCC) Building. The Range Operations Center is the central coordinating location for all activity on the Edwards Test Range. At the center of the room is the Operations Duty Officer (ODO) console. At this console, the ODO and a Range scheduler coordinate all missions using the Edwards Range. Surrounding the ODO console are a ring of Range Control Officer (RCO) consoles. The RSO consoles are used to support individual test missions. Other consoles located in the Range Operations Center control telemetry acquisition systems and Time Space Position System (TSPI) instrumentation systems. By locating the RSO console in the Range Operations Center, the Range Safety Officer can retain situational awareness of the other flight test activity occurring on the Edwards Test Range.



Range Operations Room and Location of Range Safety Console. (Figure 5)

Range Safety Console Picture.
Figure 6

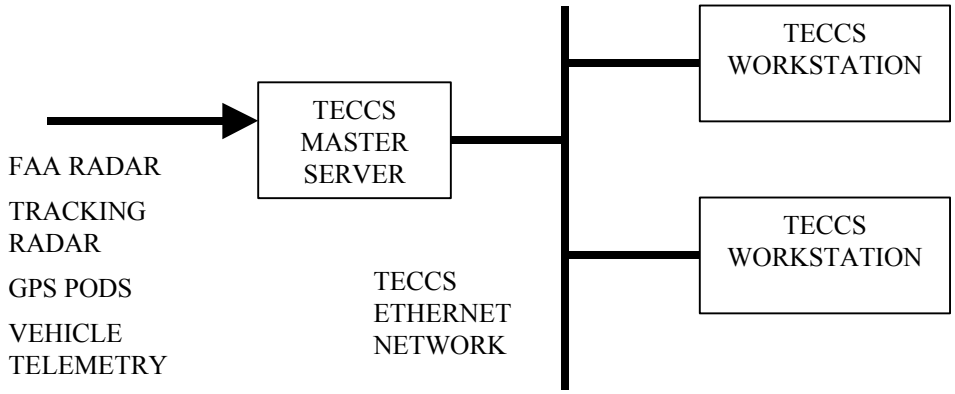
RANGE SAFETY STATIONS

Two individual stations make up the Range Safety Console. This provides the AFFTC Range Safety Office with the capability to support two concurrent test missions or both stations can be operated together to support a single mission for increased system redundancy. Both stations provide the Range Safety Officer (RSO) with all the data and tools necessary to determine the test vehicle performance and as a last resort terminate the vehicle in order to prevent injury and/or destruction of property. Each Range Safety Station provides the RSO Time Space Position Information (TSPI) displays, telemetry displays, and video displays. Communications capability is provided to link the RSO with all the participants in the test mission. Each station also includes the Master Control Panel for the CTS and a system to record CTS waveforms. Nearly all the components used in the RSO console were developed previously for other projects at AFFTC, and were used “off the shelf” to support the Range Safety application.

TIME SPACE POSITION INFORMATION (TSPI)

The Test and Evaluation Command and Control (TECCS) system is used to provide Time Space Position Information displays at each Range Safety station. TECCS accepts input from multiple Federal Aviation Administration (FAA) surveillance radars, local tracking sensors (GPS, tracking radars), and aircraft position information received in telemetry from the RT/PFP telemetry processor. TECCS is a client server system. A TECCS master server at Ridley Mission Control Center transmits TSPI target tracks to client workstations throughout the Range (including the Range Safety Console) in real-time.

The TECCS displays can be pre-configured before each test mission with background overlays displaying the planned vehicle flight path, navigation waypoints, and geographical areas the test vehicle should avoid (i.e. population centers). Vehicle position data is then plotted on top of the background overlay. An Instantaneous Impact Predictor (IPP) program has been developed and incorporated into TECCS. The IIP provides a constantly updating estimate of where debris would fall from a terminated vehicle in real-time. TECCS was developed for the AFFTC by Computer Sciences Corporation and operates on a Compaq Alpha Workstation.



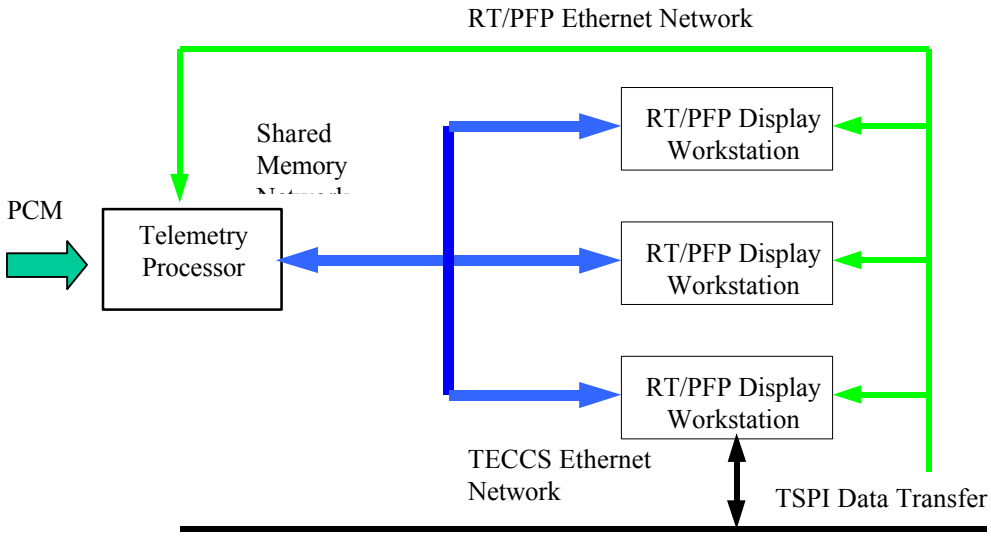
Range Safety TECCS System Block Diagram
Figure 7

TELEMETRY DISPLAYS

Telemetry displays are provided to the RSO console by the RT/PFP telemetry processing system. In parallel to telemetry processing, all telemetry data is recorded on an Ampex DCRSi telemetry recorder. Two RT/PFP workstations are provided at each RSO station. RT/PFP is used to ascertain vehicle health from telemetry including attitude, airspeed, and flight termination system status. The RT/PFP system used for Range Safety is the same system used to provide telemetry processing for the mission control rooms at Ridley Mission Control Center. If the test is being conducted from RMCC, the same telemetry processing system can be used to send telemetry data to both the mission control room and the Range Safety Console. The RT/PFP telemetry processor has the capacity to process up to six streams of Pulse Amplitude Modulation (PCM) telemetry at rates up to 20 Mb/ps. Multiple test vehicles can be supported concurrently if required. The telemetry processor configuration can be switched from one UAV to another in less then 2 minutes to support back to back test missions at AFFTC. All RT/PFP telemetry attributes information is loaded from a single Iomega Jaz removable hard disk.

After processing in the RT/PFP telemetry processor, data is transferred to the RSO console RT/PFP workstations by a Universal Memory Network (UMN) shared memory system.

An Ethernet network is also used to command and control the RT/PFP system. The RT/PFP enhanced version of the DataViews software package is used to display telemetry on a SGI Indigo^2 Workstation. Workstation display configuration can be changed in real-time by the users if needed. Engineering Units data can be recorded on the telemetry processor or by each individual workstation. Another RT/PFP workstation is used to run software that places aircraft telemetry data onto the TECCS network for display on TECCS. Two data analysis applications were developed for Range Safety. One application is a graph used to indicate aircraft altitude. Waypoint data is loaded into the application when it is executed. Commanded altitude is then displayed for each waypoint. The graph then displays whether the test vehicle is above or below the commanded altitude.



RT/PFP System Diagram
Figure 8

VIDEO DISPLAYS

Video displays at each Range Safety Station are connected to the RMCC Video Control Center (VCC) PESA video switch. Any video source entering RMCC can be displayed at the Range Safety Console. The RSO can change video sources using a video source selector at each station or VCC can perform the change. Possible video sources include video telemetered from the test vehicle, video from tracking radars, and video from telemetry trackers. VCC has the capability to record any video source entering the Range for review at a latter time.

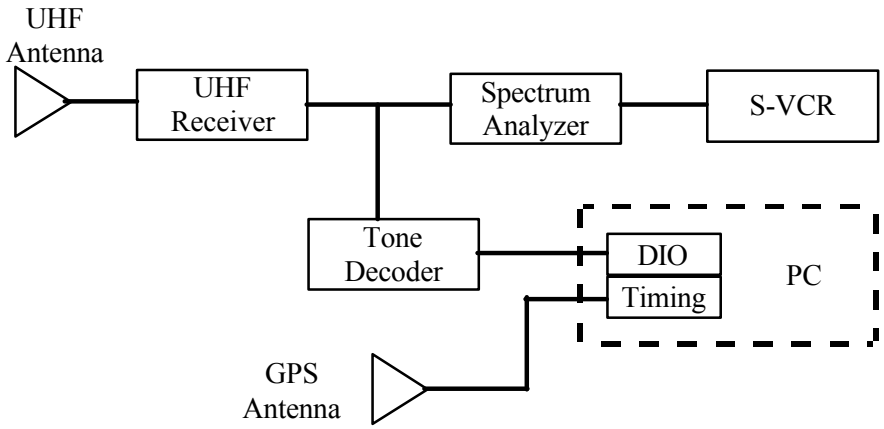
RANGE SAFETY COMMUNICATIONS

The Edwards Digital Switch (EDS) provides communications for the Range Safety Console. Subscriber Terminal Units (STU) the end device for the EDS system are installed

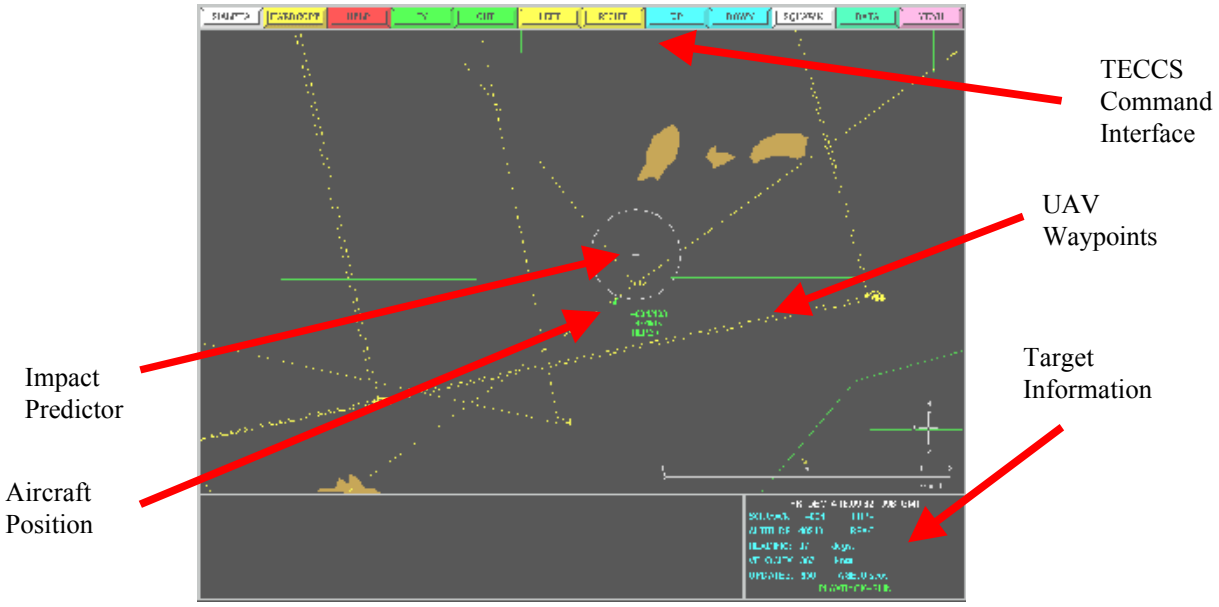
in each RSO station. Each STU unit has the capability to provide 18 channels of communications to the RSO. The STU combines air to ground communications, intercommunication networks, and telephone communications into a single device. For Range Safety, the capability to interface to the Edwards Trunked Radio System was also added. This RSO is able to communicate with the public safety personnel at Edwards (Fire, Security Forces, and Ground Safety). A hand held radio is also located at the RSO console to provide direct communications with the command transmitter site in case of EDS failure.

CTS RF WAVE FORM RECORDING SYSTEM

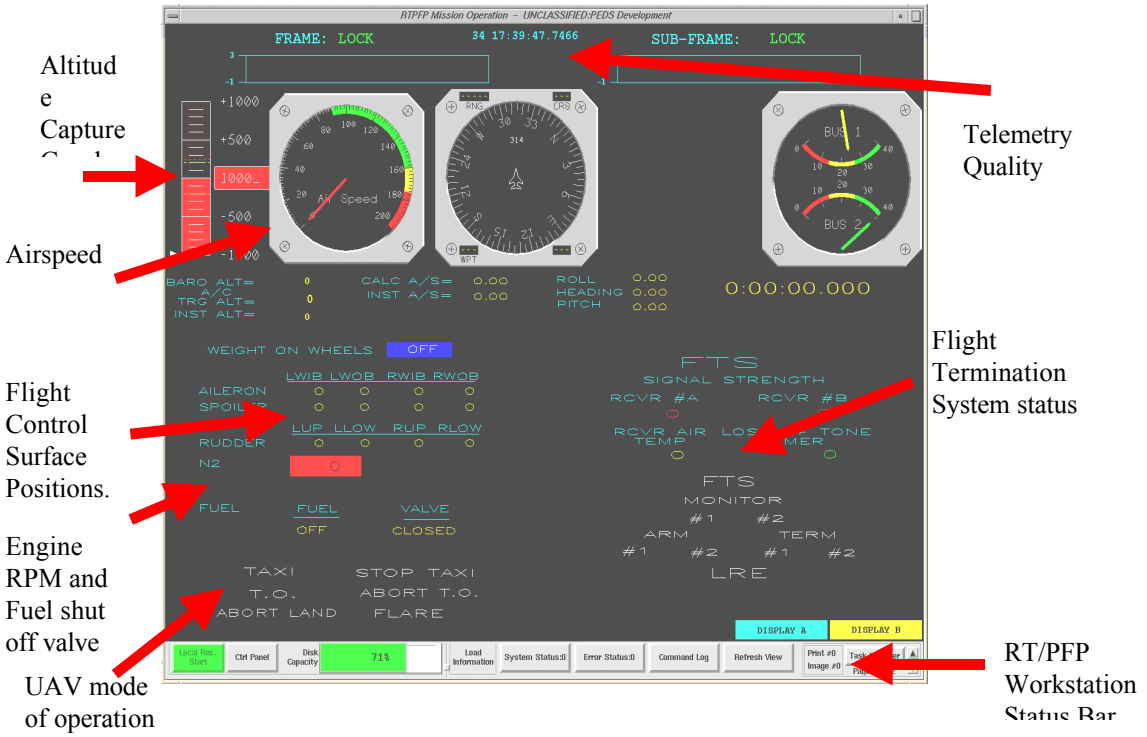
Based on the data provided by TECCS and RT/PFP the RSO will use the MCP to control the CTS. The CTS RF waveforms are received at the RSO station using an UHF receiver and a spectrum analyzer. The CTS RF waveforms are recorded on a VHS recorder located at each RSO station. IRIG time is inserted into the video before recorded to provide reference time. Before each test mission, the CTS system is tested, and the RF waveforms are recorded on tape. The CTS RF waveforms are then recorded during the test mission to provide a record of CTS operation. The Range also uses a PC system with a tone decoder to record and time tag all tones transmitted from the CTS during a test mission.



CTS RF Waveform Recording System Diagram
Figure 9



Range Safety Time Space Position Display
Figure 10



RT/PFP Typical Range Safety UAV Telemetry Display
Figure 11

CONCLUSTIONS

At this time, two command transmitter systems have been installed and the Range Safety Console installation has been completed at Edwards AFB. This system provides both a local Range Safety function at AFFTC, and the capability to extend system coverage with a mobile capability. This development was completed by reusing components developed for previous development programs at AFFTC, re-using discarded equipment, and by using off the shelf components. This development strategy provided the quickest route to completing this project on schedule, under budget, while also providing a quality product to be customer the AFFTC Range Safety Office. Several UAV projects have been supported by this system and we plan to support many in the future.