

# **REAL TIME DIGITAL STRIP CHART EMULATION**

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## **ABSTRACT**

The efficiency of range telemetry as currently practiced is somewhat limited by the display technology employed. The manpower, space, and accuracy problems associated with current methodology are examined. The limitations of some new approaches are discussed. The concept of Real Time Digital Strip Chart Emulation (RTDSCE) and the benefits inherent to such a technical approach are presented and discussed in detail. These benefits include reduction of manpower and space requirements by the use of the workstation concept, the elimination of D/A conversion by direct recording of digitized signals, and the facilitation of critical realtime viewing through high resolution video monitoring.

## **INTRODUCTION**

The efficiency of range telemetry as presently practiced is somewhat limited by the display technology employed. Direct pen writing strip chart recorders continue to be the display instrument of choice because they are the only chart recording devices which are truly real time. In contrast, array writing recorders have not been well suited to flight test because they are not real time devices. While pen recorder technology has kept pace with the general electronics industry, there are still limitations associated with the use of an analog machine in the digital flight test environment. The Real Time Digital Strip Chart Emulation process is designed as an integrated telemetry display process which utilizes current technology to overcome most of the limitations of pen and array recorders.

## **BACKGROUND**

Early in the history of telemetry, range display facilities were designed around the strip chart recorder. Each pen represented an important parameter of any given test. But telemetry was a perfect application for digital technology and soon much of the processing of telemetry data was computerized. This meant that data which originated as analog was

digitized on-board and remained digital through the telemetry stream until it came to the display step, where it had to be D/A converted to be compatible with the analog strip chart. Not surprisingly, most installations still follow these same processing steps. The investment in D/A conversion equipment and system design has been great while there has been no suitable digital strip chart equipment available as an alternative.

Advances in the sophistication of air and spacecraft placed increased demands on telemetry processing capability. A dozen strip charts quickly grew into several dozen, or a hundred, or more each requiring set-up and calibration by a trained technician. Further, each and every test may require totally different procedures. During a mission, a skilled operator can only monitor a few of the many units in one room. The result is a tremendous requirement for manpower. While these personnel are highly skilled and dependable, each step in any process that involves human intervention is a potential source of error. Before a new process can be defined, an analysis of current techniques and equipment is in order.

## **CURRENT SOLUTIONS**

The current solutions for telemetry data display and quick look viewing include pen writing strip chart recorders, light beam oscillographs, and linear array recorders. Each has its own advantages and disadvantages (see figure 1).

### **Pen Recorders**

The pen strip chart recorder has been the standard telemetry display device since the early days of the US space program. This type of recorder is by nature a real time device. The writing system is designed so that the moving pens can be easily viewed as they record telemetry data. If a vital parameter goes critical during a mission, the user can see it immediately and take action.

Because of the mechanical inertia in the writing system, pen recorders are limited to recording signals up to about 100Hz. Also, as analog machines they require manual calibration and adjustments such as limit setting and scaling. These set-up operations can become very operator intensive as they must be repeated for each channel of data on many strip charts.

Another disadvantage is the required D/A conversion step itself. Once the data is in analog form, it is susceptible to noise that could obscure vital information. Sources of noise could be connections of dissimilar metals or electromechanical noise induced in analog signal cabling.

## Telemetry Data Monitoring: Current Solutions

Display Technology	Advantages	Disadvantages
Direct Writing (Strip Chart)	<ul style="list-style-type: none"> <li>- Viewable pens ideal for real time quick look.</li> <li>- Ink units provide permanent trace on non- fade paper.</li> </ul>	<ul style="list-style-type: none"> <li>- Limited Frequency response</li> <li>- Analog machine:               <ul style="list-style-type: none"> <li>* requires D/A conversion for data display.</li> <li>* requires manual calibration and setup.</li> </ul> </li> </ul>
Indirect Writing (Light Beam Oscillograph)	<ul style="list-style-type: none"> <li>- High paper speeds</li> <li>- High frequency response</li> </ul>	<ul style="list-style-type: none"> <li>- Analog machine:               <ul style="list-style-type: none"> <li>* requires D/A conversion for data display.</li> <li>* requires manual calibration and setup</li> </ul> </li> <li>- Delay in viewing of data while paper develops.</li> <li>- Photo paper subject to fading under ordinary room light.</li> <li>- Minimal computer interfacing.</li> </ul>
Linear Array	<ul style="list-style-type: none"> <li>- Machine digital by nature.</li> <li>- Minimum of moving parts.</li> <li>- High frequency response.</li> <li>- Printer/plotter capability.</li> </ul>	<ul style="list-style-type: none"> <li>- Delay in trace viewing unacceptable in realtime critical applications.</li> <li>- Thermal paper subject to fading.</li> <li>- Low chart speeds with thermal array</li> </ul>

**Figure 1.**

## **Light Beam Oscillographs**

For recording of signals faster than 150 Hz, light beam oscillographs are preferred because of their high frequency response and fast paper speeds. The disadvantage of this technology is the inherent time delay associated with the developing of the trace on the photosensitive paper. Also, the life of the data is short because the traces fade under ordinary room lighting conditions.

Like the pen recorder, light beam oscillographs are analog machines requiring manual calibration and setup to assure that all output will be properly formatted and scaled. Additionally, since LBOs use somewhat obsolete technology, many products have not been redesigned for 10 years or longer. Hence they lack the current computer interfacing capabilities to allow remote control from a host mainframe.

## **Linear Array Recorders**

Advances in digital technology have led array recorders to be used for telemetry display. The two principle writing methods are electrostatic array and thermal array. These machines have specific advantages that make them attractive for telemetry data display. Since thousands of styli make up the print head, data must be processed in digital form and a microprocessor determines which of the styli will be activated for printing graphical data as well as text. As strip chart emulators, array recorders can potentially eliminate both the D/A step in data display and the manual calibrations required by analog recorders. Also, the array writing technology improves bandwidth well beyond that of pen recorders.

Current array recording technology does have a limitation that prevents it from being the primary display device during realtime critical missions. This is a slight delay from the time the data is printed to the time it emerges from the recorder and can be viewed. This problem makes the stand alone array recorder unsuitable when safety of flight is the primary consideration.

## **REAL TIME DIGITAL STRIP CHART EMULATION (RTDSCE) PROCESS**

When defining a new approach to telemetry data display the following requirements are vital:

1. The process should allow the data to be viewed in real time.
2. The process should eliminate the need for a D/A conversion for display.
3. The process should minimize the amount of required operator intervention.

These goals should be achieved with consideration given to the limited space available in telemetry ground stations. The RTDSCE system which fulfills these requirements is intended to replace the strip chart recorder as the primary data display device. It is composed of four subsystems: a realtime controller, a dedicated keyboard, a high frequency video monitor and a high speed printer.

## **Controller**

The system is centered around a controller which manages all inputs in real time. These inputs include digital telemetry data from a processor or front end equipment, control inputs from a host computer and manual inputs from the operator. Data is merged with critical information such as scales, engineering units, time code, user text and grid lines resulting in a flexible display and permanent record.

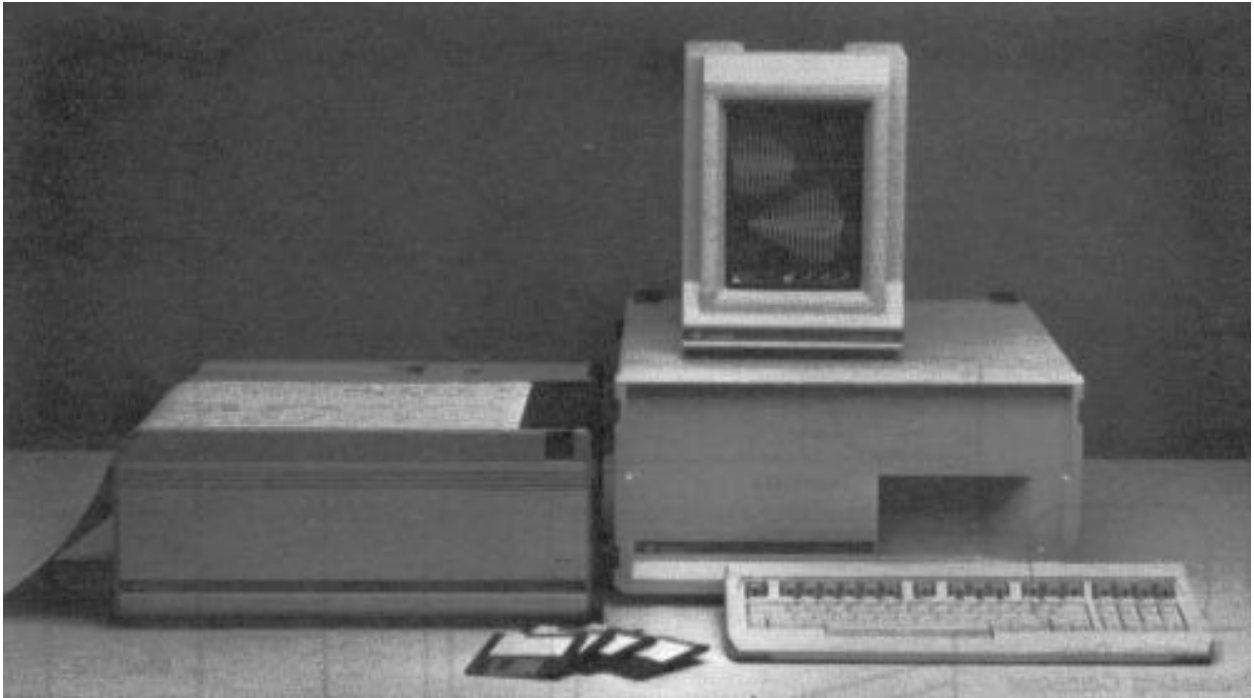
The controller can be programmed locally using the monitor and keyboard. The user has full control over the display format including trace width, grid lines and text. Once the required format is programmed, the configuration can be stored via a floppy diskdrive resident in the controller. This allows the set-up for a particular type of mission, say the test of a specific vehicle, to be stored and on subsequent missions involving the same vehicle, the configuration can be quickly retrieved and the system set up time is minimal. Since the data is handled in noise free digital form, all scaling and signal limits information can be programmed and stored thus eliminating many redundant operator tasks.

A built-in word processor can store up to 12 pages of user text and up to 32 pages of “on-the-fly” messages. User text can be printed as an introduction to the test record. “On-the-fly” messages are printed immediately upon receipt of a preselected character from the keyboard or host computer. They are used to document events that occur during the mission without having to write directly on the chart. For example, the operator could preprogram text for an event he expects during the mission. When he observes the occurrence of the event, he presses a single key to print the message. Alternately, if the event can be detected by the telemetry data processor, printing can be achieved by a command over the interface between controller and processor.

## **Display**

The video monitor is considered the primary display device. All test data is scrolled in real time across the screen with high resolution. The monitor size may be selected based on viewing requirements and the size of the room: 9 inch screen for workstation type set up, 20 inch for across the room viewing and 12 inch for mid-distance operation. The monitor also acts as a prompting device during off-line set-up. Hard copy is generated by a high speed electrostatic printer operating at .25 to 500mm/second. These speeds are

independent of the scrolling speeds of the monitor. The chart recorder and monitor can be configured to display different signals simultaneously. For example, the system can be configured so that only the realtime critical signals are viewed on the monitor while the chart recorder prints all parameters.



**Figure 2. Real Time Digital Strip Chart Emulation subsystem components: Printer, High Frequency Video Monitor, Controller, Keyboard.**

### **Digital Recording**

The controller receives formatted digital signals via a 16-bit parallel interface or an 8-bit parallel (IEEE-488) bus. The system displays a reconstructed analog representation of every channel without the need for DACs and analog cabling. Position and scale can be quickly changed by the local operator or host mainframe. Up to 80 channels may be received simultaneously and when data is being acquired at a rate faster than the display (or print) rate of the the system, a peak capturing routine displays all fast transitions and transients at full amplitude. The system can also accomodate up to 80 discrete or event channels.

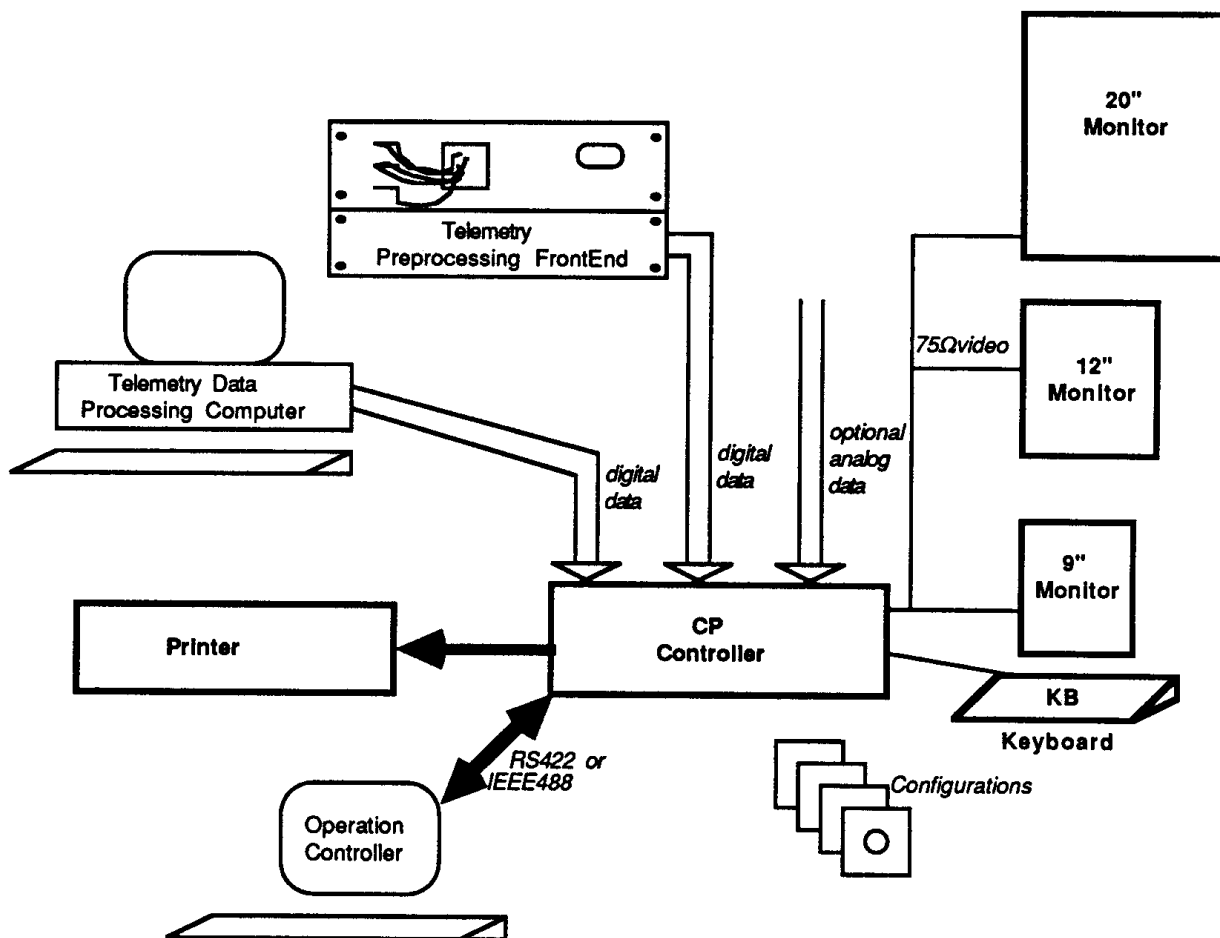
### **System Flexibility**

The controller, keyboard, monitor and printer are all separate modules and need not be located in the same rack. For instance, printers can be placed in another part of the facility, say a chart room, where their noise will not distract mission personnel. Several monitors

may be mounted in the same console, away from the controller, where they can be viewed by a single operator to improve space efficiency. Several slave monitors can be connected to a single controller's redundancy is required.

## CONCLUSION

The Real Time Digital Strip Chart Emulator is an integrated system designed to improve range telemetry efficiency through state of the art data display. As test vehicles become more sophisticated and data processing equipment advances, display devices must keep pace to insure the effective use of available manpower. The RTDSCE system seeks to solve the current display problems with today's technology and improve overall ground station productivity.



**Figure 3. Real Time Digital Strip Chart Emulation in the telemetry data display environment**