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THE NEVADA AUTOMATED DIAGNOSTIC SYSTEM (U)

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THE NEVADA AUTOMATED DIAGNOSTIC SYSTEM (U) ¹

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Abstract

The system design criteria, progress to date, and planned future development of the Nevada Automated Diagnostic System are presented.

NADS is a centralized, digital, data acquisition, transmission and analysis system being developed by LLL and EG&G. It is designed to expedite the diagnosis of underground nuclear tests and their effects.

The system described consists of a time-shared central controller and processor; a Digital Equipment Corporation PDP-10, with numerous standard peripherals and specialized interfaces. Data from Forward Area experiments is assembled in a forward communication facility - NADVAN - transmitted to a Control Point facility - NADCEN - and recorded or processed in real time. The data thus acquired is available for experimenters to process, as appropriate, in an interactive, time-shared, manner. The controller also provides for control and monitoring of data gathering equipment.

Standard units which have been developed to acquire test data in a digital form are described. Criteria are presented which will allow experimenters not directly associated with NADS to interface non-standard units. The manner in which NADS provides a general utility to link an experimenter and his data gathering equipment is detailed.

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Introduction

Data acquisition and recording techniques currently in use at the Nevada Test Site have developed over a number of years. These techniques emphasize the careful handling and capture of an analog phenomenon with post-event analysis of this signal, usually on a digital processor. This form of data collection has resulted in complex, highly specialized self-contained, stations clustered in a recording trailer park near event surface ground zero. As the complexity of field experiments, both in individual experiment sophistication and in numbers of experiments has increased, the transmission and recording of data in the Forward Area has become a major expenditure of both manpower and material.

The Nevada Automated Diagnostic System (NADS) concept was developed to apply the most modern technology available to the NTS data acquisition and analysis effort. Four principal design goals were identified:

1. To provide a reliable system which, with smooth transitions and minimum cost:
 - a. Meets the requirements of existing measurements.
 - b. Can be expanded to serve increased channel requirements.
 - c. Can be adapted to incorporate new measurement techniques.
2. To transform data to a digital representation at the earliest possible point in the processing path.
3. To minimize Forward Area setup and maintenance manpower requirements.
4. To provide the capability for remotely controlling experiments in an interactive manner through a central location for:
 - a. Setup,
 - b. Calibra
 - c. Mainte.. agnostics,
 - d. Repair
 - e. Dry-run and event data acquisition.

From these principles, NADS has evolved as a hardware-software system. NADS is a data acquisition, transmission and processing system that receives signals from experimenters' transducers, and provides digitizing mechanisms, multiplexing equipment, and microwave equipment to transmit the data to a central location. At this central location, in the CP compound, a control processor directs recording, decommutation, and processing equipment and provides, to the user, data in a readily processable form. Return links provide for experimenter feedback for control and configuration of the forward area equipment.

System Configuration

Figure 1 is a simplified block diagram of the NAD System. The left portion is located in the Forward Areas and is initiated with inputs from user transducers. After multiplexing of these data, they are transmitted to NADCEN, Bldg. CP-14, where the data are recorded, processed, and made available to experimenters.

Acquisition Units

The raw data enter NADS through "Acquisition Units". This is a general term for any subsystem which can input one or more transducer outputs and output a digital representation of the input signals. Units currently under development are discussed later in the paper. In general, acquisition units contain interfaces to the Control and Monitor System (CAM) to provide calibration, interactive control, and status checking. Acquisition units fall into two broad categories; low- and high-speed. Equivalent standard systems are FM multiplex trailers and single-sweep oscilloscopes. The distinguishing feature is that the low-speed units generate a continuous signal for transmission to NADCEN. This output signal may be at any bit rate up to 9.83×10^6 bits per second. Standard rates of 75×2^N bits per second are accommodated. The limit of 9.83 Mb/s has been established due to current limitations in multiplexing, microwave, recording, and processing.

The high-speed units contain, or directly interface to, buffer memories. These units handle data with extremely high instantaneous data rates, but of limited duration.

NADVAN

The NADVAN is a Forward Area communications and multiplexing facility. All signals coming from acquisition units are isolated and synchronized. They then pass through up to three levels of multiplexing resulting in a transmission bandwidth of 314 megabits per second. From the point of signal entry to the NADVAN, until the data are safely recorded at NADCEN, the data is handled on parallel, fully redundant, links. This insures that no single component or unit failure can result in the loss of data.

The NADVAN can also contain a small processor and associated memory for control and readout of the high-speed acquisition units.

A further function of the NADVAN is to fan-out the CAM control signals and to multiplex the CAM monitor signals. These signals use a communications path separate from the data path.

Communications

Each event will have two redundant wideband data links. The links are capable of carrying up to thirty 9.83 Mb/s data streams. If more than one event site is on the air at a given time, remote switching will control which transmitters are to broadcast.

For each event site, there will be a dedicated 9.83 Mb/s link. Switching will allow the selection of any of the bit streams to this dedicated link. This allows single channel operation when another event has control of the wideband links.

Each site will also have links dedicated to the out- and back-links of the CAM System. These same links will carry communications for terminals located at event sites.

Data Recording and Interface

At NADCEN the data are demultiplexed and recorded on wide-, intermediate- or narrow-band tape recorders. The wide-band recorders, especially built for NADS, record thirty channels of 9.83 Mb/s for up to one minute. More standard recorders provide longer term recording for data rates of 1.5 Mb/s and below.

The recorders are controlled by the processor, both for recording and playback. A tape search and control unit is used with a special timing code, based on the IRIG A format, which allows one microsecond timing resolution.

On playback, or alternatively, in real time, the data play through bit and frame synchronizers and through interface equipment into core memory or onto disk storage.

NAD-10 Processor

The central processor is an augmented Digital Equipment Corporation PDP-10. This unit is a 36-bit, one microsecond computer currently equipped with 80K words of memory, fifteen million words of disk storage, and a wide assortment of peripheral equipments. Both the memory and disk storage are scheduled for expansion in the near future.

The processor operates under a time-shared operating system and is currently capable of servicing 32 concurrent users. A wide variety of high level programming and application languages are supported.

CAM System

The control and monitor system operates as a slave to the NAD-10. A Varian 620/1 computer formats and transmits commands generated by user programs operating in the NAD-10. In addition it monitors, in real time, the status conditions returned from acquisition units. These conditions are compared with boundary or threshold conditions furnished from the NAD-10 and when an out-of-bounds condition is encountered, the main processor is notified.

User Terminal System

Three categories of user terminals are supported by NADS. For local use there is a system of eight interactive graphic display terminals, which may be expanded to 32 as required. These terminals are capable of displaying data in real time and allow a user to dynamically interrogate or manipulate displayed data. The system is equipped with a hard-copy device for production of 8 1/2 x 11 plots.

Two types of keyboard-send-receive (KSR) terminals are available. In addition to standard teletype, thirty-character-per-second thermal process terminals are available.

Finally, storage-tube display terminals are supported. Both these graphic terminals and the KSR terminals may be used away from the CP area. It is expected that terminals will be supported at event sites for use during acquisition unit installation. These will be serviced over secure microwave links.

Progress to Date

System

The concept of NADS as a system development dates from late 1968. Prior to this a smaller system configured around a PDP-8, had been operating in CP-1. This system had demonstrated the feasibility of making digital measurements on a limited scale. To provide a smooth transition and to allow for the earliest possible testing of system components NADS began participating on events using the FDP-8 as the central processor. From the Fall of 1970 until late 1971 some elements of NADS were on most LLL events. Low-speed acquisition units, wide-band recording, the CAM System and the MADVAN concept were demonstrated to be viable system components. Additionally, several techniques and components of the high-speed acquisition units were field tested.

Beginning with the Diagonal Line event, the PDP-10 and its associated equipment have participated. This participation has been limited, to date, to post-dry run and post-event analysis of the data received.

Acquisition Units

Development work and field testing has been carried out on several forms of acquisition unit:

LoFAU - The first unit developed was the Low Frequency Acquisition Unit (Figure 2). This unit and its successor, the MidFAU, are described in another paper. The unit accepts up to 61 signals with frequency content up to 7 KHz. The unit includes signal conditioners, amplifiers, and a multiplexed analog-to-digital converter and outputs a 9.83 Mb/s data stream. Interfaces to the control and monitor system are included. Resistance and voltage calibration units are internal to the unit allowing remote calibration.

MidFAU - The Mid Frequency Acquisition Unit is now under development. It will provide several improvements including variable multiplexing of the data channels, greater common mode isolation, and several features to ease field operation.

CLIFFER - A unit has been developed to determine shock propagation by measurement of cable length as a function of time. An acquisition unit is capable of measuring seven cables, each every 10 microseconds.

Reaction History - A number of measurement techniques have been developed. The principal tool has been discriminators/time-interval-meters. In addition, a peak detector which provides the time and amplitude of a relative signal peak has been field tested with success. For the slower portions of the signal, ten megasample analog-to-digital converters have been used.

Magnetic Matrix - Advanced R&D has been done on a magnetic thin film recorder. This unit is described in another paper. The recorder has great promise for use as a single transient recorder, however, much development work remains.

Optical Sampling Transient Analyzer - A system to measure very fast transients is being developed. Sub-nanosecond width laser pulses are passed through a traveling wave Kerr Cell and detected by photodiodes. This system can ultimately be expected to yield measurement response for gigahertz signals. Again, much R&D remains before it can be considered for routine field use.

Current Efforts

The development of the system described above is a continuing effort. A major emphasis at the moment is participation in the Diamond Sculls event. We are fielding five LoFAU's to make some 230 measurements. Two of the LoFAU's will be supercommutated yielding only 29 channels each, but providing approximately 15 KHz frequency response per signal. These 230 channels will require only about 20 cable runs to the trailer park, and no trailer park support other than a NADVAN will be necessary.

Once these units are set up and verified to be working all calibration and dry running will be done from NADCEW using the CAM System. Development of software and operating procedures for this calibration is one of the largest efforts projected for preparation for Diamond Sculls.

In addition to the Diamond Sculls participation, NADS is active on many of the LLL events now scheduled. One of the largest efforts now in progress is the development of an integrated high-frequency system for making reaction history measurements. In this system, all measurements will be made using CAMAC modules (CAMAC is a computer compatible successor to NIM modules). Various components mentioned above, e.g. peak detector, discriminator/TIM, A/D converters, etc., are being integrated into this "HiFAU". When available, the HiFAU is expected to replace some 60% of the oscilloscopes now used by LLL.

NADS as a Utility

The system components described above are being implemented in the form of a utility, a data "mass transit system". The most important requirement identified to allow this is the development of standard and easy to use interface techniques. The two interfaces for an experimenter are at the data input and at the interactive computer terminal. For data input two prime means of interface are identified. The user may either interface an analog signal with a NADS acquisition unit - most known transducers can be handled by one of these - or the user may present any of the common pulse-code-modulated (PCM) forms of data bit stream to the NADVAN for multiplexing. Very few restrictions are imposed on either method.

At the terminal interface the user will have at his command a large repertoire of routines which function in a dialog mode. These are developed to require a minimum of knowledge of PDP-10 system operation.

In addition to the input and output interfaces required for data flow there is a third, more important, "interface". This is the establishment of an operating staff with an understanding of experimenters' problems, and the ability to help them easily to use the system.

The major components of the system and of the required interfaces are now available and contributing to the testing program. The system has the capability and is developing the capacity to serve not only the LLL experimental community, but also others participating in the testing of nuclear devices. Although, as with any other utility, NADS will exhibit both advantages and disadvantages, we believe that use of this system can relieve experimenters of much of the more mundane efforts and expense of experimentation and thus allow greater concentration on the primary task of devising and utilizing meaningful measurement techniques.

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Figure 1 NADS simplified block diagram

DATA ACQUISITION UNIT, 61 CHANNEL HIGH LEVEL (10MBIT/sec)

Figure 2