Optoelectronic System for Measuring Heights Above a Floor

One technician can take measurements that previously involved four workers.

John F. Kennedy Space Center, Florida

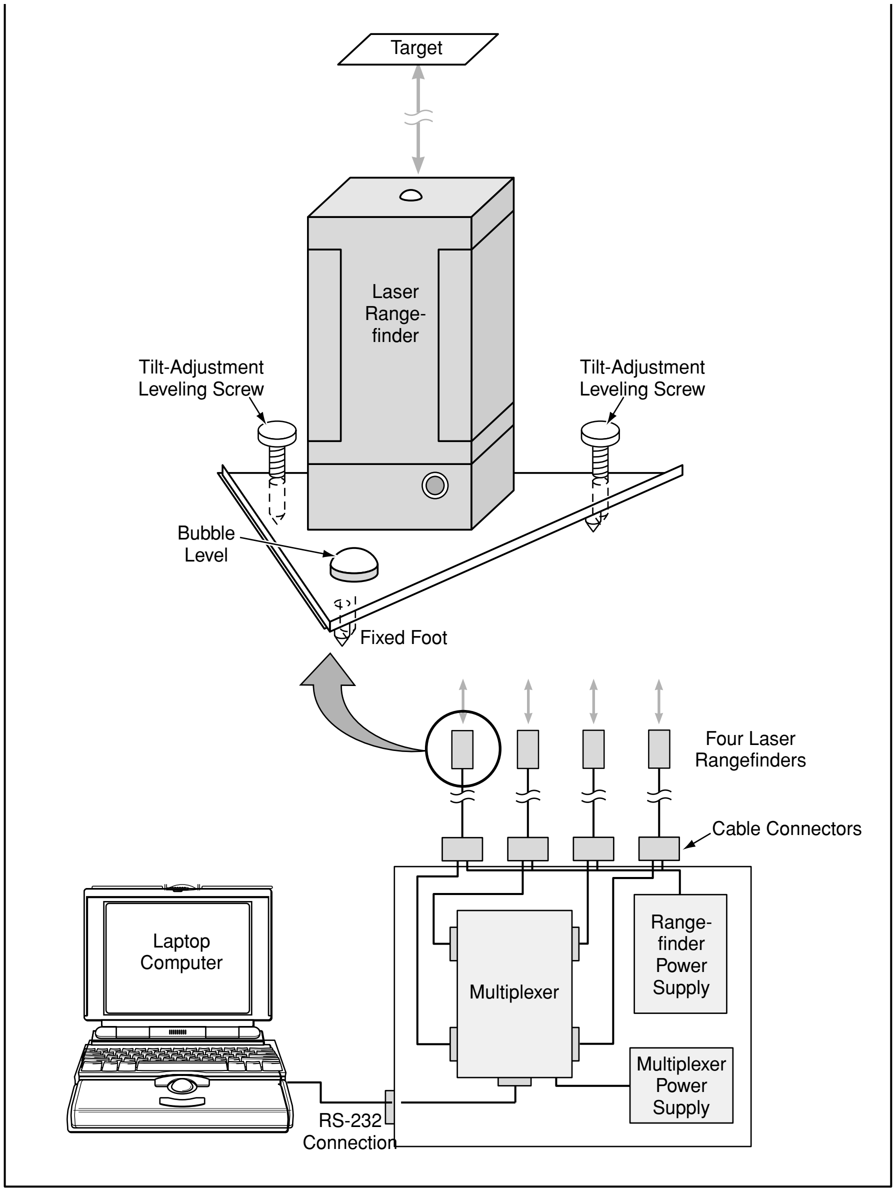
An optoelectronic system has been developed for measuring heights, above a floor, of designated points on a large object. In the original application for which the system was conceived, the large object is a space shuttle and the designated points are two front and two rear points for the attachment of jacks for positioning the shuttle at the height and horizontal pitch specified for maintenance operations. The front and rear jacking points are required to be raised to heights of 198±1/4 in. (502.9±0.6 cm) and 120.6±1/4 in. (306.4±0.6 cm), respectively.

Prior to the development of this system, the measurement for each jacking point involved an error-prone, time-consuming procedure in which two technicians were needed to position two telescoping rods with graduations of 1/16 in. (1.6 mm.), an inspector was needed to ensure that the rods were vertical, and the technicians reported the readings to a fourth person who directed the jacking and leveling from a position 30 to 40 ft (9 to 12 m) away. In contrast, the present system can be operated by one person, and once the initial setup of the system has been completed, the system performs and processes the height measurements quickly on command.

The system (see figure) is based on the use of laser rangefinders to measure the heights. As such, it bears some similarity to the laser-rangefinder-based systems described in “Apparatus and Technique for Measuring Distance Between Axles” (KSC-11980) *NASA Tech Briefs*, Vol. 24, No. 3 (March 2000), page 76 and “Using Laser Rangefinders To Align Two Structures” (KSC-12040) *NASA Tech Briefs*, Vol. 25, No. 1 (January 2001), page 16a.

Each laser rangefinder is mounted on a triangular platform that is placed on the floor below one of the jacking points. The laser rangefinder is aimed upward at a target attached temporarily to the jacking point. The platform is equipped with tilt-adjustment screws and a bubble level to enable correction for any deviation of the floor from flatness. The bubble level is accurate to ±0.2° — well within the applicable tolerance of ±2° corresponding to a height error of ±1/8 in. (0.3 cm).

The four laser rangefinders are connected via cables to a multiplexer located in an electronic enclosure. The multiplexer enables serial data communications between the laser rangefinders and a laptop computer. The computer is programmed with special-purpose software for controlling the rangefinders and the multiplexer.



Four Laser Rangefinders Measure the Heights of four jacking points above a floor. The rangefinders are controlled and monitored via a computer. A complete measurement cycle takes less than three seconds.

The software generates a graphical display containing an image of the space shuttle with vertical bars superimposed at the jacking points to represent the heights. The height readings are displayed numerically. Each bar is also color-coded: green if the height is within tolerance and either yellow, steady red, or flashing red, depending on the sign and magnitude of the deviation from tolerance. The nominal values, tolerances, and/or other height values for triggering the various colors can be set by use of a normally hidden menu in the computer display. Typically, the system takes less than 3 seconds to perform all four distance measurements and process them into the display. In the event of failure of one of the rangefinders, the software generates a “data drop out” message instead of displaying the corresponding height measurement and color.

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Further information is contained in a TSP [see page 1].

KSC-12098

Signal-Conditioning Amplifier Recorders

The cost and complexity of a data-acquisition system would be reduced.

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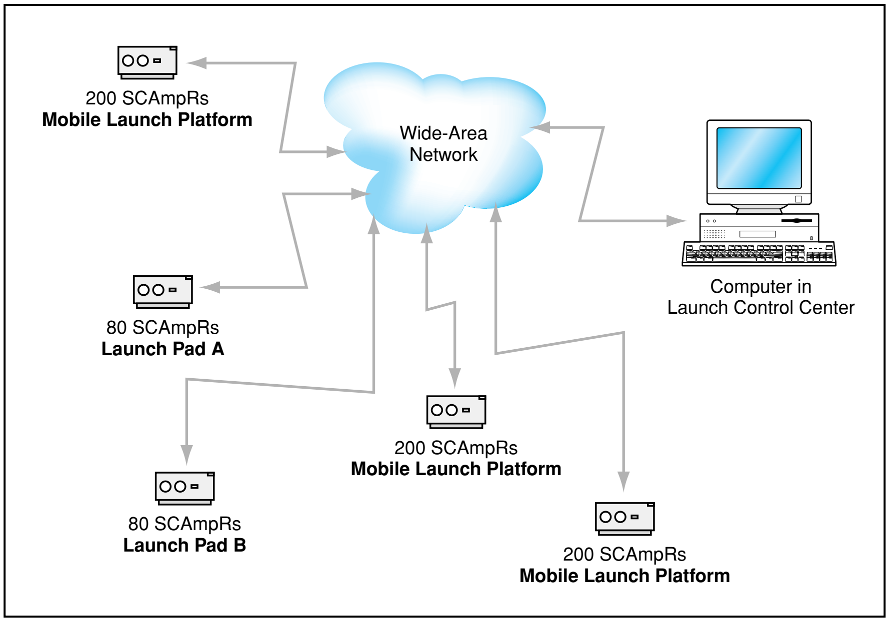

Data Would Be Recorded Temporarily by the SCAmpRs and later transmitted to the computer in the launch control center via the wide-area network. This arrangement is less complex than is that of the present system, in which the data are transmitted to redundant recording equipment via a redundant and more complex system of communication links and interfaces.

Signal-conditioning amplifier recorders (SCAmpRs) have been proposed as a means of simplifying and upgrading the Kennedy Space Center (KSC) Ground Measurement System (GMS), which is a versatile data-acquisition system that gathers and records a variety of measurement data before and during the launch of a space shuttle. In the present version of the GMS system, signal conditioning amplifiers digitize and transmit data to a VME chassis that multiplexes up to 416 channels. The data is transmitted via a high-speed data bus to a second VME chassis where it is available for snapshots. The data is passed from the second VME chassis to a high-speed data recorder. This process is duplicated for installations at two launch pads and the Vehicle Assembly Building (VAB). Since any failure of equipment in the data path results in loss of data, much of the system is redundant. The architecture of the existing GMS limits expansion or any modification to the system to meet changing requirements because of the cost and time required. A SCAmpR-based system is much more flexible.

The basis of the simplification, flexibility, and reliability is the shifting of the recording function to the individual amplifier channels. Each SCAmpR is a self-contained single channel data acquisition system, which in its current implementation, has a data storage capacity of up to 30 minutes when operating at the fastest data sampling rates. The SCAmpR channels are self-configuring and self-calibrating. Multiple SCAmpR channels are ganged on printed circuit boards and mounted in a chassis that provides power, a network hub, and Inter-Range Instrument Group (IRIG) time signals. The SCAmpR channels share nothing except physical mounting on a circuit board. All circuitry is electrically separate for each channel. All that is necessary to complete the data acquisition system is a single master computer tied to the SCAmpR channels by standard network equipment. The size of the data acquisition system dictates the requirements for the specific network equipment.

The computer polls each channel for health status and data snapshots. The bandwidth of the network dictates the extent of the data snapshots. It is likely that in most applications the health status/data snapshot frame can be obtained often enough to pass all data in real time to the master computer. Data is time tagged and stored safely in non-volatile memory at the SCAmpR where it remains for retrieval regardless of the status of the communication network. Once a SCAmpR is commanded to record, no further communication is necessary to successfully complete a measurement. Even the loss of the IRIG time input will not cause a disruption because each SCAmpR channel will automatically revert to generating time if the input is interrupted.

A SCAmpR can record data in any of a variety of ways upon command. For example:

- A SCAmpR can be configured to record and time-stamp data only when a predefined minimum change occurs, for example during a long fueling operation where flows and pressures would normally remain constant.
- A SCAmpR can be commanded to start recording at a future time, for a given duration, so that in the event of a failure of communication at a critical time, data would still be recorded as originally intended. As long as communication continued, the commanded starting time could be adjusted (as would be needed to accommodate a hold in the launch countdown).
- A SCAmpR can be commanded to record data samples at a specified rate or to sample at different specified rates at specified times in the future.

Inexpensive commercial-off-the-shelf (COTS) hubs integrate the SCAmpR chassis into a communications network. Transfer of data and other communications, such as commands and health status, will be performed by a standard method of network communication. The current implementation is a polling form of TCP/IP. Any number of computers can be connected to the network for viewing or rebroadcasting of data snapshots in addition to commanding and monitoring health status of the SCAmpR channels.