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Many electronic dynami positioning systems that use a variety of technologies, such as laser ranging, UHF signal ranging and satellite ranging, are currently available. Wth the advances in technology, these systems are undoubtedly becoming more and more accurate. In fact, real-time submeter accuracy using the differential Global Positioning System (GPS) in a boat, aircraft, or ground vehicle is not unrealistic. However, verifying positional accuracy at this level of accuracy of a moving platform is difficult. Close-range terrestraial photogrammetry offers a proven and accepted method for this verification, using mostly off-the shelf components and technology. Such a system is being developed at the U.S. Army Engineer Topographic Laboratories.

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DYNAMIC POSITIONING SYSTEMS PHOTOGRAMMETRIC TEST COURSE

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ABSTRACT

Many electronic dynamic positioning systems that use a variety of technologies, such as laser ranging, UHF signal ranging and satellite ranging, are currently available. With the advances in technology, these systems are undoubtedly becoming more and more accurate. In fact, real-time submeter accuracy using the differential Global Positioning System (GPS) in a boat, aircraft, or ground vehicle is not unrealistic. However, verifying positional accuracy at this level of accuracy of a moving platform is difficult. Close-range terrestrial photogrammetry offers a proven and accepted method for this verification, using mostly off-the-shelf components and technology. Such a system is being developed at the U.S. Army Engineer Topographic Laboratories.

INTRODUCTION

The U.S. Army Corps of Engineers (USACE) uses a variety of electronic positioning systems, primarily in hydrographic surveying, with accuracies ranging from one to three meters. However, GPS systems of decimeter accuracy or better are currently being developed, and it is anticipated that these systems will be widely used within USACE. The better accuracies are generally accepted within USACE simply through repeated use and comparison with other systems. Actually determining the accuracy of time-tagged positions to a few meters or less is difficult; the faster the system is moving and the higher the test accuracy, the more difficult verification becomes. The U.S. Army Engineer Topographic Laboratories (USAETL) thus began searching for a reliable method to test the accuracies of dynamic positioning systems.

Such verification of positioning systems would require comparison with a system of known and accepted accuracy, or a "truth" system. This system must be capable of approximately two centimeters accuracy while moving at 10 to 15 miles per hour. This reflects the anticipated accuracy of real-time carrier phase GPS and typical speeds of survey boats. Due to limited resources and manpower, the system also must have a total cost of no more than $100,000 and must be able to be operated by non-experts.

USAETL considered several methods, such as laser ranging and comparison with an inertial system. However, photogrammetry was eventually designated as the method that would provide the needed accuracies and could be obtained within the practical constraints. In a study performed by Dr. Kam Wong of the University of Illinois, a positional accuracy of two centimeters was deemed possible using two fixed cameras viewing an area approximately 400 by 400 feet. The speed of the test vehicle could be up to 10 miles per hour. Dr. Wong was instructed to investigate the use of

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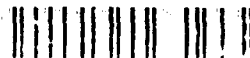
charge-coupled device (CCD) array cameras, since such a digital system would eliminate film processing and provide near-real-time positions. However, an off-the-shelf CCD array system was not available and some custom software develpment was needed. Thus the cost and simplicity of use constraints were not met, and it was decided to use a conventional filmed-based system.

Figure 1 on the following page illustrates the concept of the photogrammetric test system. Two cameras, mounted on tripods, view a designated test area stereoscopically. A vehicle with the positioning system to be tested passes through the test area while logging test positions. A radio link synchronizes the positioning system outputs with the camera shutters, thus producing photographs at the instant that the positioning system logs coordinates. The true coordinates are plotted from the photos and are then compared to the test positions.

SYSTEM DEVELOPMENT AND LOCATION

Shortly after the study performed by Dr. Wong, the Tennessee Valley Authority (TVA), based on their extensive experience with close-range photogrammetry, was tasked to develop the photgrammetric test system. The project was divided into five general tasks:

1. Select and procure the cameras.
2. Develop the test system procedure.
3. Perform tests at home site with existing equipment.
4. Implement system at test course.
5. Perform tests with system at test course and instruct USAETL personnel on use of the system.

A suitable location for the test course was found on the grounds of the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland. The area has clear unobstructed views for the cameras and has favorable terrain relief needed for precise determination of three-dimensional coordinates. Also, personnel at NIST are available for validation of camera and photogrammetric target monuments.

TEST COURSE

The test course, as shown in Figure 2, is an area 400 by 450 feet. The two cameras are positioned 400 feet apart on the front line. Eight photogrammetric targets are positioned along two parallel lines within view of the cameras. The vehicle with the test positioning system travels between the two lines of targets, logging test coordinates and simultaneously activating the camera shutters through a radio link. Each target consists of a four foot vertical range pole with two small spheres, one at the top and one near ground level. This design will be easily identifiable in a photograph and will give unambiguous points for stereo plotting. The layout of the targets and the test course produces the optimum geometry for obtaining the needed accuracies from plotting.
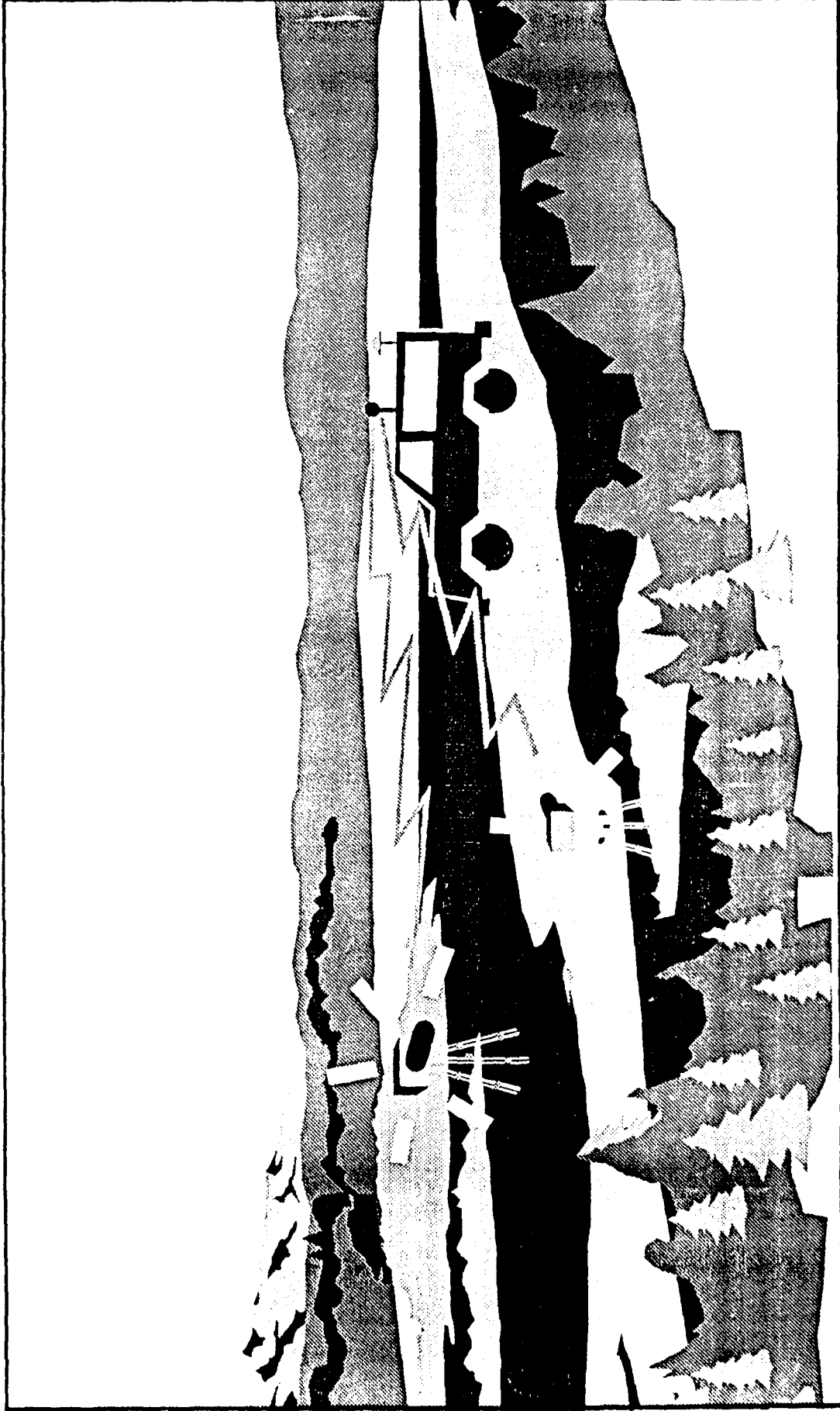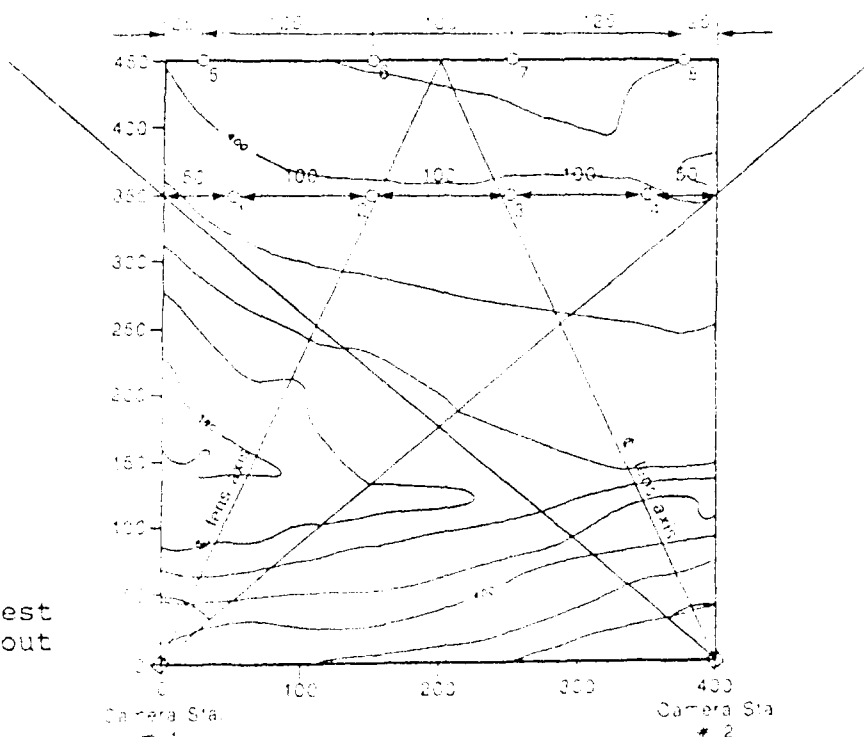
Figure 1 Photogrammetric Test System Concept

Figure 2 Test
Course Layout

TIME-CORRELATED PHOTOGRAMMETRIC SYSTEM

Most positioning systems output coordinates at some fixed time interval. This signal also will be used to activate the camera shutters through an on-board radio transmitter. The cameras to be used for this project are Rolliemetric 6006 metric cameras with built-in grid, focusing stops and factory calibration. The initial positioning system to be tested will be a GPS unit since USAETL is currently developing such systems for hydrographic surveying. The GPS units to be used have a pulse-per-second output which will be amplified and then transmitted to the camera driver. It is anticipated that other, non-satellite based systems, such as UHF ranging systems, also will be tested, and these also have output pulses that can be used to drive the cameras.

Time Correlator

In order to achieve the precise synchronization needed for the 2-5 centimeter positioning accuracy, timing between the positioning system and the cameras of less than a millisecond is needed. This requires that the transmitting and mechanical delay due to the shutter be determined. This delay is then used to advance the transmitted signal to the cameras.

A time correlator was developed by Dr. K.S. Yang of the University of Illinois to measure this delay. This device has a panel of six rows of high-intensity LEDs. Upon

receiving the start signal, a set of counters begins accumulating pulses at a precise rate of 5000 Hz. Thus each pulse represents 0.2 milliseconds of time. The contents of those counters are displayed on the top three rows of LEDs. The rows are arranged in 1X, 10X and 100X unit intervals, each unit being exactly 0.2 milliseconds. The start pulse also is used to activate the camera shutters. A photograph of the correlator panel is then taken. After the film is developed, the exact time the shutter opens, as measured in unit intervals, is indicated by those LEDs that are lit. The bottom three rows of LEDs are used to measure the time the shutter stays open. The LEDs in these rows are lit individually in sequence at the unit interval rate. Each LED stays on for precisely 0.2 milliseconds. The first LED in the fourth row lights up in synchronization with the start pulse. The total number of LEDs seen lit within this group on the developed film is the aperture time measured in terms of the unit interval.

System Operation

A clock within the transmitter is then synchronized with the output pulses of the positioning system. This is done by observing the signals on an oscilloscope and setting the transmitter clock accordingly. The time delay determined by the time correlator is then entered into the transmitter. The camera pulse is then advanced according to the transmission and shutter delay, producing a photograph at the instant of the positioning system output.

SYSTEM DEVELOPMENT STATUS

The complete photogrammetric test system was to have been developed by September 1990. However, some errors were found in the custom options in the cameras shortly after the cameras were received from the manufacturer. TVA is awaiting receipt of the corrected cameras, at which time in-house tests with the time correlator and transmitting unit will begin. It is anticipated that the system will be installed on the test course and trial runs will begin in April 1991.

As mentioned previously, the initial system to be tested will be a differential GPS system. The transmitter and time correlator will initially be configured to receive signals from an Ashtech 12-channel receiver. Tests on other terrestrial electronic positioning systems that are used for hydrographic survey also are anticipated. Since these systems commonly involve range transmitters located several miles away, the photgrammetric system may be ported to a harbor area in which the cameras are mounted aboard a survey vessel and the photgrammetric targets are mounted on shore. The cameras thus become mobile units moving with the positioning system to be tested.

REFERENCES

Wong, Kam W. 1989, _Precise Dynamic Photogrammetric Positioning Systems_, Contract Number DAAL03-86-D-0001 with the Army Research Office.

Yang, K.S. 1989, _An EPS/GPS Time Correlator_, Contract Number TV-79393T with the Tennessee Valley Authority.