ADVANCES IN RADAR TRAINING

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INTRODUCTION

Radar operator training has traditionally been accomplished by a combination of instruction utilizing either radar simulators or the operational equipment. Typically, training can be conducted more effectively with the radar simulator where the simulator reproduces the characteristics of the operational radar system to a high degree of accuracy.

Simulating the ground mapping modes of radar has proved to be a technical challenge because of the large quantity of data to be stored, retrieved, processed and displayed. Accurate ground mapping radar simulation, nevertheless, is required by the Armed Forces to provide realistic training and at the same time reduce flight time required for radar training on the operational equipment. Digital Radar Landmass Simulators (DRLMS) currently being delivered to the Navy and the Air Force by Honeywell are proving to have the simulation fidelity necessary to train radar operators in a ground-based device.

TRAINING WITH DRLMS

The Digital Radar Landmass Simulator (DRLMS) devices built by Honeywell are capable of training pilots and navigators in the use and operation of multimode, air-to-ground mapping radars. This training includes the interpretation of radar presentation, the optimum adjustment of the radar system and the acquisition of targets and fix points.

Teaching radar scope interpretation demands that the radar simulator provide an accurate representation of the radar display. The presentation generated on the scope of an operational radar is difficult to learn to interpret. This difficulty is largely related to the differences between how a radar detects ground features and how the same ground features look to an observer. Because of this difference, many hours of training are required to teach a radar operator what he will observe on a radar display for a wide range of operating conditions.

Radar scope interpretation training places demands on the information content of the radar data base on the computation required to construct the simulated radar display.

Operational radar systems typically provide a variety of controls to the operator including video gain, receiver gain, intensity, sensitivity time control, mode control, etc. Training the radar operator to achieve optimal adjustment of these controls under a wide variety of operating conditions imposes demands on the fidelity of simulation of the circuits used in the operational radar equipment. This training requires an accurate representation of each control as well as of the interaction between controls.

Radar landmass simulators are typically a subsystem within a weapon system trainer, navigation trainer, bombardier-navigator trainer, etc. The radar simulator is used in conjunction with other equipment in the trainer to teach operators how to navigate an aircraft, deliver a weapon, etc. This training encompasses radar fix taking, offset fix taking, air-to-ground ranging, etc., which place requirements on the accuracy of the information in the data base and the computations used in constructing the simulated radar presentation.

TECHNICAL DESCRIPTION OF THE DRLMS

The information content of the data base stored in a radar landmass simulator is the characteristic fundamental to the fidelity of its presentation. Only features encoded in the data base can be reconstructed and displayed on the simulated radar presentation. The selection criteria used to assess what features should be encoded in the data base and the parameters defining what characteristics of each feature should be encoded ultimately determine the ability of the simulator to reconstruct a display suitable for training radar operators.

SOURCE DATA

Elevation

Prior to proposing DRLMS for the Undergraduate Navigator Training Simulator in 1970, Honeywell conducted an extensive analysis of source data suitable for developing the associated data base. The best source of elevation data for the Continental United States (CONUS) was the digitally encoded magnetic tapes prepared by the Army Topographic Command. These tapes contain elevation data on a 208-foot grid as extracted from the Series 250 Topographic Charts. The elevation at each grid point is interpolated to a resolution of one foot with an accuracy consistent with the contour interval of the encoded chart. Hydrographic information was encoded by Honeywell from the Series 250 charts to assure that closed bodies of water had a constant elevation and that running water had a consonant elevation profile.

Reflectance

The best source of radar reflectance information in 1970 was the Series 200 Air Target Charts. These charts contain information depicting the relative radar signal strength for all features satisfying their associated selection criteria. For areas of the CONUS not charted on the Series 200 Charts, Honeywell effectively created equivalent charts by cartographically overlaying radar manuscript data on Series 250 charts. All features on these charts were given a feature identification code and a feature identification number prior to being encoded in a digital format. This digital encoding was accomplished to a resolution of 83 feet.

Source Data Compilation

These source data have now been compiled into a radar data base for the Western CONUS. An extensive verification process consisting of over one million data points has been accomplished to assure that this data base satisfies the accuracy and resolution requirements of the UNTS and A-7E WST programs. More significantly, the radar presentations generated by the UNTS and the A-7E DRLMS devices have been compared to the presentation of the operational radars for a variety of flight conditions including low level ground mapping, terrain following and terrain avoidance. These comparisons have proven that this data base contains the information content necessary to provide radar operator training throughout the flight envelope specified in the UNTS and A-7E programs.

DATA STORAGE/RETRIEVAL SUBSYSTEM

Equally important to the source data in assuring adequate fidelity of the simulated radar presentation is the data storage/retrieval subsystem and the display reconstruction hardware. The data storage/retrieval subsystem consists of IBM 2314-type, moving-head disc drives, fixed-head drums and random access memories, uniquely configured and controlled to manipulate the radar data in real time. These hardware elements are designed to assure that no degradation of the data stored in the data base occurs in the transfer process.

SPECIAL PURPOSE COMPUTER

The function of reconstructing the radar presentation from the information stored in the data base is accomplished in a digital Special Purpose Computer (SPC). The programs contained in the SPC solve the phenomenological radar range equation. The algorithms programmed into the SPC have been optimized to perform the computations in radar real time while assuring sufficient accuracy and resolution to provide a suitable radar presentation under the specified operating conditions. The SPC employs a pipeline architecture consisting of over twenty computational stages and having a cycle time of 600 nanoseconds. The SPC computes all geometric terms used in the radar range equation using three-dimensional vector calculations. From the geometric computations the appropriate gains and attenuations of the phenomenological radar range equation are computed. Results of acceptance testing and of comparison with operation radar performance have proven that the data storage/retrieval and the SPC provide accurate reproduction of a radar presentation including geometric and signal strength effects.

ACCURACY OF SIMULATION

Training radar operators to optimally adjust a radar system requires an accurate simulation of the operational radar system. To assure accurate simulation, transfer functions of all the necessary characteristics of the operational hardware were obtained from the equipment manufacturer. Both individual functions and the interaction between those functions were analyzed prior to designing the simulation hardware. Transfer functions were measured on operational hardware and the results of those measurements were programmed into the SPC. The DRLMS devices built for the UNTS and the A-7E programs have been proved to have the fidelity of simulation necessary to teach radar operators what each control effects, the interaction between controls and how to optimally adjust a radar system under a variety of operating conditions.

COMBINING FIDELITY AND ACCURACY

The ultimate test of a radar simulator is the combination of the fidelity and the accuracy of its presentation. The accuracy of the radar simulator is of paramount importance since its presentation must correlate with the charts used by the radar operator, the data on all instruments and the simulations of other sensor systems. The radar presentation is ultimately used to update the position of the airplane, to provide information to the weapon delivery simulation or to assist in determining the flight path of the airplane. Accuracy of the data base and the display reconstruction is imperative to assure that pilots, navigators and system operator can be trained to optimize the effectiveness of their total weapon system.

DRLMS STATE-OF-THE-ART

The DRLMS devices produced by Honeywell for the Navy A-7E program and the Air Force Undergraduate Navigator Training System (UNTS) program are representative of the state-of-the-art in radar simulation. They are proving that today's technology can provide radar simulators with sufficient accuracy and fidelity to train operators to extract maximum effectiveness from their radar systems.