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PROBLEM SUMMARY FOR SF-11-121-106/8132 FOR THE PERIOD 1 JANUARY--ETC(U)
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NAVAL UNDERSEA
RESEARCH AND DEVELOPMENT
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⑥ PROBLEM SUMMARY FOR SF-11-121-106/8132
FOR THE PERIOD 1 JANUARY 1969 TO 30 JUNE 1969, (U)

⑩ by
G. A. Turton

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⑪ SEPTEMBER 1969

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ILLUSTRATIONS

1.0 INTRODUCTION

1.1 Objective

The objective of this article is

To generate a proposed technical approach (PTA) to combined active/passive sonar classification and tracking, and To perfect advanced general purpose sonar data analysis techniques based on the most recent developments in detection, estimation and modulation theory. To provide technical assistance to NAVSHIPS and its contractors in program planning and related exploratory development projects.

1.2 Background

For the past several years, the Signal Recognition division has provided NAVSHIPS with a wide variety of technical services in the active sonar area ranging from theoretical and operational analyses to hardware development and evaluation. During the past six months, the work under task 8132 has been shifted in emphasis from a diverse and general effort in active sonar detection and classification to a more concentrated effort in synthesis and performance evaluation of combined active and passive sonar tracking and classification techniques. To bring the PTA to a more practical level, the AN-SQQ-23 PAIR receiver has been chosen as the research vehicle from which tape recorded sonar data will be obtained for final performance evaluations. It is expected that techniques developed within this program will be directly applicable to the PAIR receiver as well as other sonars incorporating surface duct modes.

1.3 Approach

Measurements of an active sonar contacts' spatial distribution, temporal behavior and spectral emission/response characteristics will be incorporated in a sequential evaluation procedure to determine:

1. Whether or not the contact is a target.
2. Target track and apparent threat level.
3. Further action that should be taken to obtain better measurements.

Measures currently being considered to fulfill these requirements include STARLITE, TMA, (range, bearing, Doppler and track) and passive spectral levels. Procedures will be devised whereby these measures can be extracted from the PAIR receiver and processed to yield reliable classification and tracking information. To the greatest extent possible, these procedures will be automated to free the sonar operator from difficult and fatiguing operations.

1.4 Current Status

During the past six months, the following work areas have received the greatest emphasis:

1. Conclusion of previous studies not directly associated with the PTA. Reports issued (Section 3.4 of this report) include "Joint Active and Passive Sonar Signal Processing," "Performance Analysis of Detectors for Active Sonar" and "A Study of STARLITE Applications." Two months' work remains to be completed on continuous aperture arrays. (Section 2.1.2).

2. Data Collection Study. A study contract with Sperry Gyroscope Corp. has been completed which outlines in detail a two phase plan for transcribing and formatting AN-SQQ-23 PAIR tape recorded Sonar Data to be used with the ASDACS system. However, phase II of this plan must be deferred until FY-71, unless $100K of extended funding for FY-70 becomes available. (Section 2.2.1).

3. Echo Simulation. An acoustic target model and corresponding echo equations have been developed which will be used to generate synthetic target echoes. These echoes will be injected into simulated or tape recorded sonar noise to simulate active sonar beamformed data which will in turn be used as inputs to simulated STARLITE, and target motion analysis processors. (Section 2.1.1).

4. ASDACS Facility. Several routines for data handling and plotting have been developed for the ASDACS facility which greatly increase its versatility and data processing capabilities. Weekly, monthly and semi-annual maintenance procedures have been established, and hardware documentation is now complete. (Section 2.2.2).

The accomplishments in these and other work areas are more completely detailed in the remainder of this report.

1.5 Plans, Milestones

1. Sept. 1969. Complete the software for an algorithm which digitally adds simulated target echoes to simulated or tape recorded sonar noise to simulate the fore and aft array beamformed outputs of the PAIR receiver.

2. Nov. 1969. Use the simulated beamformed outputs above as inputs to a simulated STARLITE clue extractor and evaluate its performance relative to target parameters such as range, aspect, bearing, turning rate, and speed. Use the results to generate a set of operating limits for these parameters.

3. Develop a set of target motion estimators which can be used to determine whether or not the sonar contact echo parameters lie within the STARLITE operating limits previously established. This estimator set will include the following:

   a. Oct. 1969. A range-bearing sum-difference scanner and display to obtain range-bearing estimates from the forward array of the PAIR receiver. The processor will incorporate a replica correlator instead of a square law detector to increase processing gain. The display is a multimode sonar digital display (MSDD) which will be interfaced with the ASDAC system.

   b. Dec. 1969. A bearings only estimator which will accept both active and passive signals from the fore and aft array. If the contact bearing as measured in processor (a) lies within the STARLITE operating limits, the wide aperture technique may be used to increase bearing accuracy even further.

   c. Dec. 1969. Doppler estimator using the PAIR FM down-up slide pulse in a replica correlator.

   d. Feb. 1970. Implement tracking algorithm which accepts inputs from (a), (b), and (c) to solve for target heading and speed in a minimum number of echo returns. Accurate target track data can then be used to determine whether or not the contact lies within the STARLITE operating limits i.e. whether or not STARLITE measurements are valid.

4. Nov. 1969. Complete Phase I of data collection program. Phase I consists of transcribing several analog tapes of beamformed data from the fore and aft dome of the AN-SQQ-23 PAIR receiver, and performing spectral analysis of the data to locate artifacts that may have been produced by the PAIR system PME recorder. Also obtain analog filter circuits which will allow playback and separation of the active and passive beamformed data in the ASDACS facility.

5. May 1970. Develop a set of logic equations which will compare STARLITE; TMA and Passive data on a ping by ping basis to determine degree of contact resemblance to a submarine target, and its track relative to our ship.

6. July 1970. Develop software for the MSDD display to monitor the classification logic computations and the outputs of the TMA processors.

7. Dec. 1970. Simulate total track classify subsystem and complete performance evaluation with synthetic echo data and make necessary revisions.

8. Jan. 1971. Complete Phase II of data collection program.

9. May 1971. Complete performance evaluation of overall subsystem with Phase II tape recorded echo data.

10. July 1971. Output P.T.A.

2.0 AREAS OF INVESTIGATION

2.1 Applied Research

2.1.1 ECHO SIMULATION

A computer program has been written to generate simulated submarine target echoes to be used in the simulation and testing of several sonar signal processors prior to the use of actual tape recorded sonar echoes. Examples of sonar data processors to be tested include STARLITE clue extractors, range, bearing and Doppler estimators, target tracking routines, and a sequential classification clue evaluation program. The parameters of the synthetic echoes are known and completely controllable, thereby eliminating ambiguity between malperformance and effects due to unknown data artifacts during the first stage of processor development. After the processors have been proven for these "idealized" echoes, they will be further tested with actual tape recorded sonar echoes.

The target parameters that will be incorporated in the simulated echoes include range, bearing, velocity, heading, aspect, turning rate, target structure and wake effects. The own ships parameters that will be included are speed, heading, pitch, roll and yaw components along the line of sight, and beam pattern effects. To the extent possible, medium effects such as multipath reflection will also be injected into the echo simulations.

A two dimensional acoustic target model has been developed which consists of N ideal reflectors randomly distributed inside an ellipse whose dimensions along its major and minor axes are 100 yards and 10 yds., respectively. The reflection coefficient of each reflector is randomly selected and lies between 0 and 1 except for certain reflectors with coefficients between 0.5 and 1 chosen to emphasize the major reflective submarine hull structures. The model is shown in Figure 1.

A general equation for synthetic echoes is being derived which sums the echoes from all the individual reflectors of the acoustic target model taking into account the relative motion of each reflector for any given set of assigned target and own ship's motion parameters. The time sampled values of the echo are digitally computed from the echo equation and stored on

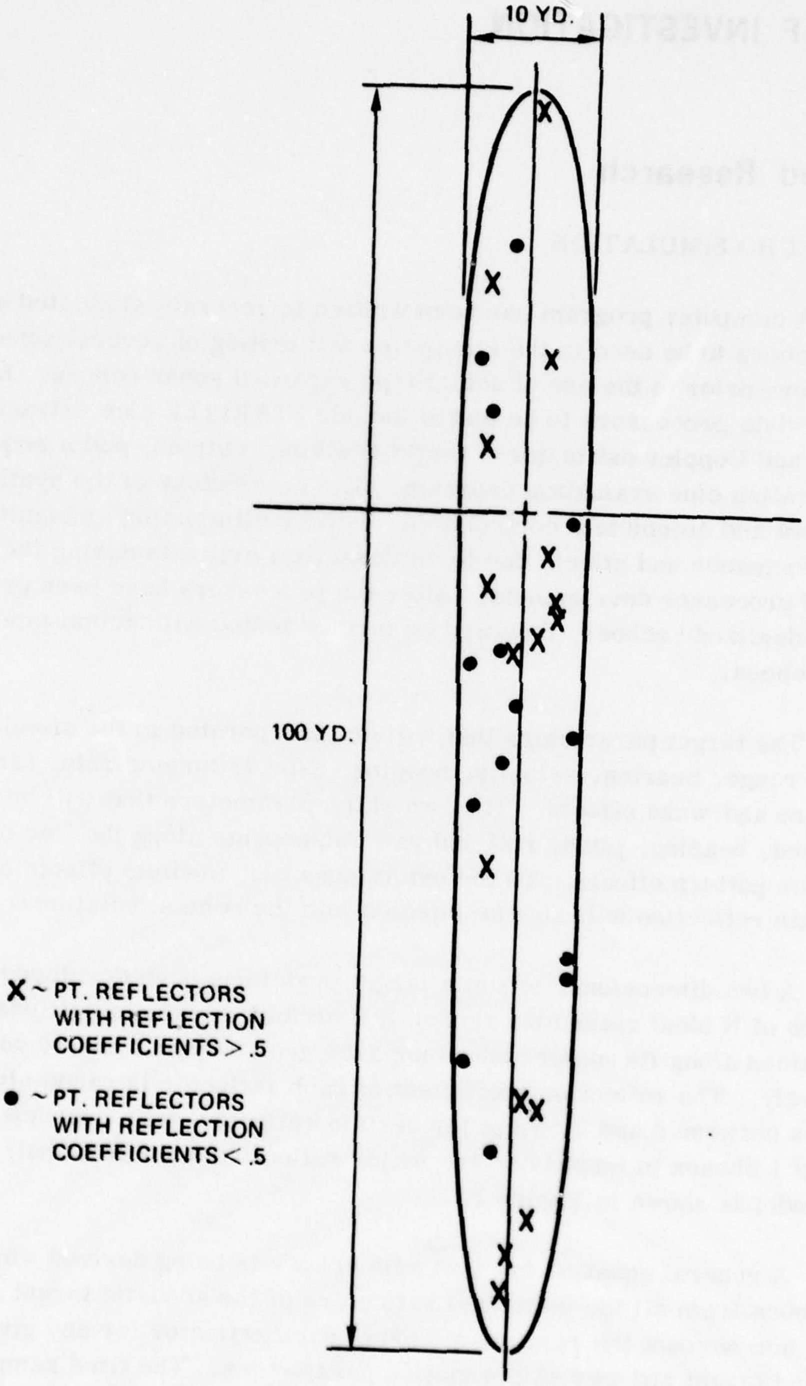

Figure 1. Two dimensional acoustic Target Model.

digital tape to be used as inputs for digital simulation of sonar data processors. In this manner, sequences of target echoes can be generated to simulate any desired target track for multiple ping sequential processors.

A computer algorithm is being developed for ASDACS which will accept the digitally stored echoes and add them to synthetic or tape recorded sonar noise signals. During this operation, the echo amplitude and phase are adjusted to simulate the output of a sonar beamformer for any bearing angle relative to the direction of the beam. Several beams can be simulated in this fashion to provide inputs to simulated range and bearing estimators.

Figure 2 is a representation of the impulse response function for the acoustic target model with 30 reflectors assumed to be stationary at an aspect angle of 45°. The plot consists of one "delta function" for each reflector, whose amplitude corresponds to the randomly generated reflection coefficients.

Figure 3 is a plot of a synthetic echo generated from the above impulse response function and sampled at 20 KhZ. The mathematical form of the assumed transmitted signal s(t) is given by the following equation.

$$s(t) = \frac{\sin 157t}{157t} \cos 31,400t.$$

This corresponds to a 2 ms. CW RDT pulse at a carrier frequency of 5 KhZ. This pulse was chosen for graphic purposes as it illustrates the highlight structure resulting from the acoustic model.

Figure 4 is an acoustic scattering pattern showing maximum echo amplitude as a function of aspect angle for the acoustic target model. The lobe structure is typical of linear arrays of acoustic reflectors, and it is very similar to measured submarine scattering patterns appearing in the literature.[1, 2]

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[1] Daniels, E. L. and LeBlanc, L. R., Active Sonar Classification Study: Summary Progress Report, 1 July 1966 to 1 July 1967. BUSHIPS Contract No. Nobsr-95064. Raytheon Co. 10 August 1966. (CONFIDENTIAL)

[2] Leiss, W. J., Submarine Target Strength Summary Part X TM 204. 4611-11, Pennsylvania State University, ORL, 9 Dec. 1964.

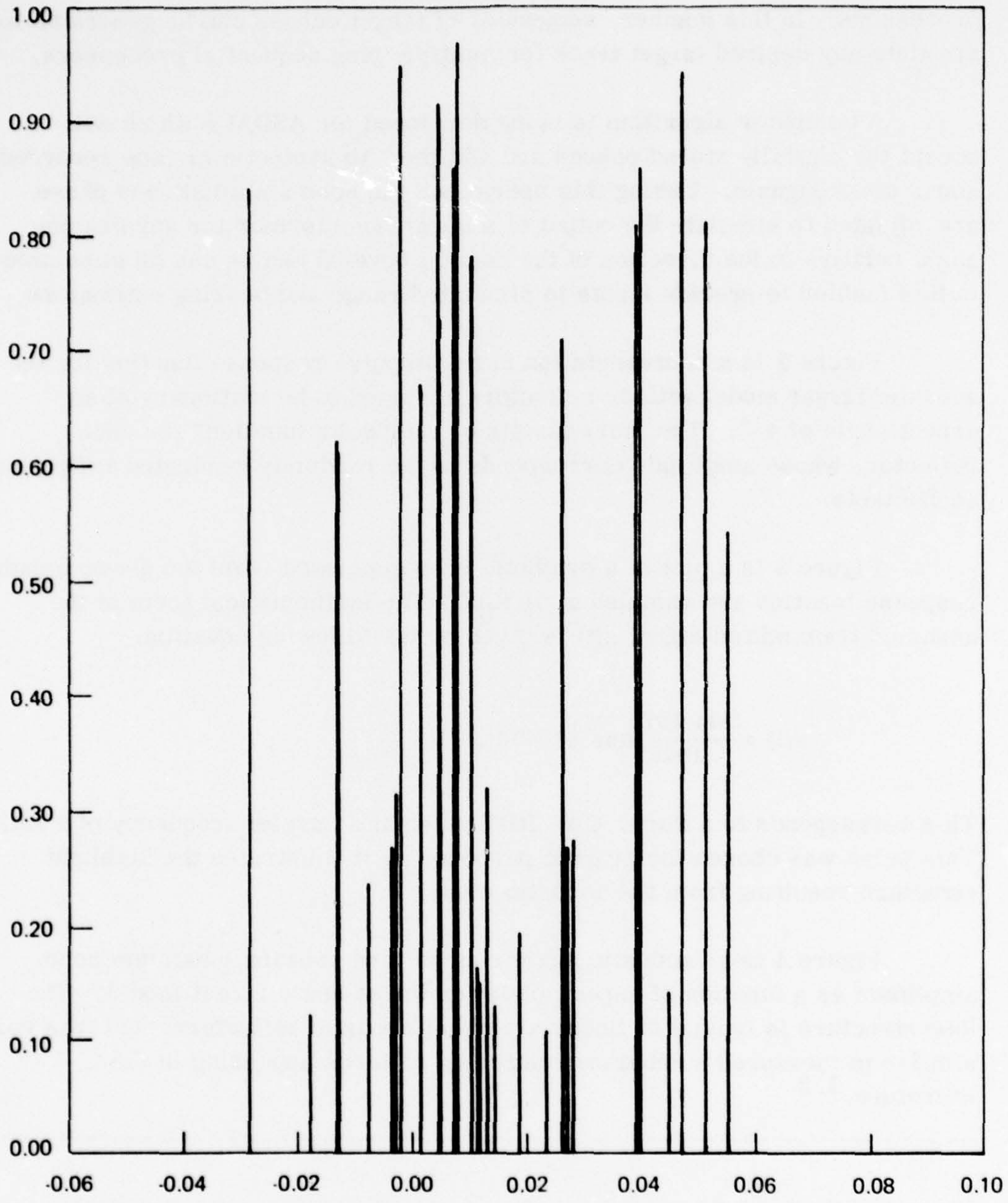

Figure 2. Impulse response function of acoustic model for a 45° aspect angle.

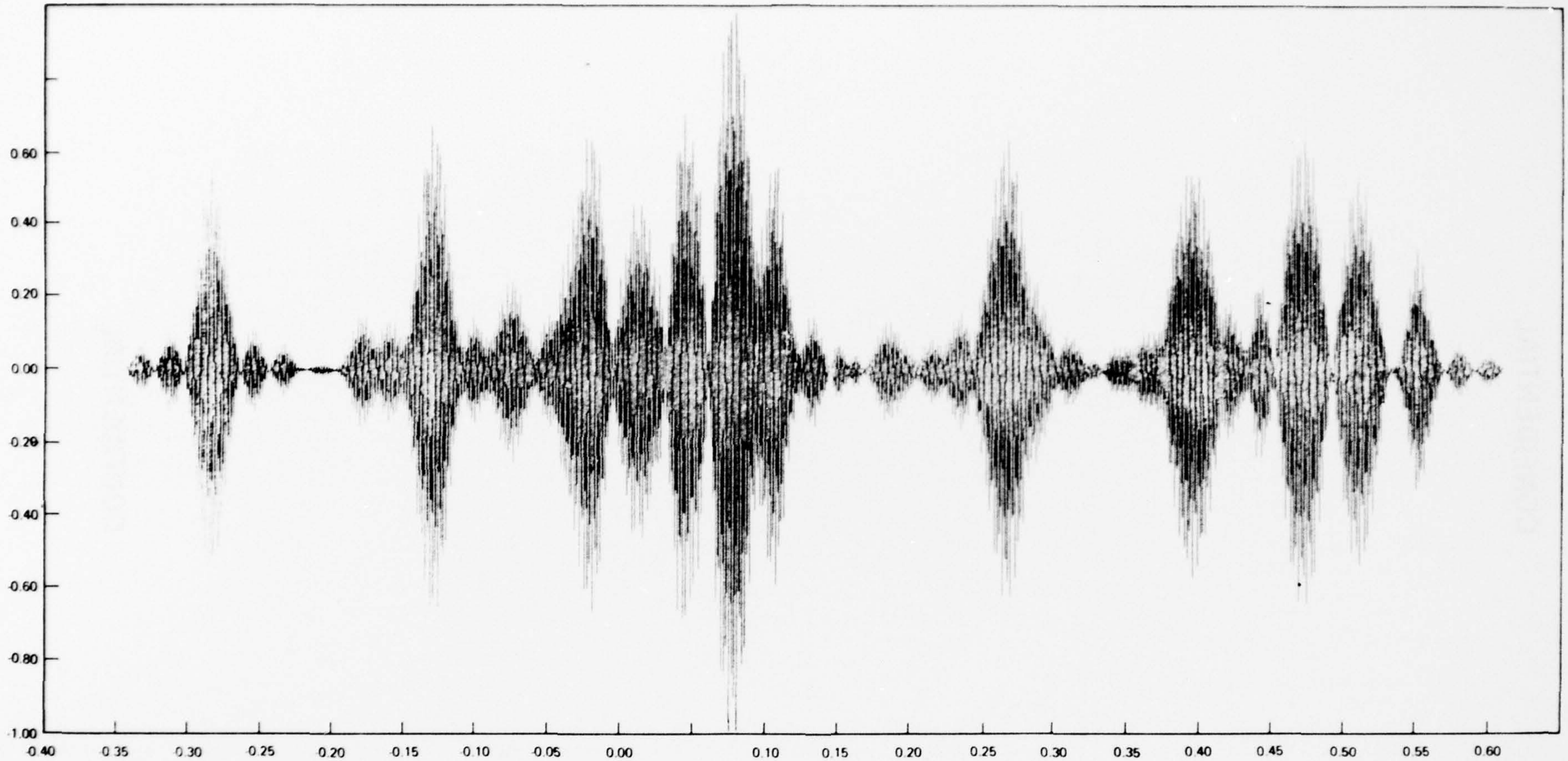

Figure 3. Synthetic echo impulse response function of Figure 2.

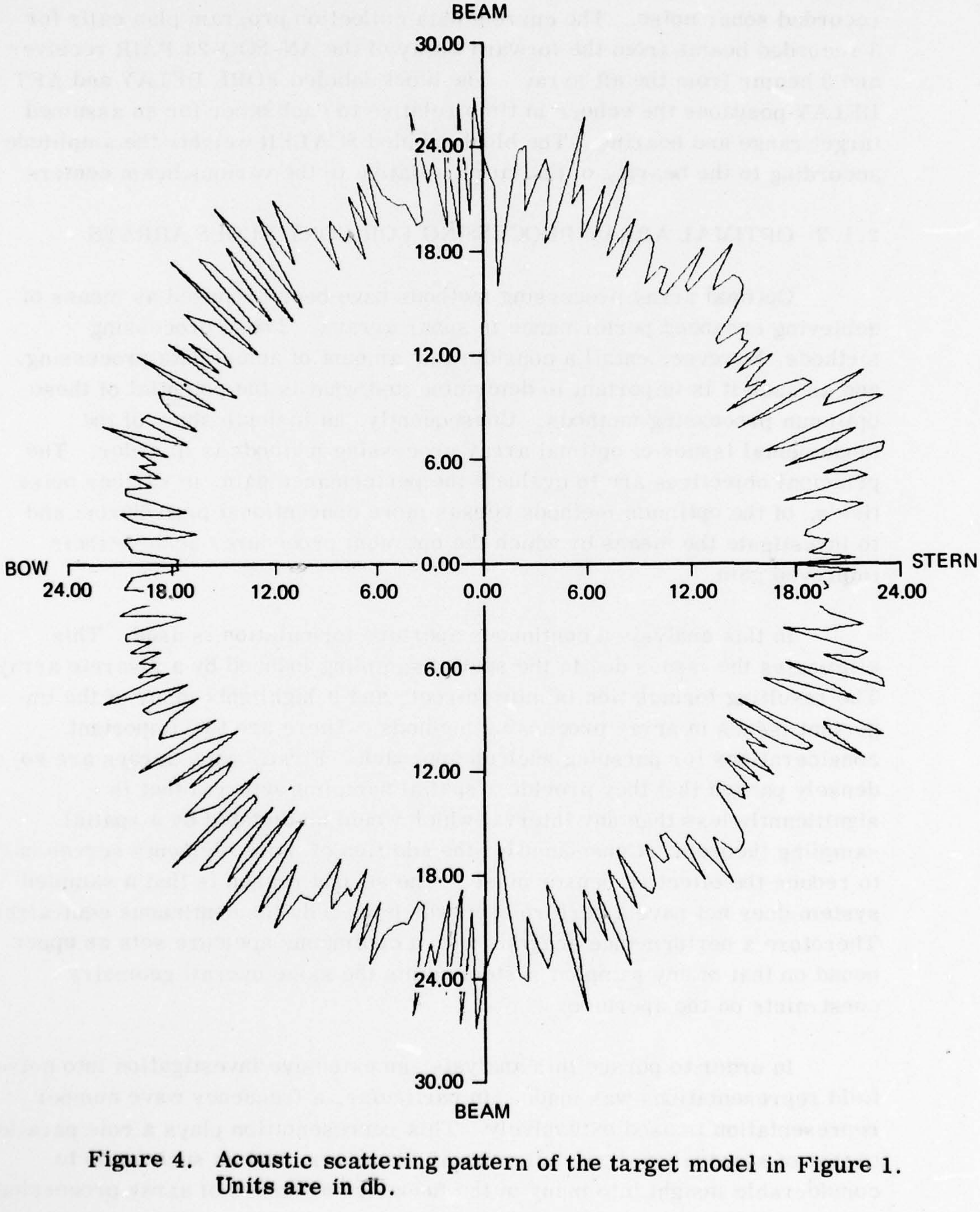

Figure 4. Acoustic scattering pattern of the target model in Figure 1. Units are in db.

Figure 5 is a block diagram of the computer algorithm for simulating a beamformer output using the synthetic echoes and either synthetic or tape recorded sonar noise. The current data collection program plan calls for 5 recorded beams from the forward array of the AN-SQQ-23 PAIR receiver and 3 beams from the aft array. The block labeled FORE DELAY and AFT DELAY positions the echoes in time relative to each other for an assumed target range and bearing. The block labeled SCALER weights the amplitude according to the bearing of the target relative to the various beam centers.

2.1.2 OPTIMAL ARRAY PROCESSING FOR CONTINUOUS ARRAYS

Optimal array processing methods have been proposed as means of achieving enhanced performance in sonar arrays. These processing methods, however, entail a considerable amount of actual data processing, and as such it is important to determine just what is the potential of these optimum processing methods. Consequently, an in depth study of the fundamental issues of optimal array processing methods is in order. The principal objectives are to evaluate the performance gain, in various noise fields, of the optimum methods versus more conventional procedures; and to investigate the means by which the optimum procedures achieve their improved gain.

In this analysis a continuous aperture formulation is used. This eliminates the issues due to the spatial sampling induced by a discrete array. The resulting formulation is more direct, and it highlights many of the important issues in array processing methods. There are two important considerations for pursuing such an approach. First, many arrays are so densely packed that they provide a spatial sampling interval that is significantly less than any interval which would be dictated by a spatial sampling theorem. Consequently, the addition of more elements serves only to reduce the effective sensor noise. The second reason is that a sampled system does not have a performance which exceeds the continuous equivalent. Therefore a performance analysis with a continuous aperture sets an upper bound on that of any sampled system within the same overall geometry constraints on the aperture.

In order to pursue this analysis, an extensive investigation into noise field representations was made. In particular, a frequency wave number representation is used extensively. This representation plays a role parallel to that of spectral analysis in temporal processes, and as such leads to considerable insight into many of the fundamental issues of array processing.

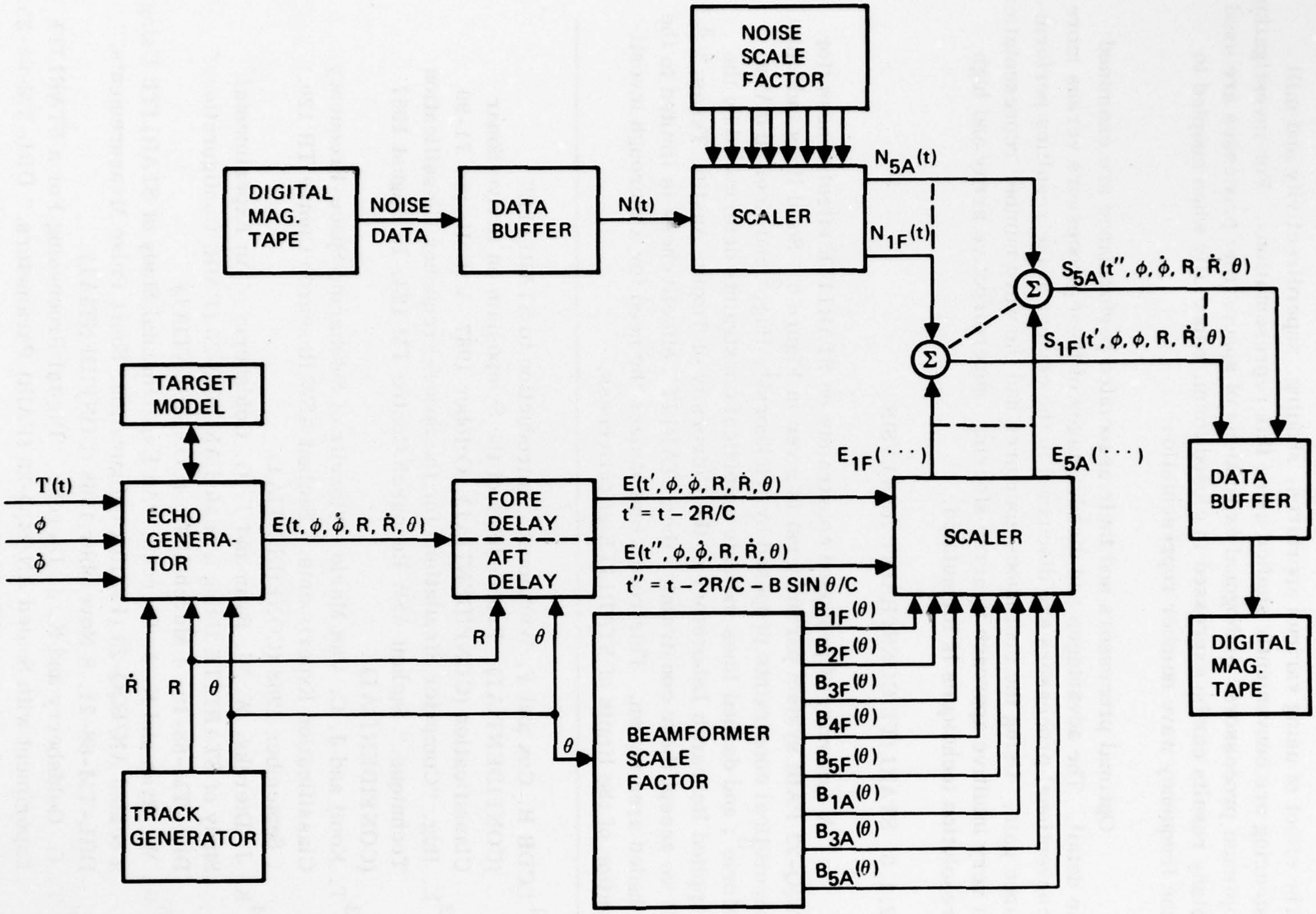

Figure 5. Block diagram of computer algorithm for adding simulated beamformed echoes to actual or simulated sonar noise.

The effect of using various apertures, shading, superdirectivity and mill steering are conveniently studied using this representations. For investigating opimum processors, orthogonal expansions of space/time processes are used. Many results can be expressed in closed form, especially when coupled to the frequency wave number representation.

Optimal processors and their associated performance are examined in detail. The advantages and disadvantages of these processors versus more conventional processors are discussed in the contect of the resulting performance gain. Using the continuous apertures and the wave number representation, a very intuitive approach to array steering, superdirective array and high resolution techniques is formulated.

2.1.3 STARLITE CONSTRAINT ANALYSIS

A summary of proposed constraints on STARLITE effectiveness (for SQQ-23 PAIR system parameters) is given in Figure 6. Solid lines indicate theoretical constraints proposed by Wiekhorst[1], Hug,[2] and Kooij and Van Morle[3]; and dashed lines indicate empirical constraints determined by the Applied Research Laboratory of the University of Texas, Austin, Texas.[4,5,6] If we accept these constraints, then STARLITE effectiveness is limited to the shaded area shown. This result emphasizes the need for a thorough investigation of the limits of STARLITE effectiveness.

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[1] LCDR H. Cox and F. Wiekhorst, "Introduction to STARLITE" (CONFIDENTIAL), Proceedings of the Symposium on Active Sonar Classification (CONFIDENTIAL), October 1967, Vol. II, pp. 71-99.

[2] E. Hug, "Computer Simulations for the Space-Frequency Classification Technique," Saclant ASW Research Centre TM 123, 15 August 1967 (CONFIDENTIAL).

[3] T. Kooij and J. C. Van Marle, "Results of Submarine Space-Frequency Classification Experiments," Saclant ASW Research Centre TR 120, 1 September 1968 (CONFIDENTIAL).

[4] K. J. Diercks, W. W. Ryan and T. G. Goldsberry, "An Experimental Study of STARLITE Using a Scaled AN/SQQ-23 (PAIR) Configuration," DRL-TM-68-10, 4 March 1968. (CONFIDENTIAL)

[5] W. W. Ryan and K. J. Diercks, "An Experimental Study of STARLITE Using a Scaled AN/SQQ-23 (PAIR) Configuration, Short Pulse Measurements," DRL-TM-68-21, 8 November 1968 (CONFIDENTIAL).

[6] T. G. Goldsberry and K. J. Diercks, "Digital Processing For a STARLITE Experiment with Scaled AN/SQQ-23 (PAIR) Parameters," DRL-TM-68-25, 6 February 1969 (CONFIDENTIAL).

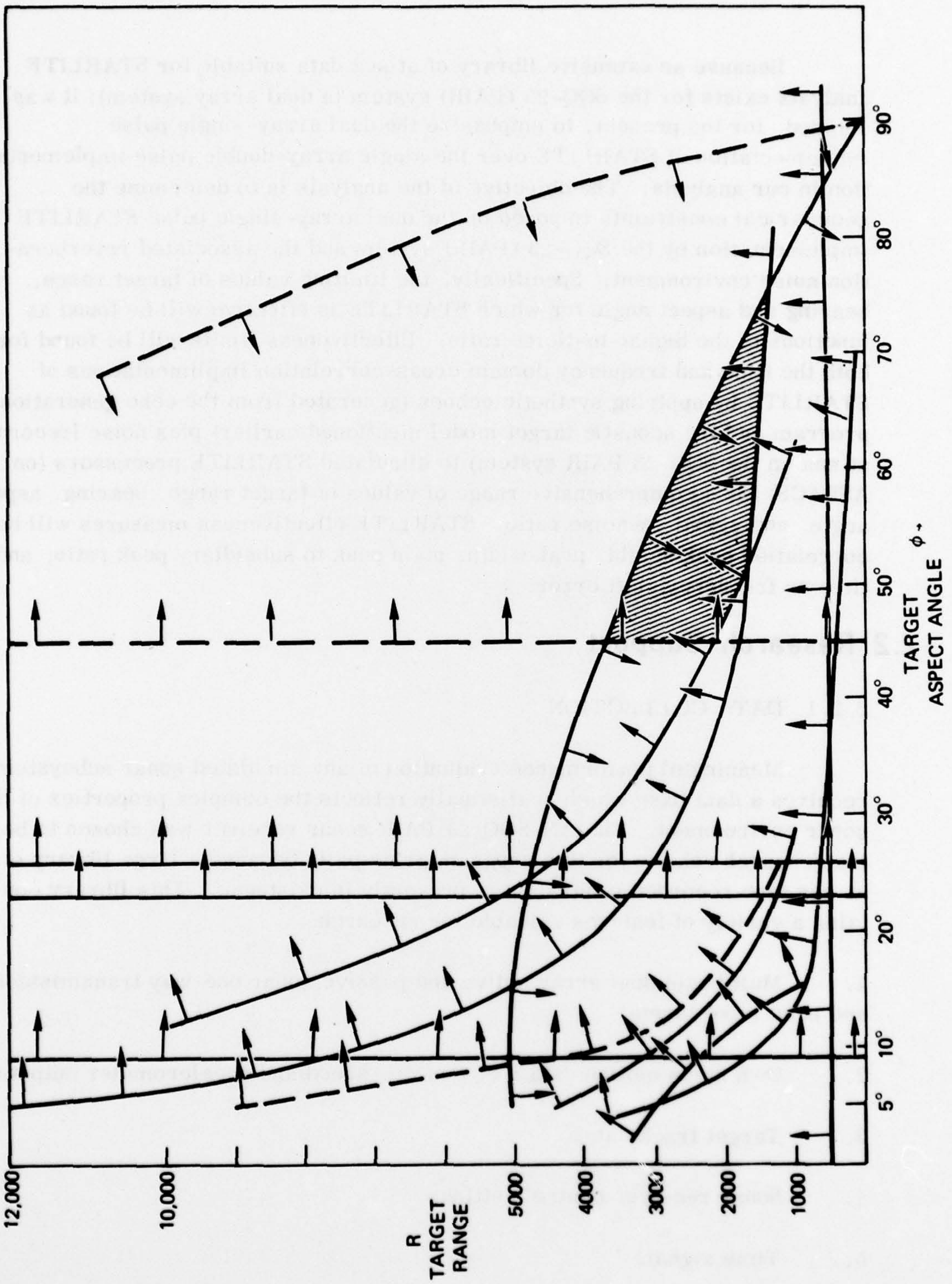

Figure 6. Summary of STARLITE constraints for SQQ-23 PAIR sys. parameters.

Because an extensive library of at sea data suitable for STARLITE analysis exists for the SQQ-23 (PAIR) system (a dual array system); it was decided, for the present, to emphasize the dual array-single pulse implementation of STARLITE over the single array-double pulse implementation in our analysis. The objective of the analysis is to determine the geometrical constraints imposed on the dual array-single pulse STARLITE implementation by the SQQ-23 (PAIR) system and the associated reverberation noise environment. Specifically, the limiting values of target range, bearing and aspect angle for which STARLITE is effective will be found as functions of the Signal-to-Noise ratio. Effectiveness limits will be found for both the time and frequency domain cross-correlation implimentations of STARLITE by applying synthetic echoes (generated from the echo generation program and the acoustic target model mentioned earlier) plus noise (recorded at sea on the SQQ-23 PAIR system) to simulated STARLITE processors (on ASDACS) for a comprehensive range of values of target range, bearing, aspect angle, and signal-to-noise ratio. STARLITE effectiveness measures will be correlation peak height, peak width, main peak to subsidiary peak ratio, and time or frequency shift error.

2.2 Research Support

2.2.1 DATA COLLECTION

Meaningful performance evaluation of any simulated sonar subsystem requires a data base which realistically reflects the complex properties of the sonar environment. The AN-SQQ/23 PAIR sonar receiver was chosen to be the research vehicle for this program principally because a large library of at sea tape recorded sonar data is presently in existence. This library contains a variety of features valuable for research:

1. Multibeam dual array active and passive sonar one-way transmissions and echo wave forms.
2. Own ships motion data i.e. course, speed and accelerometer outputs.
3. Target track data.
4. Sonar receiver control settings.
5. Time signal.

In addition, several of the PAIR data collection exercises were executed on the St. Croix tracking range, providing accurate position data for own ship and target sub. These position plots are referenced to a clock signal synchronized with the time signal on the data tapes.

Several of these features are particularly well suited to the study of space-time-frequency classification techniques. The dual array of the AN SQQ/23 PAIR receiver is necessary for wide-aperture measurements such as STARLITE, and both active and passive bearing determination. Although the aft array beamformers produce large sidelobes in the active transmission frequency bands, the target echoes on the tapes are strong enough to be easily located in the main lobe, especially since the run geometry is known for all the data collection exercises.

Evaluation of STARLITE clues and experimental tracking techniques requires accurate track data for both the receiving ship and the target submarine. The sonar synchro track data and the accompanying St. Croix range track data is ideal for this particular purpose. Related to track data, localized receiving ship motion (components of pitch, roll and yaw along the line of sight to the target) is necessary for differential Doppler correction when these effects are serious enough to corrupt STARLITE frequency shift measurements.

To be useful for research at NUC, the PAIR taped sonar data must be transcribed into a format suitable for playback into the ASDACS system. The analog sonar echo data was originally recorded directly from the PAIR array staves on the PME 83 channel recorder. This stave data must be beamformed to reduce the number of data channels and re-recorded on 14 track analog tapes compatible with the Ampex FR-1800L recorder in ASDACS. Auxiliary analog data such as own ships accelerometer and gyro signals must be converted to digital samples and formatted on 7 channel IBM compatible digital tape. Digitally recording the auxiliary data is necessary because the beamformed echo data requires all available data channels on the analog tape leaving only the digital tape deck in ASDACS to input auxiliary data. It is also desirable to preprocess the auxiliary data prior to transcription. in order to provide more useful inputs to ASDACS.

For example, accelerometer data can be digitized and converted to own ships velocity along the line of sight to the target prior to recording on digital tape, thereby eliminating the need to perform the calculations in

ASDACS. This preprocessing and transcription must be done on the PAIR receiver prototype and tape playback facility at Sperry Gyroscope Corp., Great Neck, New York. Toward this end, NUC awarded Sperry a one-half man-year contract to devise a plan for data transcription which included the necessary hardware and software add-ons to the PAIR playback facility. The resulting report recommended two phases of data conversion. Phase I consists of transcribing only analog beamformed echo and reverberation data, with no auxiliary digital data. The reverberation data would serve as a noise background for synthetic echoes generated in ASDACS to develop and debug data processing programs. The active echo data would be used to determine the quality of the PME tape playback system, and for preliminary echo processing experiments.

Phase II consists of transcribing both active and passive sonar waveforms on analog tape and auxiliary data on digital tape. These tapes would be used for performance evaluation of previously developed signal processing programs. Figure 7 shows a block diagram of the proposed date transcription and tape formatting plan for Phase II.

Because of a lack of available funds, current plans for the balance of FY 70 include the completion of Phase I only. The total cost of implementing both Phase I and Phase II is estimated to be $110K. The cost of implementing Phase I alone is $30K. Both of these figures include $15K for analog filters and heterodyning circuits necessary for playback of 8 active beam channels and 6 passive beam channels into ASDACS. Phase II will be included as a budget request item for FY 71 unless extended funding is available before then.

The optimum completion time for Phase II, however, is shortly before the end of FY 70, preferably May, 1970. The PAIR program has scheduled further sea-trials including data recording in March, 1970. A larger tape library would be available to choose from shortly thereafter than at present. Postponing the completion of Phase II until FY 71 runs the risk of having the playback facility at Sperry Corp. shut down before the data collection program would be completed. The PAIR playback facility is scheduled to be dismantled between January and April 1971. Since the data collection program requires a lead time of 6-8 months in order not to interfer with current PAIR project work, initial work must begin by the first month FY 71 (July, 1970). Otherwise, the opportunity to obtain this data will be lost.

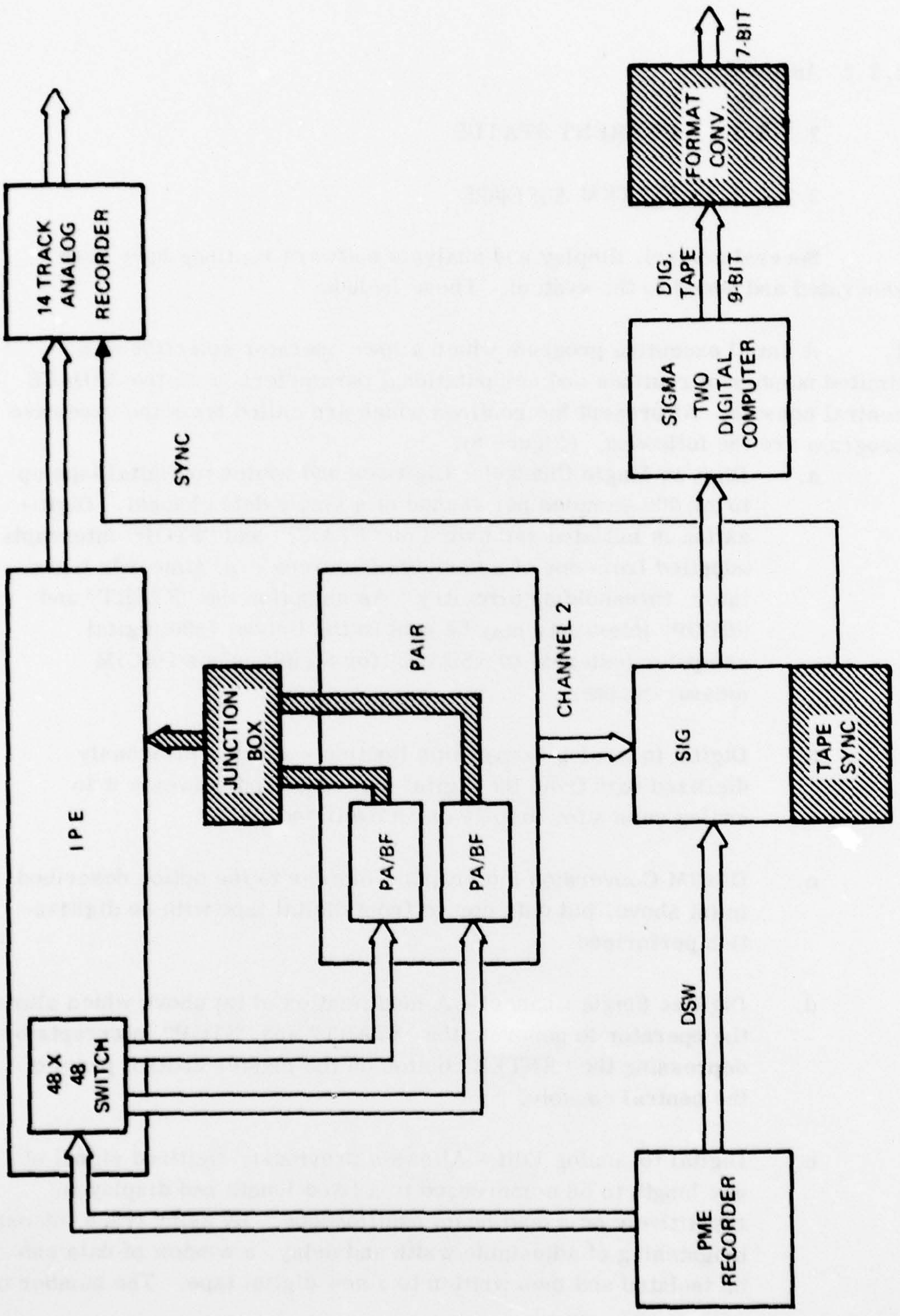

Figure 7. Phase II data collection program re-formatting operation. Block Diagram.

2.2.2 ASDACS

2.2.2.1 CURRENT STATUS

2.2.2.1.1 SYSTEM SOFTWARE

Several control, display and analysis software routines have been generated and added to the system. These include:

1. A small executive program which allows operator selection of a limited number of routines and computational parameters from the ASDACS central console. At present the routines which are called from the executive program are the following: (Figure 8).

   a. Digitize Single Channel - Digitizes and writes to digital tape up to 25,000 samples per second of a single data channel. Digitization is initiated and halted on "START" and "STOP" interrupts supplied from one of a variety of sources e.g. time wds translator, thresholding circuitry. As an option the "START" and "STOP" interrupts may be sent to the Univac 1230 digital computer (external to ASDACS) for simultaneous DACIM measurements.

   b. Digital to Analog Conversion Routine - accepts previously digitized data from the digital tape units and converts it to analog values for display on an oscilloscope.

   c. DACIM Conversion Interrupts - Similar to the option described in (a) above, but data comes from digital tape with no digitization performed.

   d. Digitize Single Channel - A modification of (a) above which allows the operator to generate the "START" and "STOP" interrupts by depressing the "ENTER" button on the master control panel of the central console.

   e. Digital to Analog Edit - Allows a previously digitized signal of any length to be compressed to a fixed length and displayed repetitively on a dual beam oscilloscope. By using trace intensity brightening of adjustable width and delay, a window of data can be isolated and then written to a new digital tape. The number of

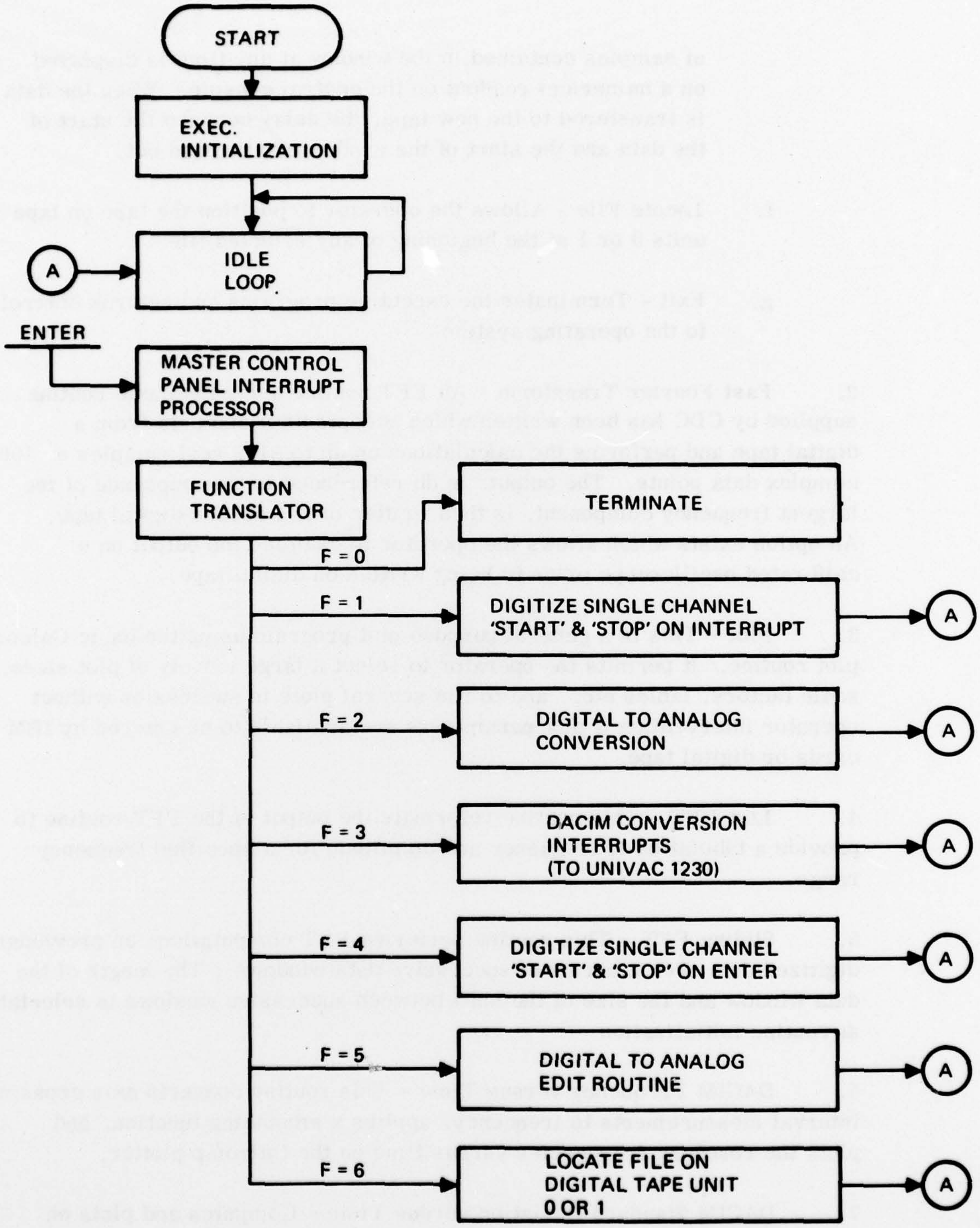

Figure 8. Functional diagram of executive program operational flow.

of samples contained in the window at any time is displayed on a numerical readout on the central console. When the data is transfered to the new tape. the delay between the start of the data and the start of the window can be read out.

f. Locate File - Allows the operator to position the tape on tape units 0 or 1 at the beginning of any selected file.

g. Exit - Terminates the executive programs and returns control to the operating system.

2. Fast Fourier Transform - An FFT routine using the basic routine supplied by CDC has been written which accepts digitized data from a digital tape and performs the calculations on up to 8192 real samples or 4096 complex data points. The output, in db referenced to the amplitude of the largest frequency component, is then written onto a second digital tape. An option exists which allows the operator to examine the output on a calibrated oscilloscope prior to being written on digital tape.

3. Plot - This is a general purpose plot program using the basic Calcomp plot routine. It permits the operator to select a large variety of plot sizes, scale factors, lables etc., and to run several plots in succession without operator intervention if plot parameters are available to be entered by IBM cards or digital tape.

4. List FFT - This routine reformats the output of the FFT routine to provide a tabulation of frequency and amplitude for a specified frequency range.

5. Sliding FFT - This routine performs FFT computalions on previously digitized data over a series of successive data windows. The length of the data window and the size of the shift between successive windows is selectable at routine initialization.

6. DACIM Frequency versus Time - This routine converts axis crossing interval measurements to frequency. applies a smoothing function. and plots the resulting frequencies versus time on the Calcomp plotter.

7. DACIM Standard Deviation versus Time - Computes and plots on the Calcomp plotter the results of standard deviation computations on

DACIM output.

8. Ambiguity Function Plot - This routine generates a three dimensional plot of any ambiguity function that can be computed on the Univac 1230 comp computer (external to ASDACS).

9. Sliding RMS - This routine is similar to the sliding FFT except that the RMS level over the entire frequency range is computed for previously digitized data.

10. Duplicate Tape - This routine reads data from one digital tape unit and creates a duplicate on the other tape unit.

In addition to the above software development, a digital multimode sonar display console has been obtained on loan for use with the ASDACS system. It accepts its inputs from the UNIVAC 1230 digital computer which is tied in with ASDACS.

2.2.2.1.2 SYSTEM MAINTENANCE

Weekly, monthly, and semi-annual preventive maintenance schedules have been established. These include running the AMM-17 and SMM-17 maintenance monitor weekly to assure that the computer and associated digital equipments are performing within required accuracy limits.

Recommended spare parts for ASDACS have been ordered and partially received. Completion of the spare parts inventory is expected by December 1969.

2.2.2.1.3 SYSTEM DOCUMENTATION

Copies of 27 different manuals covering the system organization, individual equipments in ASDACS and CDC supplied software routines have been received. Documentation of all hardware is now complete. Software documentation requires further clarification by CDC.

2.2.2.2 FUTURE DEVELOPMENT PLANS

The items included here are considered to be general purpose data

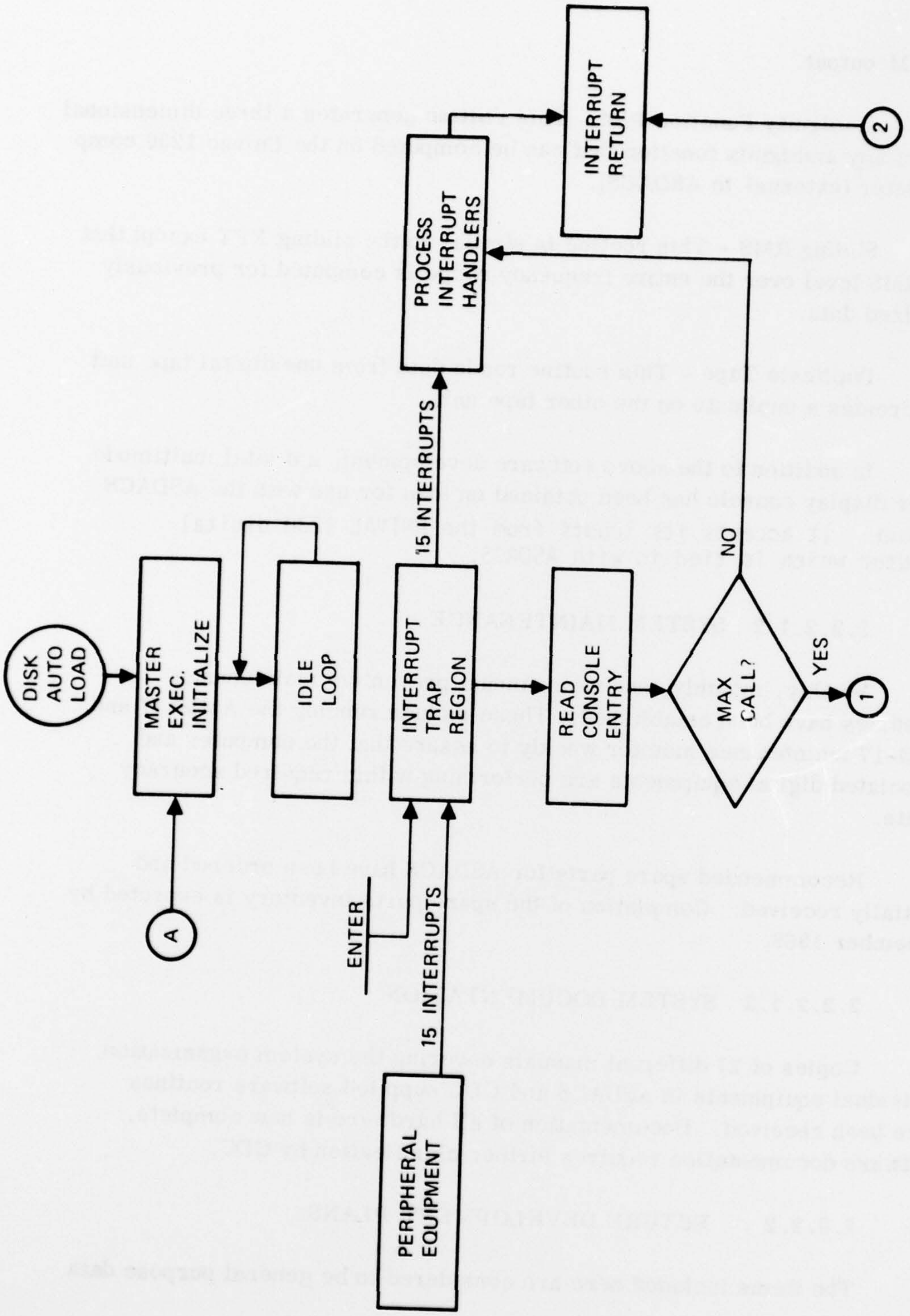

Figure 9. Block diagram of master executive program operational flow.

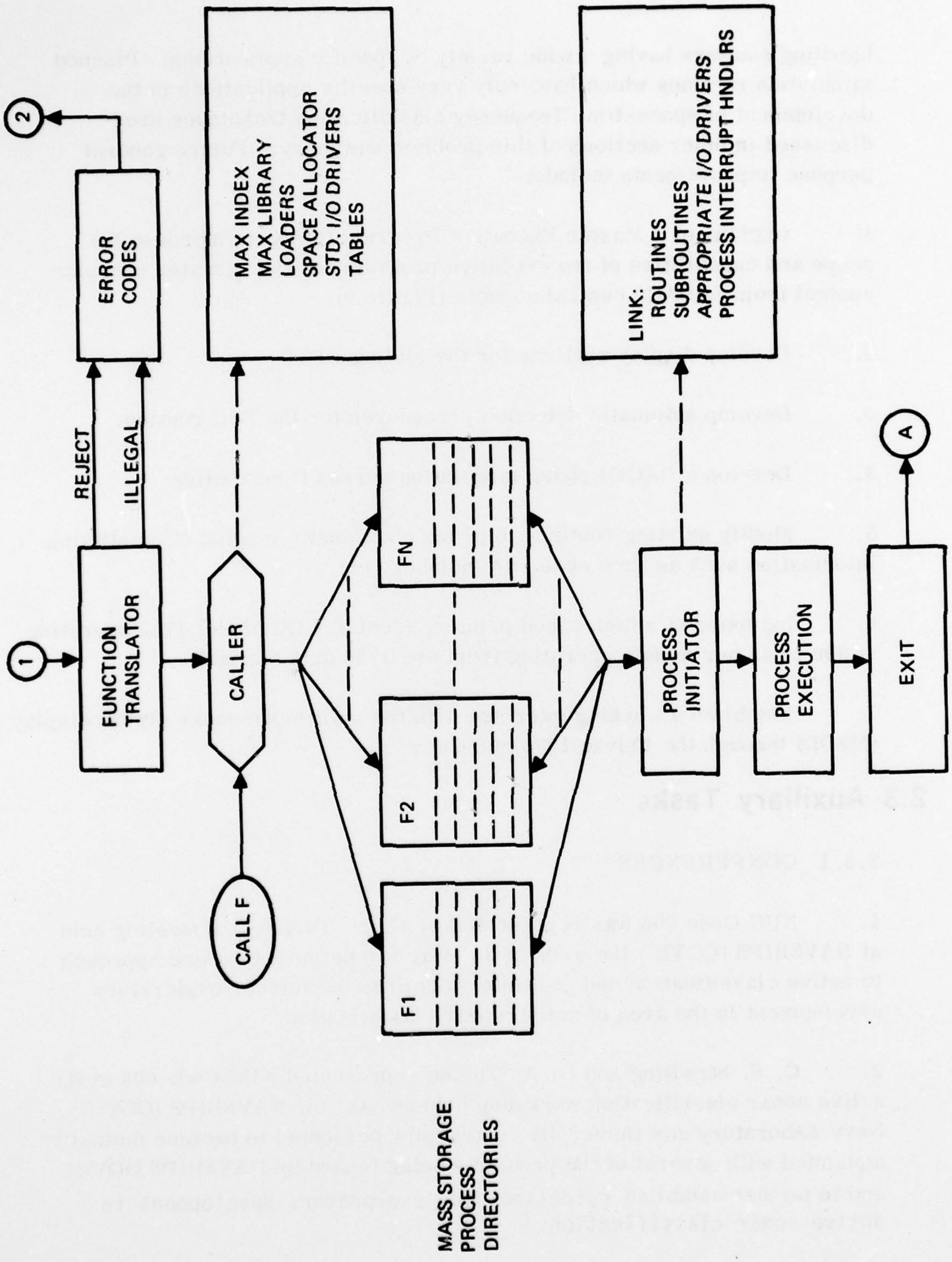

Figure 9. Continued

handling routines having a wide variety of specific applications. Planned simulation routines which have only very specific applications in the development of space-time-frequency classification techniques are discussed in other sections of this problem summary. Future general purpose improvements include:

1. Implement a Master Executive Program (MAX) to increase the scope and capabilities of the executive program to allow greater operator control from ASDACS central console (Figure 9).

2. Develop display routines for the sliding FFT.

3. Develop automatic detection procedures for the Edit routine.

4. Develop a DACIM phase modulation versus time routine.

5. Modify existing routines to provide automatic logging of identifying information such as time code, file number, etc.

6. Inclusion of a high speed printer, (rental) CDC Model 1742 operating at 300 lines per minute operating from one 1700 data channel.

7. Establish a working interface with the multimode sonar digital display (MSDD) through the Univac 1230 computer.

2.3 Auxiliary Tasks

2.3.1 CONFERENCES

1. NUC Code 606 was represented by G. A. Turton at a meeting held at NAVSHIPS (OOVIC) the week of 31 March to define a baseline approach to active classification and generate guidelines for further exploratory development in the area of active sonar classification.

2. C. S. Stradling and G. A. Turton represented NUC Code 606 at the active sonar classification workshop held at NUC for NAVSHIPS (OOVIC). Navy Laboratory and University contractors personnel to become mutually aquainted with several of the problems being funded by NAVSHIPS OOVIC and to further establish guidelines for exploratory development in active sonar classification.

2.3.2 TRAINING

A. T. F. Ball, L. P. Mulcahy, C. S. Stradling and G. Turton completed course entitled "Detection, Estimation and Modulation Theory" given at the Center by Bolt, Beranck and Newman Inc.

B. J. L. Teeter continued his part-time doctorial program during the winter and spring quarters at U.C.S.D. with course work in Detection Theory and related mathematics.

C. G. Schumacker, D. Bolks, and E. Tynen attended a three week on-the-job training session covering ASDACS operation conducted by Control Data Corp. in January 1969.

2.4 Technical Reports Issued

1. C. S. Stradling and A. B. Baggeroer, "Joint Active and Passive Sonar Signal Processing Using Arrays (U)," NUC TP 121, In Printing (CONFIDENTIAL)

2. J. L. Teeter, "Performance Analysis of Detectors for Active Sonar (U)," NUC TP 130, March 1969 (CONFIDENTIAL)

3. D. G. Olson and J. Watring, "A Study of STARLITE Applications (U)," NUC TP 152, In Printing (CONFIDENTIAL)

4. G. A. Turton and C. S. Stradling, "Problem Summary for SF 11-121-100/8132 For the Period 1 July 1968 - 30 December 1968 (U)," NUWC TN 232, February 1969 (CONFIDENTIAL)

5. G. A. Turton, "Doppler Measurement Characteristics of Bendix Monoppler (U)," NUWC TN 233, February 1969 (CONFIDENTIAL)