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COMPUTER SYSTEM REQUIREMENTS ANALYSIS DEVICE 2F112, F-14 WEAPON--ETC(U)

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Technical Report: NAVTRAEQUIPCEN IH-262

COMPUTER SYSTEM REQUIREMENTS ANALYSIS, DEVICE 2F112, F-14 Weapon System Trainer

Computer Laboratory
Naval Training Equipment Center
Orlando, Florida 32813

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NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

Technical Report: NAVTRAEQUIPCEN IH-262

Computer System Requirements Analysis, Device 2F112, F-14 Weapon System Trainer

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This report documents the procedures and methodology used in determining the computer speed and storage requirements for Device 2F112 WST F-14A aircraft with a wide angle visual system. Three candidate computer systems are chosen for detailed analysis to determine the processing requirements. These requirements are best met using a multiple SEL 32/55 computer configuration. The information and data derived serve three basic needs: (a) Identification of total computer system requirements of a (Cont'd)

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typical modern real-time simulator/training device; (b) Base-line requirements guidance for future trainer computer system architectural concepts being investigated in an in-house research task involving application of microprogramming techniques, microcomputer technology and high level languages; and (c) Delineation of the fundamental analysis procedural steps necessary to adequately evaluate and define computer system requirements for trainers.

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SECTION I

INTRODUCTION

This report documents the quantitative results of a detailed analysis of the computer requirements of Device 2F112, F-14A Weapon System Trainer. The analysis was performed in 1975 under in-house research Task 5741, Simulation Computing Techniques. The information and data derived serve three basic needs:

a. Identification of total computer system requirements of a typical modern real-time simulator/training device.

b. Base-line requirements guidance for future trainer computer system architectural concepts being investigated in an in-house research task involving application of microprogramming techniques, microcomputer technology and high level languages.

c. Delineation of the fundamental analysis procedural steps necessary to adequately evaluate and define computer system requirements for trainers.

Device 2F112 was chosen for this analysis on the recommendation and request of the Naval Training Equipment Center Director of Engineering. There was a significant independent need to determine the minimum computer system and processing requirements of this trainer when a wide-angle visual subsystem and adaptive maneuvering logic for a computer synthesized aircraft were added.

The simulation requirements are initially discussed in terms of simulation program processing requirements identified in the data compilations in the Appendixes. The computer processing capability, as well as a realistic estimate of the program organization and implementation, is subsequently derived from the program requirements. The results of the complete analysis are provided in the Appendixes in the order in which the analysis steps were performed.

In general, the analysis methodology followed in this report is shown on procedural flow diagrams (Section 3, Figures 1, 2, and 3). Due to the accelerated nature of the requirement for the analysis several of the steps indicated were either by-passed or combined with other steps. Such an analysis methodology was considered valid since the end results (as presented in the various appendixes) were not intended to specify the detailed design of a computer system - only the basic processing capability requirements of the several CPU's involved.

SECTION II

STATEMENT OF PROBLEM

Computer system requirements analysis involved two fundamental steps: (1) identifying the total 2F112 WST simulation program processing requirements, including visual and synthetic aircraft capabilities; and (2) determining the size and capability of a computer system that can meet the real-time program processing requirements.

The 2F112 WST specification in conjunction with a flight math model provided the flight-aero simulation requirements and the tactics simulation requirements. The visual subsystem requirements were derived from the visual specification for the 2F112. The visual system computation and control mathematics were derived from a math model described in a NASA Technical Note.[1] The basis for estimating the program requirements for the computer-synthesized target aircraft was also a math model described in a NASA Technical Report.[2] Applicable excerpts from these reports are also included in Appendix A.

A preliminary analysis was performed to determine the total processing requirements for this device. This analysis indicated that at least four processors would be required. An overview of the simulation functions which the trainer must accomodate indicated that the total simulation problem could be conveniently divided into four identifiable functional groups. These are: (1) flight-aero simulation, (2) weapons delivery simulation (tactics), (3) visual simulation and control, and (4) computer-synthesized target simulation. This division will allow the simulation programs for each group to be specified and designed in a modular configuration and analyzed in a relatively independent manner. Such a modular approach will facilitate future modification of the simulation program or subprogram brought about by changes in the training requirements or the addition of new operational equipment.

The next step was to determine if the total processing load could logically be divided among four processors. This was accomplished by allocating each of the four major simulation functional groups to a separate processor. A detailed computer system analysis was then performed. The details are described in Section III.

1. NASA Technical Note D-7304, Description and Performance of the Langley Differential Maneuvering Simulator.
2. NASA Technical Report N61339-16-R-002, An Adaptive Maneuvering Logic Computer Program for the Simulation of One-on-One Air-to-Air Combat, Volume 1, General Description.

The software routines (program modules) and instruction estimates were identified for each function by using the following techniques: (1) actual instruction counts from existing trainer programs with similar requirements, (2) detailed proposal estimates, (3) reasonable code estimates with estimating contingency factors based on actual math models, (4) mathematical expressions, (5) processing algorithms and (6) knowledge and experience of the investigators.

In order to determine the ability of several computers to meet the execution rates and processing requirements of the various program groupings, a weighted average instruction execution time was calculated for each of the several candidates machines under investigation. The parameter, instructions per second (or KIPS - kilo instructions per second), was determined for each major functional program group (i.e., Flight-Aero, Tactics (weapon delivery simulation), Visual Simulation and Interactive Synthetic Target).

The flight-aero instruction mix represents an average based upon the instruction mix for several operational flight trainers. The tactics instruction mix was derived by averaging a variety of instruction usages in radar simulation, data link processing, command and control, weapons simulation and weapon delivery simulation programs.[3] The visual subsystem and the computer-synthesized target simulation instruction mixes were determined by tabulating the various types of instructions required based upon the math model for these two functions.

To ensure adequate total system responses when a visual subsystem is incorporated, the system solution rate (for the flight-aero routines and for the visual control routines) was selected as 32 times per second. Submultiples of 32 (i.e., 16, 8, 4, 2, 1) were assigned to other program modules according to the required responses of those functions and the need to maintain mathematical consistency of various parameters among several of the routines.

With a frame rate of 32 per second, the maximum time available per frame (or slot) is 31.25 milliseconds. Spare processing time was specified as 25 percent of the maximum time available per frame (or time slot). The spare processing time per frame is, therefore, 7.8125 milliseconds. This is to allow for future changes in training or other simulation contingencies occurring after delivery and acceptance of the trainer. Therefore, the maximum time available in any time frame for any processing under worst-case condition is 23.438 milliseconds.

3. Author unknown, Instruction Frequency-Comparison of Different Types of Program Mixes, Table, Datamation, Dec. 1970.

Since FORTRAN IV was specified as the source programming language for the 2F112 visual subsystem, an additional contingency factor of 15 percent was applied to the visual subsystem and synthetic target system instruction count. This was to compensate for the additional code generated by the average FORTRAN IV compiler as compared to the number of instructions used on the average in assembly level coding.

Section III delineates in detail a discussion of the methods and sequential steps of the analysis procedures. The quantitative data derived from these procedures is presented in the Appendixes.

SECTION III

METHOD OF PROCEDURE

INTRODUCTION

This section describes the method of procedures used in estimating the storage (memory) and computational requirements for the real-time simulation problem of Device 2F112. The methodology may be employed in determining the computer requirement for any real-time simulation problem.

The following paragraphs describe the techniques used to determine (1) computer system storage requirements, (2) worst-case instructions executed, (3) instruction execution rates, (4) percent instruction distribution and usage, and (5) average instruction execution time capability of the several computers under investigation. This information is used in sizing and configuring a computer system to satisfy the real time simulation problem being investigated.

The numerical data used in the 2F112 analysis for the most part is based upon knowledge and experience derived from existing training systems having similar simulation requirements. The computer analysis as described is based on a weighted average instruction execution capability of the computer system under consideration, and the estimated worst-case real-time program processing requirements. Figures 1, 2, and 3 illustrate the detailed mechanics of such an analysis procedure. The Appendix tables summarize the quantitative results.

ANALYSIS SEQUENCE

The major steps associated with the computer analysis for device 2F112 were as follows (the information in parenthesis after each step relate to the analysis sequences of Figures 1, 2, and 3):

a. Estimate the module size, data and constant storage requirement for each program module (Figure 1, 2, steps 1.1.1, 1.1.1.1, 1.1.1.2, 1.1.1.4, 1.1.1.6, 1.1.1.7, 1.1.1.1.1).

b. Estimate the worst-case instruction count for each program module (Figure 2, step 1.1.1.6).

c. Determine the computer solution or iteration rate for each program module (Figure 2, step 1.1.1.8).

d. Determine the processing requirements for the total simulation problem (Figure 2, steps 1.1.1.6, 1.1.1.8).

e. Derive the percent usage factor for each class of instruction. This must be done for each of the major simulation functions (Flight-aero, tactics, visual, etc.)(Figure 2, steps 1.1.1.9, 1.1.1.10).

f. Determine computer hardware configuration which will satisfy the performance requirements as determined by d. above. Assign program functions to each processor (Figure 2, steps 1.1.1.11, 1.1.2).

g. Determine the computational workload per processor, (average number of instructions to be executed per second) which is the sum of the products of the worst-case instruction count/module and the corresponding iteration rate (Figure 2, steps 1.1.1.12, 1.1.2).

h. Perform a time slot analysis to determine if the processors being considered have sufficient processing capability to satisfy the timing requirements on a frame to frame basis (Figure 2, step 1.1.1.12).

A series of flow charts are presented to illustrate the sequential nature and steps of the computer program design and system analysis procedure. Figure 1 presents the Level 1 flow diagram of the analysis/synthesis process. Figure 2 has been expanded to Level 2 (the next lower level of breakdown). The initial activity shown in block 1.1.1.1 of Figure 3 (an expansion of the Level 2 diagram) involves organizing the overall real-time simulation program. All computer functions are allocated to various modules (routines) which comprise the complete program. A module may consist of one or more routines. The entire simulation program is composed of identifiable modules which can be flow charted, programmed (or coded) and debugged as separate logical entities (Figure 3).

The analysis of a computer system to satisfy specified performance criteria is conducted in a well-defined sequence of steps. These detailed steps are indicated in Figure 2, Analysis/Syntheses Process - Level 2. The initial step in the process is the organization of the overall computer program (Block 1.1.1.1) as further delineated in lower level functional breakdowns in Figure 3. The sequential steps of Figure 2 are correlated with the column headings of the tables in Appendix B. These tables summarize the results of all analysis steps shown in Figure 2, Block 1.1.1.1 which is further expanded in Blocks 1.1.1.1.1, 1.1.1.2, 1.1.1.6, 1.1.1.7 and 1.1.1.8. Completion of these steps establishes the program performance and processing requirements which the selected computer hardware must be capable of handling.

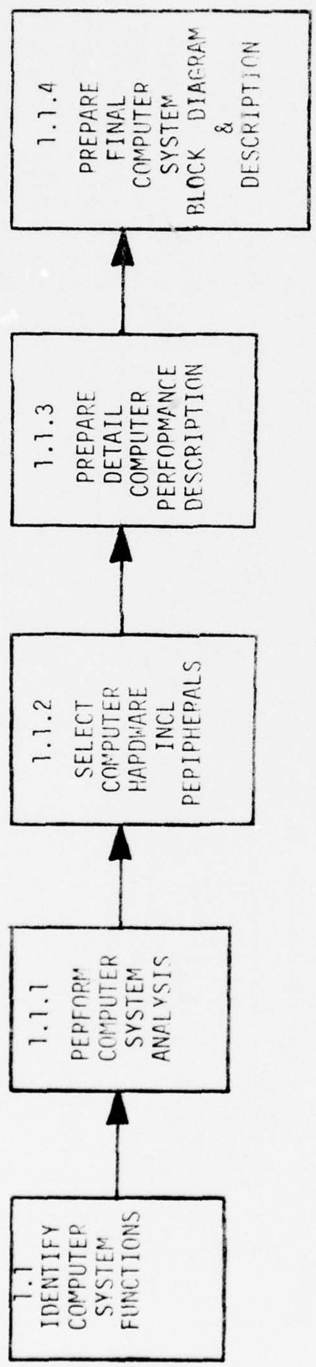

Figure 1. Analysis/Synthesis Process - Level 1

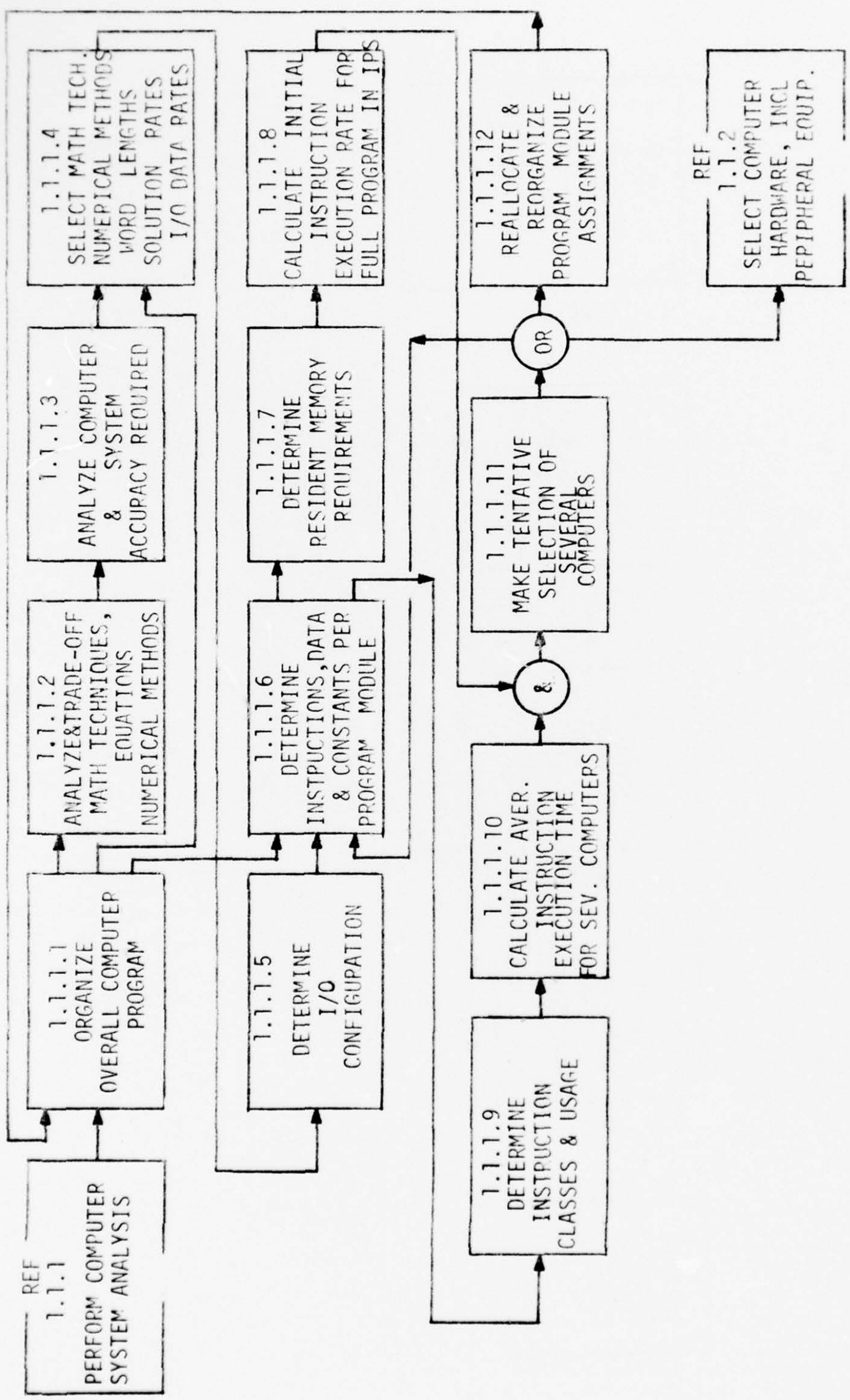

Figure 2. Analysis/Synthesis Process - Level 2

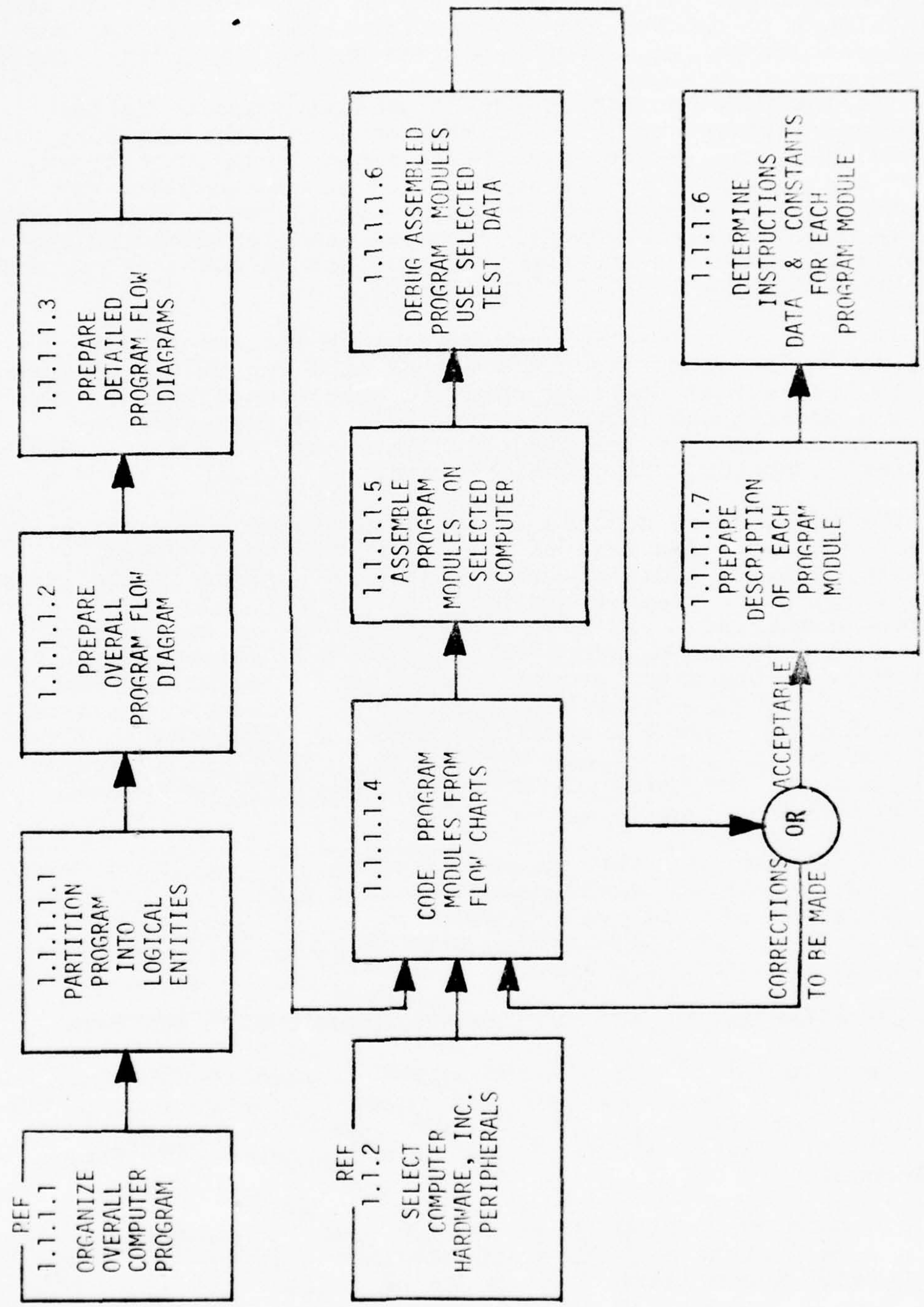

Figure 3. Analysis/Synthesis Process - Level 3

The second significant step in the analysis sequence is to determine the relative capability of computer hardware configurations to process the program involved and meet the program performance requirements derived during the initial step.

The instruction repertoires of general purpose digital computers selected for trainer applications have execution speeds which can vary significantly among instruction types. As an example, an ADD-type instruction of one computer may require only 1.5 microseconds for execution and a MULTIPLY-type may require 5.5 microseconds. Whereas, another computer may be capable of executing ADD-type instructions in 1.2 microseconds and MULTIPLY-type in 6.75 microseconds.

In order to normalize such variations from machine to machine and be able to compare two or more for execution capability, the actual computer hardware execution times are weighted by a percent-use factor representing the frequency each instruction is used in the program. This must be accomplished for each computer under consideration.

The percent-use factors (program instruction mix expressed as a percentage) for each of the major program groupings (flight, visual, tactics, etc.) that were applied in the analysis of the 2F112 trainer are shown in Table 1. To afford a consistent comparison, the same list of classes of instructions were used for each major grouping. However, percent-use factors vary between the major groups because of the nature of the routines involved. This normalization process provides a relative weighted Average Instruction Execution Time (AIET) for each computer being considered. The tables in Appendix C present this data for the three (3) different computers considered during the 2F112 analysis.

A comparison can then be made between the program performance and processing requirements shown in Appendix B and the capability of each of the computers being analyzed as shown in Appendix C. Table 2 summarizes this information for Device 2F112 from Appendixes B and C.

PROGRAM ORGANIZATION AND PERFORMANCE REQUIREMENTS ANALYSIS

The module size, data and constant storage requirements for each functional group was determined by one or more of the following methods that relate to the math models presented in Appendix A. These data were used in constructing the Tables of Appendix B.

a. Code the various modules in a given assembly language for a representative machine and tabulate each type of instruction used. These latter data would be needed to construct

Table 1, Percent Instruction Mix/Usage. Portions of the flight-aero and tactics simulation function were determined in this manner, based on recently developed training systems with similar requirements.

b. Compare the functions to be performed in each module with common functions in similar training system program modules and use the instruction count, data and constant count and instruction mix of these similar routines. This method was used in determining the storage (memory) requirements and instruction mix for portions of the flight-aero and tactics simulation functions.

c. Estimate the numbers and types of instructions, data and constant storage requirements based upon math models (Appendix Figures 4 through 7) and apply an appropriate contingency factor to each of these estimates to account for uncertainties in the estimating process. This method, in conjunction with the procedure described in Appendix A, was used to determine the storage requirements and instruction mix for the missile trajectory simulation, visual simulation and synthetic target simulation functions.

The accuracy of methods two and three obviously depends upon the experience and judgment of the individuals performing the analysis. Nevertheless, such methods are employed when time does not permit coding of all modules for all target computers under investigation. It gives an indication of the program processing involved and potential problems in sizing memory.

The estimated storage requirements for each major simulation functional group are tabulated in Appendix B tables. The summation of the instruction count of each identified routine, including appropriate contingency factors, constant and data counts for each module, determines the total storage (memory) requirement for that major functional group. In this analysis, a 10 percent contingency factor was added to each module instruction count to allow for estimating errors due to oversight, changes in training requirements and the like. Since FORTRAN IV was specified as the programming language for the 2F112 visual system and interactive synthetic target simulation, an additional 15 percent was added to each module instruction count for those simulation functions to account for inefficiencies in the code generated by FORTRAN compilers as compared to routines coded in assembly level language.

In order to allow for future expansion, spare memory for Device 2F112 was specified to be not less than 25 percent of the installed memory.

WORST-CASE INSTRUCTIONS EXECUTED

In determining the time required to execute the various program modules, it is necessary to determine the worst-case number of instructions of each module which are logically possible to be executed in a single pass through the routine. This is usually determined by examining the various paths of a detail flow diagram constructed for each module (Figure 3, 1.1.1.1.3). The longest possible path which can be traversed in a single solution frame will provide an indication of the worst-case instruction count. This instruction count, determined by methods previously discussed, can be either less than or greater than the total number of instructions comprising the total module. From a timing point of view, the worst-case numbers of instructions to be executed per pass is of primary interest for this analysis.

The worst-case instruction execution counts for the flight-aero and tactics simulation functional groups for Device 2F112 were derived from past experience and other trainer programs with similar processing requirements. The worst-case instruction count for the various flight and tactics modules varied from 0.1 to 10.0 times the module instruction count. The worst-case instruction execution counts for the visual and synthetic target simulation functional groups were estimated to be 1.0 (i.e., every instruction of each module would be executed per pass per cycle (or frame)). The worst-case instruction counts for each module of each major simulation functional group are listed in the Appendix B tables.

INSTRUCTION EXECUTION RATE

The highest execution rate for Device 2F112 was selected to be 32 times/second. The basis for selecting this execution rate was influenced by several factors which are: (1) design basis aircraft performance, (2) future performance considerations, and (3) minimization of overall simulation system time delay and subsystem time lags. Submultiple rates of 32 (i.e., 16, 8, 4, 2, 1) were assigned to other program modules according to the required responses of those modules. Execution time must not exceed total available time in a solution frame (minus 25 percent for spare) in order to provide valid system stability, simulation performance, and minimization of overall simulation system time delay and subsystem time lag.

Detailed studies[4,5] performed on real-time digital simulation of aircraft flight have established the criteria that a digital computer solution of the aero-flight equations should

4. Moore School Report 55-20, University of Pennsylvania, Simulation of a Supersonic Fighter Using a Digital Computer.
5. NAVTRADEVCEN 594-1, Analog-Digital Computers for Real-Time Simulation.

be made at the rate of not less than 20 times the highest natural frequency of the particular aircraft under consideration. The same criteria should hold for most other systems for real-time digital control and processing. Computation of dynamic parameters being displayed by cockpit instruments must occur at rates of not less than 12 to 16 times per second in order to preclude instrument jitter and/or oscillation for step changes in output data.

The minimum real-time execution rate required by the total simulation program (expressed as instructions per second (IPS)) is the summation of the product of the worst-case instruction count for each module and required solution rate for that module. The tables of Appendix B list the program modules with assigned solution rates for each of the various simulation functions. Separate tables provide the minimum real-time simulation execution rate for each major simulation functional groups (i.e., flight-aero, tactics, visual system, synthetic target).

PERCENTAGE INSTRUCTION DISTRIBUTION

After the total instruction count per module and the frequency of usage of the various classes of instructions (e.g., add, subtract, multiply, divide, etc.) have been tabulated, a percentage of each instruction type used in the total simulation program or function is computed and tabulated. This was accomplished during the course of the 2F112 analysis using information derived from procedures described in Appendix A. Table 1 provides a summary of the percent usage of various classes of instructions considered in the 2F112 analysis.

COMPUTER PERFORMANCE ANALYSIS

AVERAGE INSTRUCTION EXECUTION TIME (AIET). The percent usage of each instruction type corresponding to each major group was used to compute the average instruction execution time in microseconds for the various computer systems being considered for the 2F112 simulation task.

The AIET was calculated by multiplying the percent usage of each instruction type in the program of each major group by the execution time of the instruction as implemented in hardware in the computer being analyzed. The sum of the individual products provides the weighted average instruction execution time (in microseconds). This was repeated for each different computer under consideration for each percent mix for each major group. Each AIET was converted to an equivalent Instruction Per Second (IPS) figure in Appendix C Tables.

TABLE 1. PERCENT INSTRUCTION MIX/USAGE

Instruction Type	Flight-Aero	Tactics	AML* Target	Visual
Load	0.170	0.224	0.315	0.287
Store	0.096	0.133	0.187	0.132
Add/subt	0.170	0.096	0.110	0.170
Multiply	0.060	0.068	0.176	0.151
Divide	0.006	0.007	0.011	0.033
Logical	0.074	0.016	0.007	0.013
Shift(5 places)	0.160	0.091	0.029	0.032
Compare	0.020	0.046	0.060	0.054
Branch	0.230	0.147	0.105	0.121
Index	---	0.159	---	0.007
Reg-to-reg Opns	---	---	---	---
Input-Output (setup time plus transfer of 10 words)	0.014	0.013	---	---
Total	1.000	1.000	1.000	1.000

*AML - Adaptive Maneuvering Logic - Interactive Synthetic Target.

A tentative selection of a computer system can be based in part on the results obtained as indicated above. Those computers whose AIET is greater than the time computed in tables of Appendix B are obviously incapable of handling the minimum real-time simulation program processing requirements and must be removed from further consideration. If, of the several computers being considered, there is no single computer whose AIET is equal to or less than the required AIET, then consideration must be given to dividing the real-time simulation program among two or more processors or computers. Preliminary 2F112 computer analysis indicated that more than a single processor would be required. Consequently, the 2F112 simulation task was divided into the previously identified four major functional groups. Each was assigned to a separate central processing unit (CPU). A summary of the 2F112 real-time simulation processing requirements and the execution capabilities of the several computers is provided in Table 2.

The analysis indicates that there is only one available computer system which provides the processing capability required to satisfy the 2F112 (with visual) simulation problem (SEL 32/55). The Interdata 8/32 with lookahead is deficient for the tactics group. A feature of the 8/32 lookahead capability for increased processing performance is the use of a cache memory. This lookahead feature of the Interdata 8/32 cannot be used to its greatest advantage in a real-time simulator such as Device 2F112. Since up to 23 percent (from Table 1) of the total instructions will be Branch-type, this will result in aborting the advantages of the lookahead feature a portion of the time. Interdata 8/32 technical information[6] states that for branch operations outside the cache the additional execution time penalty can vary from 0 to 0.54 microseconds with 0.2 microseconds being a reasonably typical case. For the 2F112 analysis, the 8/32 execution time (Appendix Tables 8 through 11) was determined by averaging the branch times of 8 branch type instructions and adding 0.2 microseconds to that average.

TIME SLOT ANALYSIS

The tables of Appendix B and the preceding discussions show how the minimum program processing requirements for the 2F112 were derived. This derivation is based on the execution time of all modules being averaged over a full second. This facet of the analysis determined the initial processing and storage capabilities required of computer hardware.

6. Interdata Corp., Model 8/32 Processor User's Manual, 1975.

TABLE 2. DEVICE 2F112 PROGRAM PROCESSING REQUIREMENTS AND COMPUTER PROCESSING CAPABILITIES

PROCESSOR ASSIGNMENT	SIMULATION PROGRAM REQUIREMENTS (IPS)	SEL 32/55 (IPS)	INTERDATA 8-32 WITH LOOKAHEAD* (IPS)	XEROX 550 (IPS)
FLIGHT	556,002 (1)	729,395	597,979	370,796
TACTICS	563,396 (1)	709,069	446,688	373,566
SYNTHETIC TARGET	414,259 (1) (2)	562,398	522,684	327,107
VISUAL	345,532 (1) (2)	563,825	512,663	316,246

* Figures reflect average branch out of Cache 37 percent of time.
(1) Includes 10 percent contingency and 25 percent spare.
(2) Includes 15 percent for FORTRAN inefficiency.

However, since real-time simulation program execution is basically an iterative sequence of events within the computer, it becomes necessary to analyze the computer requirements in another level of detail to select computer hardware that is fully capable of meeting the processing time requirements per frame. This more detailed capability is determined on the basis of a time frame analysis.

For the 2F112 the highest frame rate for program solution is 32 per second. This translates to a period of 31.250 milliseconds per frame. Since 25 percent spare time per frame under worst-case processing conditions was specified, only 23.438 milliseconds are available in each time frame for processing all modules assigned to that time frame.

Each module (or routine) is assigned for execution in specific time frames (e.g., the modules required to be executed 32 times per second must be assigned to every frame, those to be executed at 16 times/second will be assigned to every other frame, etc.). The assignments of each module of each major functional group for the 2F112 analysis are indicated in tables of Appendix D.

The worst-case execution time of each module is computed for each assigned time frame. This worst-case time is the product of the worst-case number of instructions to be executed per frame and the weighted AIET of the computer being analyzed. All times calculated are summed to determine the total execution time for each frame. These individual sums represent the worst-case execution time for the individual time frames and must not exceed the available time per frame of 23.438 milliseconds.

A prime objective of this facet of the overall analysis is to minimize the worst-case time per frame. This optimization process involves a study of the assignments of each module and the contribution of each module to the total time per frame. Some reassignments can be made to reduce the worst-case time per frame. However, if it is physically impossible to assign the various modules in such ways as to reduce the worst-case time to within the allowed time, another computer (or a more powerful computer) is indicated.

The allocation of the program modules and the results of the time frame analysis for Device 2F112 are shown in Appendix D, Tables 12 through 23. It should be noted that the maximum usable processing time per frame is defined to be frame time minus the specified 25 percent spare processing time. It is conceivable that a more optimum (in processing time) allocation of program modules per time frame could exist than the one selected. The allocations used in Appendix D indicate that the specified usable processing frame time requirement could be met with at least one state-of-the-art and available computer hardware (i.e., System Engineering Laboratories Model SEL 32/55).

Several iterations of assignments were required to finally derive the module assignments shown on all tables of Appendix D.

SECTION IV

RESULTS AND CONCLUSIONS

The procedures and methodology that were used to determine the computer speed and storage requirements for Device 2F112 WST with a wide-angle visual system are described and documented in this report. The methodology described allows the engineer to determine the computational requirements (average number of instructions to be executed per second) for the total simulation problem. Should the computation load exceed the capabilities of available state-of-the-art processors, the analysis procedure illustrates an approach to solving this computer loading problem by judiciously distributing the required simulation functions among several processors. It should be noted that the initial computation load is based on the execution time of all modules comprising the total real-time simulation program being averaged over a full second. The next level of detail described is the time frame analysis. This analysis is used to determine if the selected computer hardware is fully capable of meeting the processing time requirement on a per frame basis.

The analysis method described in this report is a tool which can be utilized to gauge future trainer design approaches (both hardware and software) and to identify potential timing and storage problems as related to proposed hardware configurations. This enables the engineer to write more definitive computer system specifications for the simulation problem at hand and to perform more objective evaluations of technical proposals.

Furthermore, the results of the analyses as presented in this report will also be used as an initial basis for investigating more advanced trainer computer software and hardware technologies for future state-of-the-art trainer computer system architectures.

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NASA Technical Note D-7304, Description and Performance of the Langley Differential Maneuvering Simulator.

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APPENDIX A

SIMULATION MATH MODELS AND FLOW DIAGRAMS

FLIGHT-AERO MATH MODEL

The simulation of flight involves the determination of forces and moments which act on the aircraft due to propulsion and external environmental effects. Additionally, flight simulation involves determination of the translational and angular acceleration which results from forces and moments and finally the determination of aircraft attitude and geographical position from these accelerations. Math models for the flight simulation functions are shown in Figures 4, 5 and 6.

TACTICAL ENVIRONMENT

The tactical environment for Device 2F112 consists of airborne targets, ships, surface-to-air missile sites, AAA sites, air-to-air missiles, and an airborne controller. Additional capabilities related to the tactical environment include simulated IFF, electronic countermeasures, chaff, decoy, air-to-ground missiles, data link and navigation stations. Math model for air-to-ground targets and air-to-air target computations is shown in Figures 7 and 8.

AIR-TO-AIR MISSILE FLIGHT PATH SIMULATION

The requirement for air-to-air missile flight path simulation resulted from the addition of a visual system. The procedure employed in estimating the computer requirements, including instruction count, major data words and CPU time for missile motion simulation is as follows:

a. Problem defined (based on assumptions to establish a requirement baseline)

b. Program structure (major functional elements identified)

c. Model description with simplifications/approximations

d. General Flow Charts

e. Mathematical/FORTRAN-like statements

f. Assembly instruction count

Valid estimation requires accurate definition of requirements. In the absence of such information, reasonable assumptions must be used as the basis for estimation and documented to permit determination of validity and/or adjustments as definition of requirements evolve. General requirements for missile motion and related tasks are as follows:

LIST OF SYMBOLS

b	wing span
c	characteristic wing chord
C_D	drag coefficient
$C_{\ , m, n}$	rolling, pitching, or yawing moment coefficient
C_L	lift coefficient
$C_{X, Y, Z}$	x force, y force, or z force coefficient
C_L	typical stability derivative, in this case rolling moment due to sideslip angle
$F_{wx, wy, wz}$	total force along the x_w, y_w, or z_w axis
g	gravity acceleration
$G_{sx, sy, sz}$	gravity force along the x_s, y_s, or z_s axis
$I_{xx, yy, zz}$	principle moments of inertia about the x, y, or z axis
I_{xz}	product of inertia
$\ell_{1, 2, 3}$	direction cosine of a unit x vector onto the x_o, y_o, or z_o earth axis
L	aerodynamic rolling moment about x
L_s	aerodynamic rolling moment about x_s
m	mass
$m_{1, 2, 3}$	direction cosine of a unit y vector onto x_o, y_o, or z_o earth axis
M	aerodynamic pitching moment about y
M_s	aerodynamic pitching moment about y_s
M_x	total pitching moment about x
M_y	total pitching moment about y

M_z	total pitching moment about z
$n_{1,2,3}$	direction cosine of a unit z vector onto the x_o, y_o, or z_o axis
N	aerodynamic yawing moment about z
N_s	aerodynamic yawing moment about z_s
P	x component of body-axis angular velocity
P_s	x_s component of body-axis angular velocity
P_w	x_w component of body-axis angular velocity
$P_{x,u,z}$	component of engine thrust along the x, y, or z axis
Q	y component of body-axis angular velocity
Q_S	y_s component of body-axis angular velocity
Q_w	y_w component of wind-axis angular velocity
R	z component of body-axis angular velocity
R_s	z_s component of body-axis angular velocity
R_w	z_w component of wind-axis angular velocity
S	wing area
S_a	deflection of roll control
S_{AUXFL}	deflection of auxiliary flap
S_{Fl}	deflection of flap
S_{GV}	deflection of glove valve
S_{is}	deflection of inboard spoiler
S_s	deflection of outboard spoiler
S_{SB}	deflection of speed brake

S_{SL}	deflection of wing slot
S_R	deflection of rudder
S_z	pressure altitude (hp)
$T_{x,\ y,\ z}$	power plant moment about the x, y, or z axis
U	x component of total aircraft velocity
V	y component of total aircraft velocity
V_p	total aircraft velocity
W	z component of total aircraft velocity
x, y, z	aircraft body axes
x_x, y_s, z_s	stability axes
X, Y, Z	aerodynamic force along the x, y, or z axis
X_s, Y_s, Z_s	Aerodynamic force along the x_s, y_s, z_s axis
α	angle of attack
$\dot{\alpha}$	angle of attack rate
β	angle of sideslip
η_{AUXFL}	flexibility of auxiliary flap
η_{SFL}	flexibility of flap
μ'	airspeed components along body axis
Λ	wing sweep angle
θ	body-axis attitude angle
ϕ	body-axis bank angle
ψ	body-axis heading angle
Ω	body-axis angular velocity
$\dot{s}_x$	north component of AC velocity
$\dot{s}_y$	east component of AC velocity
$-\dot{s}_z$	rate of climb

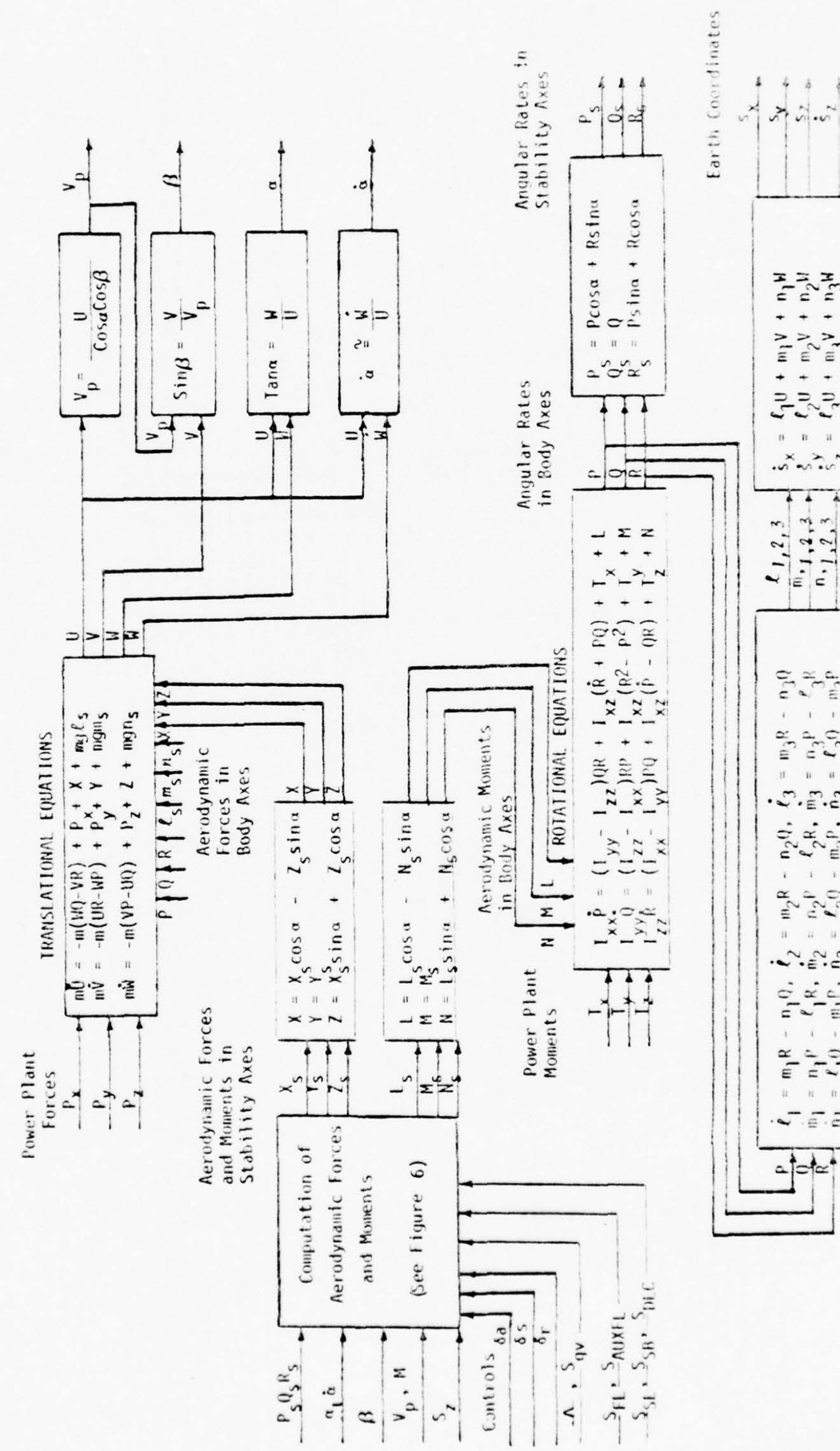


Figure 4. Block Diagram of the Flight Equations Using Direction Cosines

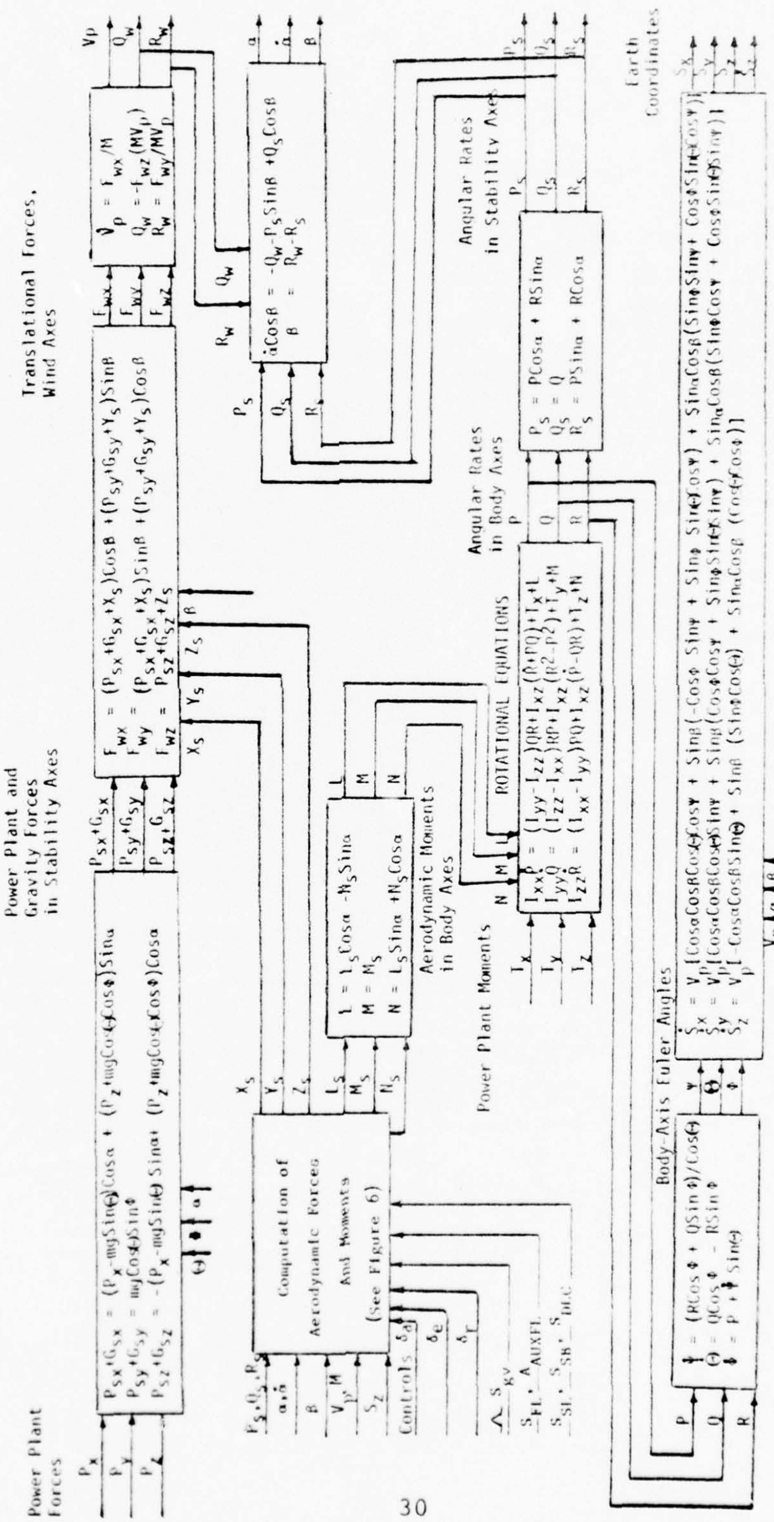


Figure 5. Block Diagram of the Flight Equations Solved in the Combined Body-Axis, Wind Axis System Using Body-Axis Euler Angles

AERODYNAMIC FORCES

$$X_s = -qsC_{D_s}$$

$$C_{D_s} = f\,(\alpha, M, S_z, \Lambda, \mu', \dot{\alpha}, \delta_{i_s}, \delta_s, \eta_{\delta_s}, \delta_{FL}, \eta_{\delta_{FL}}, \delta_{AUXFL}, \eta_{AUXFL}, \delta_{SL}, \delta_{SB}, \delta_a, \delta_{DLC}, \text{STORES, GROUND EFFECT, ENGINE})$$

$$Y_s = -qsC_{y_s}$$

$$C_{y_s} = f\,(\alpha, M, S_z, \Lambda, P_s, R_s, \delta_r, \delta_s, \eta_{\delta_s}, \delta_{FL}, \eta_{AUXFL}, \text{STORES, GROUND EFFECT})$$

$$Z_s = -qsC_{L_s}$$

$$C_{L_s} = f\,(\alpha, M, S_z, \Lambda, \mu', \dot{\alpha}, Q_s, \delta_{GV}, \delta_{is}, \delta_s, \eta_{\delta_s}, \delta_{FL}, \eta_{\delta_{FL}}, \delta_{AUXFL}, \eta_{AUXFL}, \delta_{SL}, \delta_{SB}, \delta_a, \delta_{DLC}, \text{STORES, GROUND EFFECT})$$

AERODYNAMIC MOMENT

$$L_s = -qsbC_{\ell_s}$$

$$C_{\ell_s} = f\,(\alpha, M, S_z, \Lambda, \beta, R_s, P_s, \delta_r, \delta_s, \eta_{\delta_s}, \delta_{FL}, \eta_{\delta_{FL}}, \delta_{AUXFL}, \eta_{AUXFL}, \delta_{SB}, \delta_a, \text{STORES, GROUND EFFECT})$$

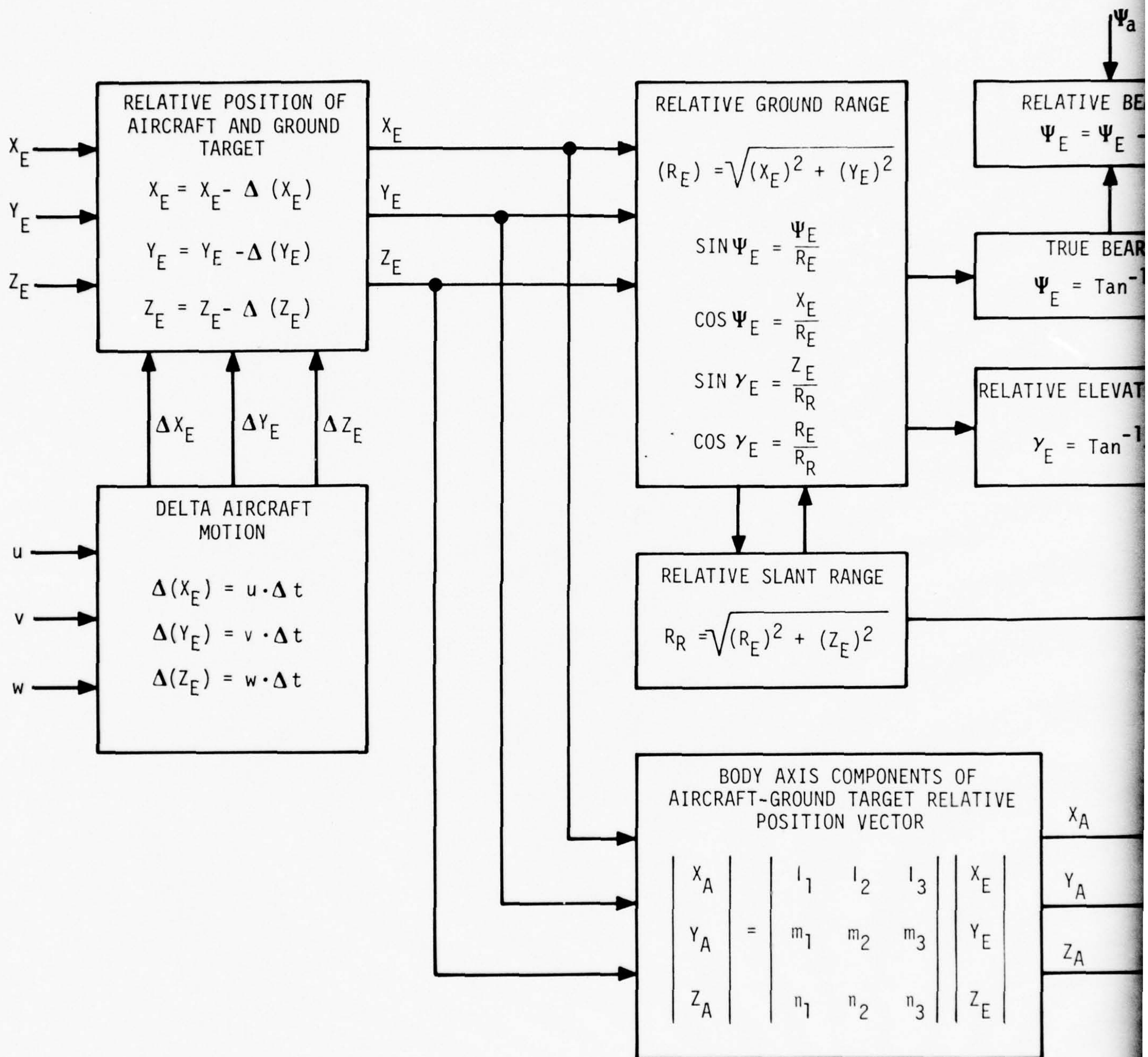
$$M_s = -qsbC_{m_s}$$

$$C_{m_s} = f\,(\alpha, M, S_z, \Lambda, C_L, \mu', \dot{\alpha}, Q_s, \delta_{is}, \delta_s, \eta_{\delta_s}, \delta_{FL}, \eta_{\delta_{FL}}, \delta_{AUXFL}, \eta_{AUXFL}, \delta_{SB}, \delta_a, \delta_{DLC}, \text{STORES, GROUND EFFECT})$$

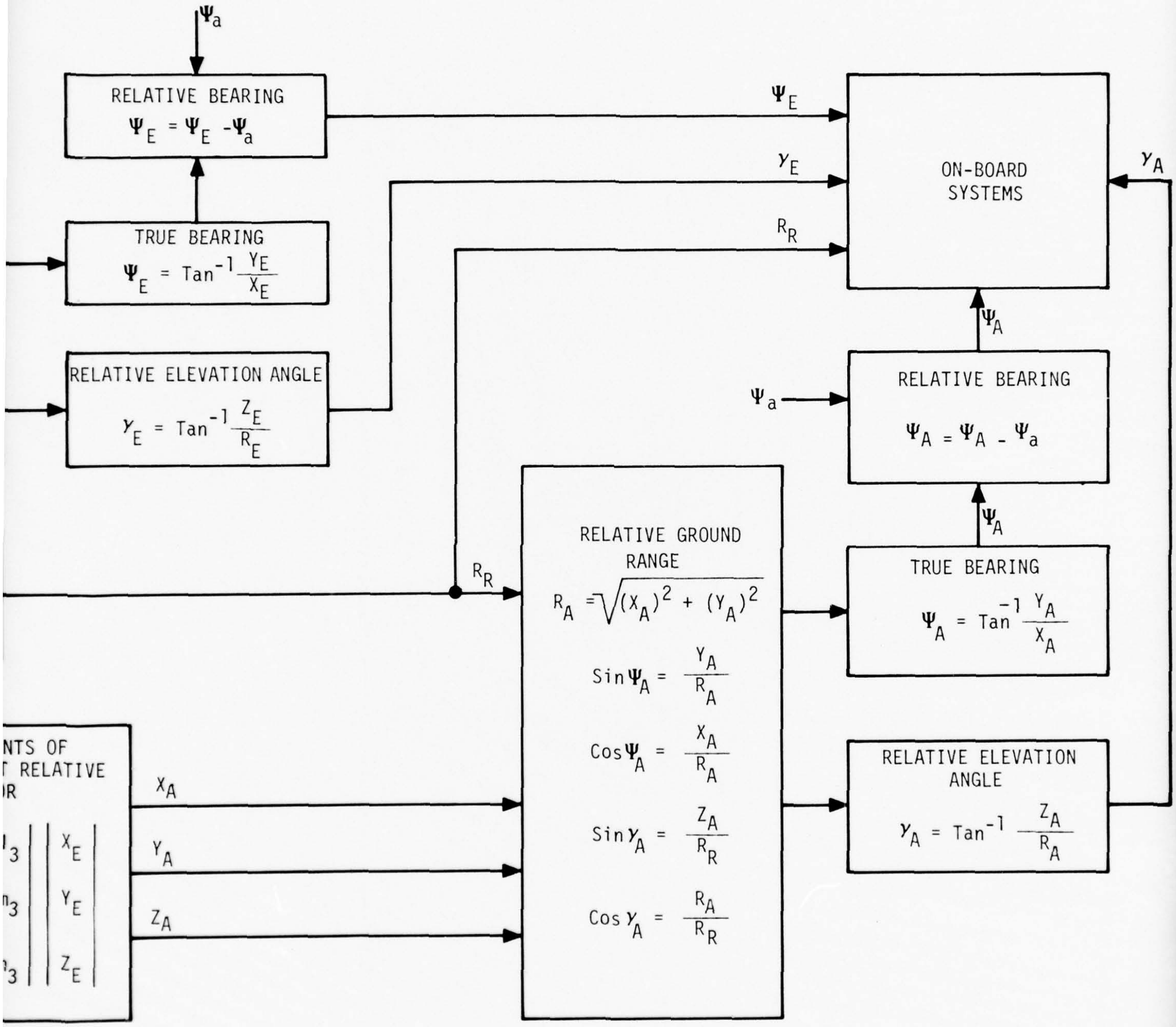
$$N_s = -qsbC_{n_s}$$

$$C_{n_s} = f\,(\alpha, M, S_z, \Lambda, \beta, P_s, R_s, \delta_r, \delta_s, \eta_{\delta_s}, \delta_{FL}, \eta_{\delta_{FL}}, \delta_{AUXFL}, \eta_{AUXFL}, \delta_a, \text{STORES, GROUND EFFECT})$$

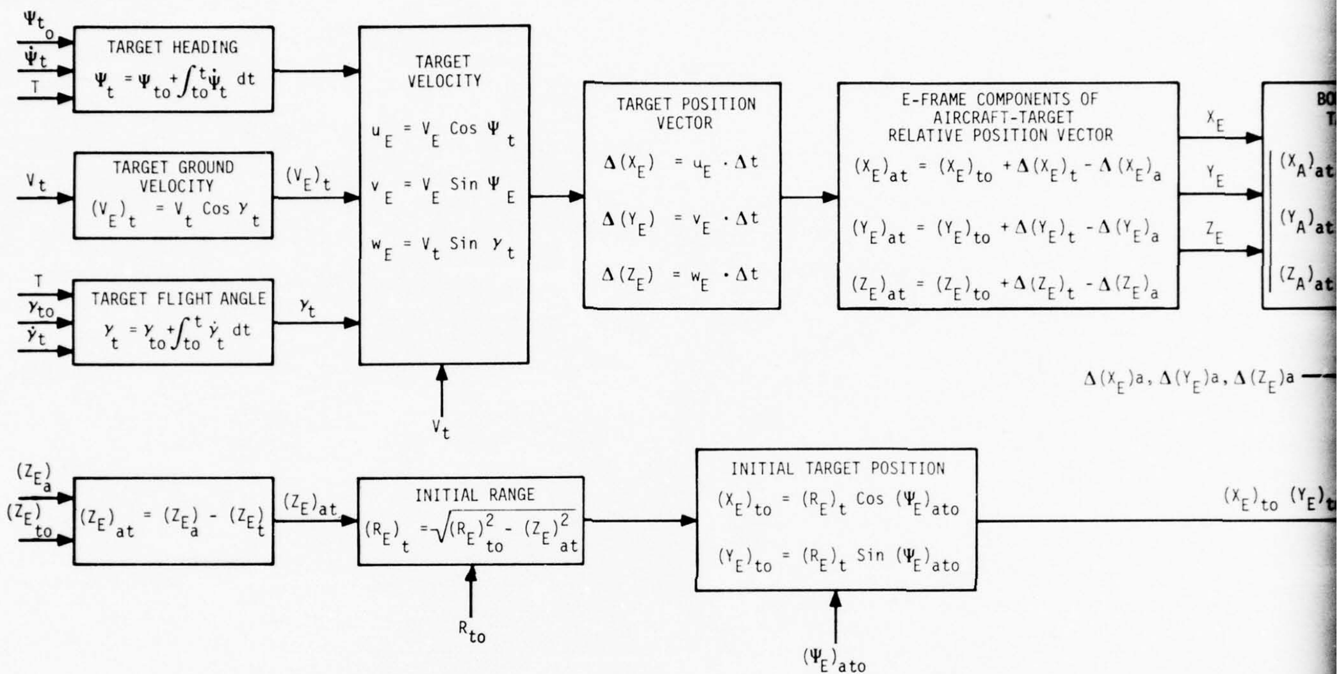
Figure 6. Aerodynamic Forces and Moments for Device 2F112

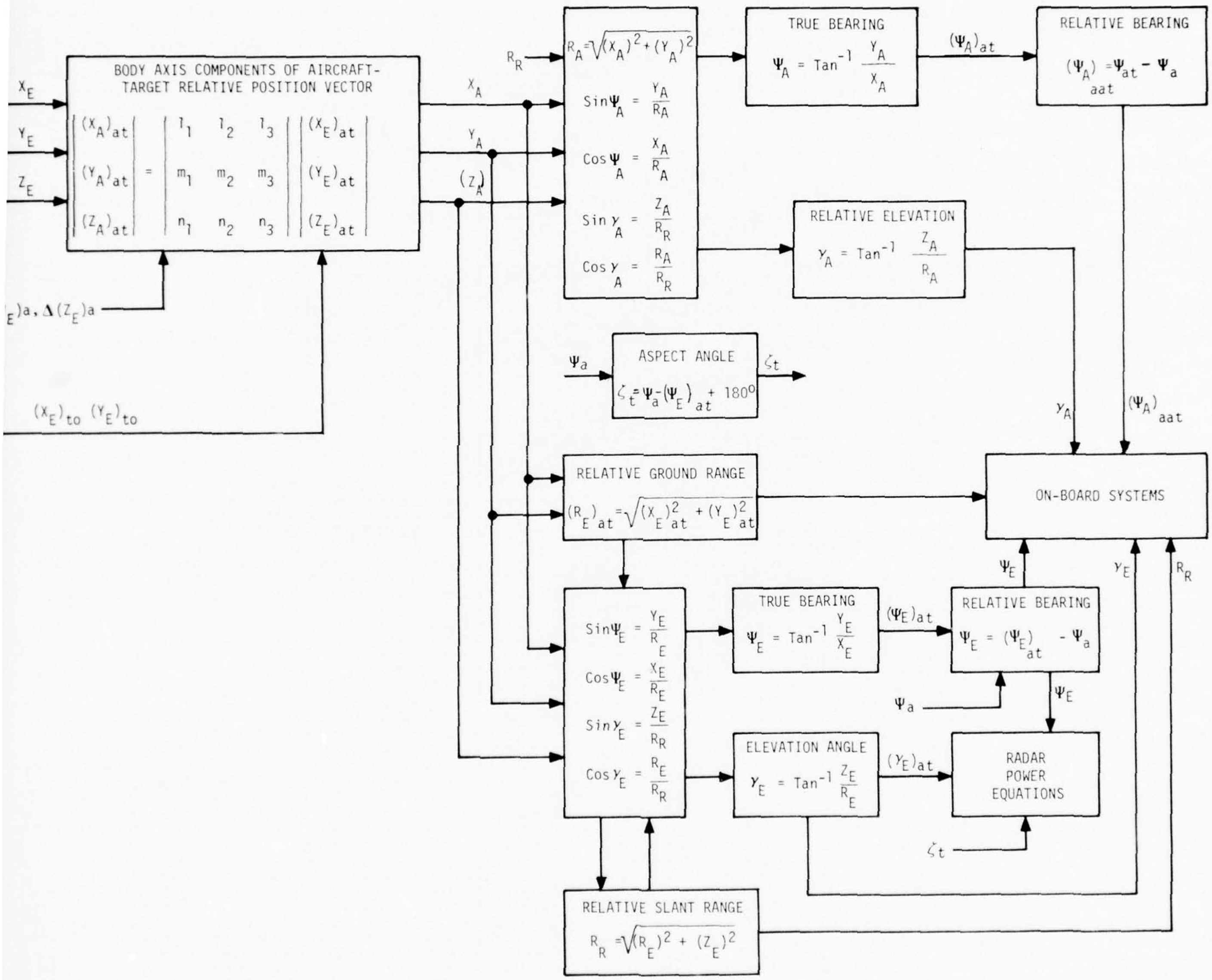


RELATIVE POSITION OF AIRCRAFT AND GROUND TARGET
X_E = X_E - Δ (X_E)
Y_E = Y_E - Δ (Y_E)
Z_E = Z_E - Δ (Z_E)
ΔX_E
ΔY_E
ΔZ_E
DELTA AIRCRAFT MOTION
Δ(X_E) = u·Δt
Δ(Y_E) = v·Δt
Δ(Z_E) = w·Δt
u
v
w
RELATIVE GROUND RANGE
(R_E) = √((X_E)^2 + (Y_E)^2)
SIN Ψ_E = Ψ_E / R_E
COS Ψ_E = X_E / R_E
SIN γ_E = Z_E / R_R
COS γ_E = R_E / R_R
RELATIVE SLANT RANGE
R_R = √((R_E)^2 + (Z_E)^2)
BODY AXIS COMPONENTS OF AIRCRAFT-GROUND TARGET RELATIVE POSITION VECTOR
X_A, Y_A, Z_A = l1 l2 l3, m1 m2 m3, n1 n2 n3 · X_E, Y_E, Z_E
X_A
Y_A
Z_A
Ψa
RELATIVE BE
Ψ_E = Ψ_E -
TRUE BEAR
Ψ_E = Tan^-1
RELATIVE ELEVAT
γ_E = Tan^-1



AIR-TO-GROUND TARGET MATH MODEL


TARGET HEADING
TARGET VELOCITY
TARGET GROUND VELOCITY
TARGET FLIGHT ANGLE
TARGET POSITION VECTOR
E-FRAME COMPONENTS OF AIRCRAFT-TARGET RELATIVE POSITION VECTOR
INITIAL RANGE
INITIAL TARGET POSITION



AIR-TO-AIR AIRCRAFT TO TARGET MATH MODEL

a. The training problem situation includes two aircraft in a one-on-one tactical encounter.

b. Max of twelve missiles in-flight in system at one time.

c. Six outgoing maximum.

d. Six incoming maximum.

e. Three different missile types.

f. General motion capabilities to support visual display projectors only. Missile dynamics to be approximations only. Will include general simulation of max G turn and velocity to depend on air density at current altitude. Control fins and control system not modeled.

g. Damage assessment to aircraft based on proximity fusing, forced miss may be included on random basis if desired.

h. Ability of aircraft to outmaneuver incoming missile will depend solely on max G turn of missile and current velocity.

i. Top priority missiles are:

Incoming: Closest range first
Outgoing: Outgoing through burnout

j. Two missile projectors. Top priority missile drives either projector required to display video. Remaining projector will display second priority missile.

k. Iteration rate 4/sec.

l. Display activation: Lamp on continuous during trajectory. Off during gimbal slewing. (repositioning)

m. Commanded G turn and velocity both based on straight line approximations with max velocity at 60K feet, min at sea level, max G at sea level, minimum at 60K feet.

n. All logic functions associated with AWG-9 Radar and missile armament and mode select criteria are assumed to be identical to that of the 15C9 Tactics Trainer. This estimate and procedure is only for flight of missile, and control of light projectors.

o. Outgoing missiles are from trainee vehicle always.

p. Incoming missiles are from enemy aircraft always.

Motion simulation is required to provide missile position in problem exercise space, scoring or damage assessment for problem aircraft, and missile light spot projector control. The prelaunch operations are already modeled as part of the 2F112 tactics portion with scoring predictions based on acceptability of prelaunch operations. The visual system incorporation required missile flight visual cues. Thus, the missile trajectory had to be added. To integrate the trajectory and modified scoring with the existing prelaunch logic control simulating missile selection, radar operation, and control functions, a basic structure (Figure 9) was selected.

The major prelaunch operation is unchanged. Associated with the missile trajectory and display controls is an active missile data list or table. The data list consists of two parts; outgoing missiles and incoming missiles, each of which has an associated file holding missile state and parameter data including:

a. Type (1, 2, 3)

b. Guidance Mode, PHASE TIME A B C (up to three phases)

c. Burn Time, Time into Trajectory

d. Inertial Position X, Y, Z

e. Heading, Heading Change Rate, Climb Rate

f. Max G Turn (Sea Level Value)

g. Speed (Max at 60K feet)

h. Target Vehicle Track Number or (Data List Pointer)

i. Position Relative to Trainee Pilot

j. Dome Position

k. Spot Size, Intensity, Flash On/Off

As missiles are launched, the data list is expanded adding pertinent data for the associated missile and as missiles strike the target or burn out the missile record data is deleted and the missile is removed from the active list. A major subroutine is provided for processing each of the missiles in the active missile list. Missile list processing includes trajectory integration, target/missile proximity computation and damage assessment, burn out determination, list updating and priority assignment for light spot projector assignment.

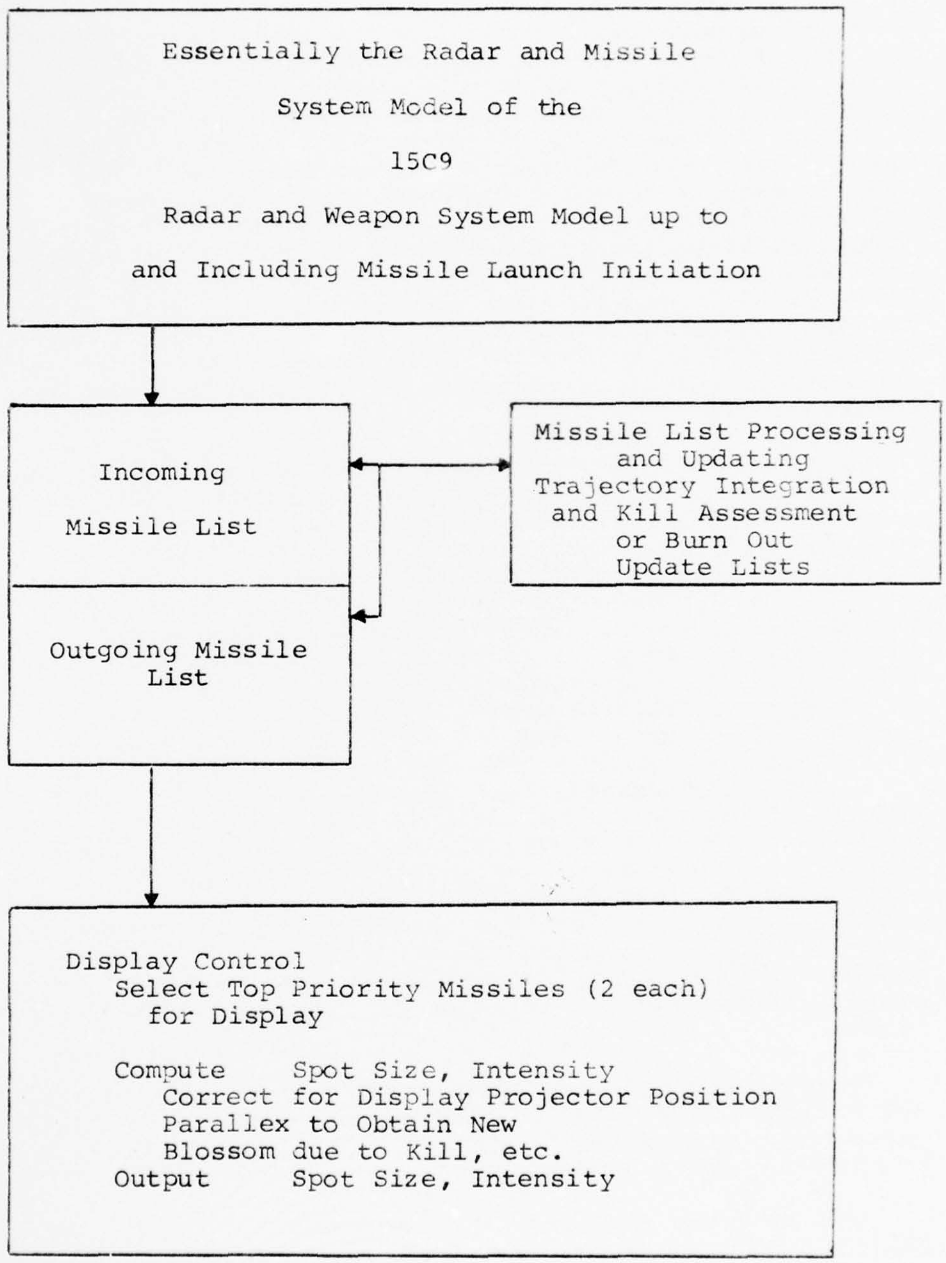


Figure 9. General Structure of Missile Motion Addition to 2F112 WST

The missile model is not to be a complete system model with aerodynamics and control system included but rather a simple kinematic model approximating missile dynamics. Missile velocity will have an assigned maximum velocity at an altitude of 60,000 feet (and above) with a straight line proportional decrease with altitude. The velocity increase and max (G) turn decrease with increased altitude is due to air density effects on total drag and aerodynamic moments. Initial velocity at launch will equal launching aircraft speed with linear acceleration to the maximum allowable for current missile altitude. Heading change rates will occur at maximum allowable G force value for current altitude until missile heading equals relative target/missile bearing. Climb/dive angle rates will be handled in a similar manner. No further explanation should be required for the missile velocity procedure.

Very general flow charts are provided as Figures 10 and 11. The charts only indicate one major path. Several are possible, but all are assumed to be equivalent in terms of time and number of instructions per pass. Processing of any one active missile commences with reading the type word for a given missile. Based on the type word, the appropriate routine is selected. Assuming here that missile type 1 was launched, the first two tests are to determine the phase of the flight (e.g., initial, mid course, terminal). Any slight differences in processing would be provided for in the separate routines for Phase 1, Phase 2, and Phase 3. "A" and "B" are variables that designate terminal time for a given phase. "TIT" designates Time-Into-Trajectory. Assuming Phase "C" (terminal phase), the routine flow chart is fairly self explanatory. Decision blocks containing A1, B1, A2, and B2 are to determine priority of the missile currently being processed. Upon detection of burn out or "hit" indications, records are deleted and/or "Flash" flags are set to direct display system to display an appropriate flare (flash) indication. The chart shown depicts what is considered the worst case pass through the missile motion routine in terms of instruction count and CPU time.

Display computations for the two top priority missiles are outlined in Figure 11. It may be necessary to perform these computations during each 1/32 sec time slot for appropriate nonflicker presentations.

The computer requirements were based on the assumption that routines shown in Figures 10 and 11 would be computed three times per 1/32 sec time slot. No single missile will be processed completely every time slot, but provisions to integrate position of each top priority missile based on rates computed during the last update of that missile are essential for each time slot.

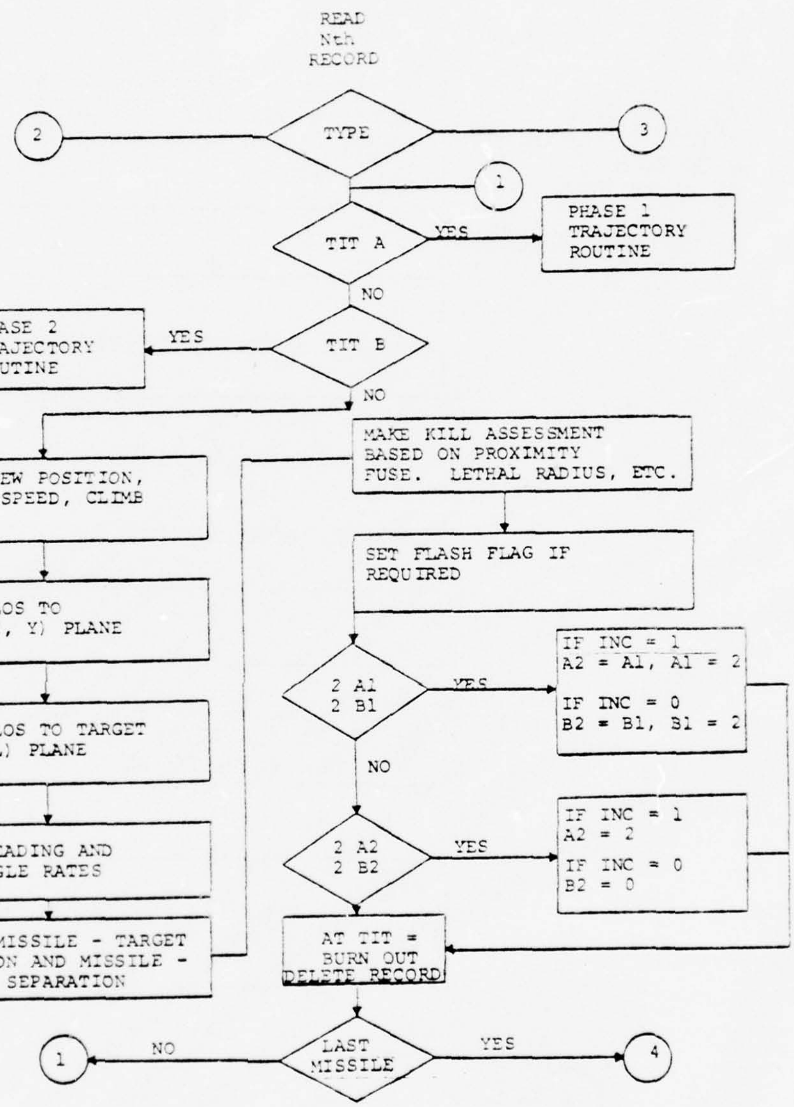


Figure 10. Basic Missile Motion Flow Chart

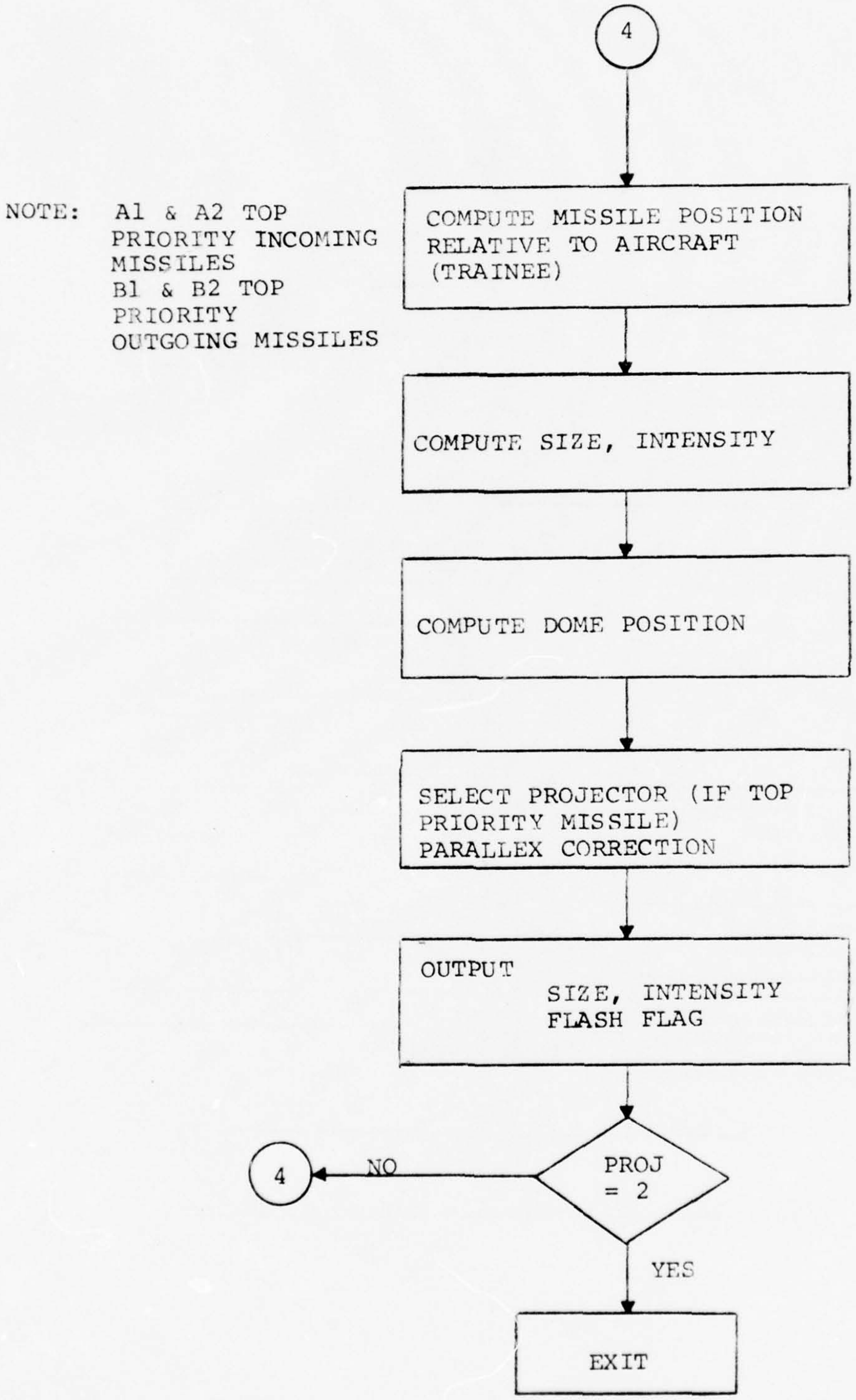


Figure 11. Display Computations Performed for Two Top Priority Missiles

The two final steps in estimating required instruction count and CPU time are interrelated and based on the math model and flow charts. The first step has to write a rough approximation of the mathematical statements required to satisfy the math model and flow charts. FORTRAN-like statements were used as an intermediate step simply because they follow directly from mathematical and logic functions and one can maintain the overall system view which could be lost in the detail of assembly instruction. The FORTRAN/mathematic statements were then scanned and an estimate of assembly instructions of the load, store, shift variety required to implement these FORTRAN statements were tallied. Each Trig Macro (SIN,COS,TAN) required addition of basic operations as tabulated below. This tabulation was based on a typical SIN-COS function routine.

	BASIC INST	NO. OF OCCURRENCES
SIN FUNCTION	Load	25
	Store	8
	Add	10
	Mult	10
	Logical	2
	Shifts	6
	Comp	5
	Branch	17
	Index	1

Since the addressing scheme for missile data is based on a record or File System relative addressing was assumed and for each load instruction one Index operation was also assumed.

In writing the math statements, each block of the flow chart was selected in order. A short section follows:

```
FLOW CHART      AVG HEADING = HEADING * HEADING RATE/2
                HEADING = HEADING + HEADING RATE
BLOCK A         THE A = CLIMB ANGLE + CLIMB ANGLE RATE
                VELOCITY = VELOCITY MIN + K * ALTITUDE
                VELOCITY (XY) = VELOCITY * COS (THE A)
                Z DOT = VELOCITY * SIN (THE A)
                X DOT = VELOCITY (XY) * COS (AVG HEADING)
                Y DOT = VELOCITY (XY) * SIN (AVG HEADING)
                X = X + XDOT
                Y = Y + YDOT
                Z = Z + ZDOT
               Z1 = Z M - ZT
               X1 = XM - XT
               Y1 = YM - YT

BLOCK B     HEAD = ARC TAN  X1/Y1

                ETC.
```

Assembly instructions are then written to implement the above.

```
BLOCK A          LOAD A
                 LOAD B
                 SHIFT B
                 ADD
                 STORE
                 LOAD A
                 LOAD B
                 ADD
                 STORE
                 LOAD A
                 LOAD B
                 SHIFT B
                 ADD
                 STORE
                 LOAD A
                 LOAD B
                 ADD
                 STORE
                 LOAD A
                 LOAD B
                 MULT
                 LOAD B
                 STORE
                 COS *
                 LOAD B

                 ETC.
```

Upon completion of coding estimates for all major Blocks of the Flow Chart (Figure 10) a tally sheet was prepared for each Flow Chart (Major Routine). The basic instruction count was added first omitting all macros. Next, each macro was handled by taking the product of its number of occurrences times the number of times each basic instruction is required during one call. In this estimate, the SIN macro was used for all Trig functions including inverse functions. Other macros such as SQRT were handled similarly.

Assuming an average instruction execution time of 1.5 micro seconds about 2 millisec is required per pass (as per missile) for basic motion and scoring. To process the two top priority missiles for display control, approximately 1.1 milli-seconds is required. Thus, to update three of the possible 12 active missiles and process two for display would require approximately 7.1 milliseconds. If this much time is available after other functions are performed, the four basic 1/32 sec processing slots will permit updating all 12 missiles.

VISUAL SYSTEM MATH MODEL

Visual system simulation involves math models which serve to transform the orientation, in inertial space, of two aircraft (one-on-one situation) into the gimbal position of the projection servos. The math model for controlling the major subsystems (sky-Earth projector, target pointing mirror, target model, target zoom and focus) is illustrated in figures 12 through 14. A detailed discussion of the math model for controlling the various subsystems and the projection geometry is provided in NASA Technical Note D-7304 Description and Performance of Langley Differential Maneuvering Simulator.

COMPUTER SYNTHESIZED TARGET

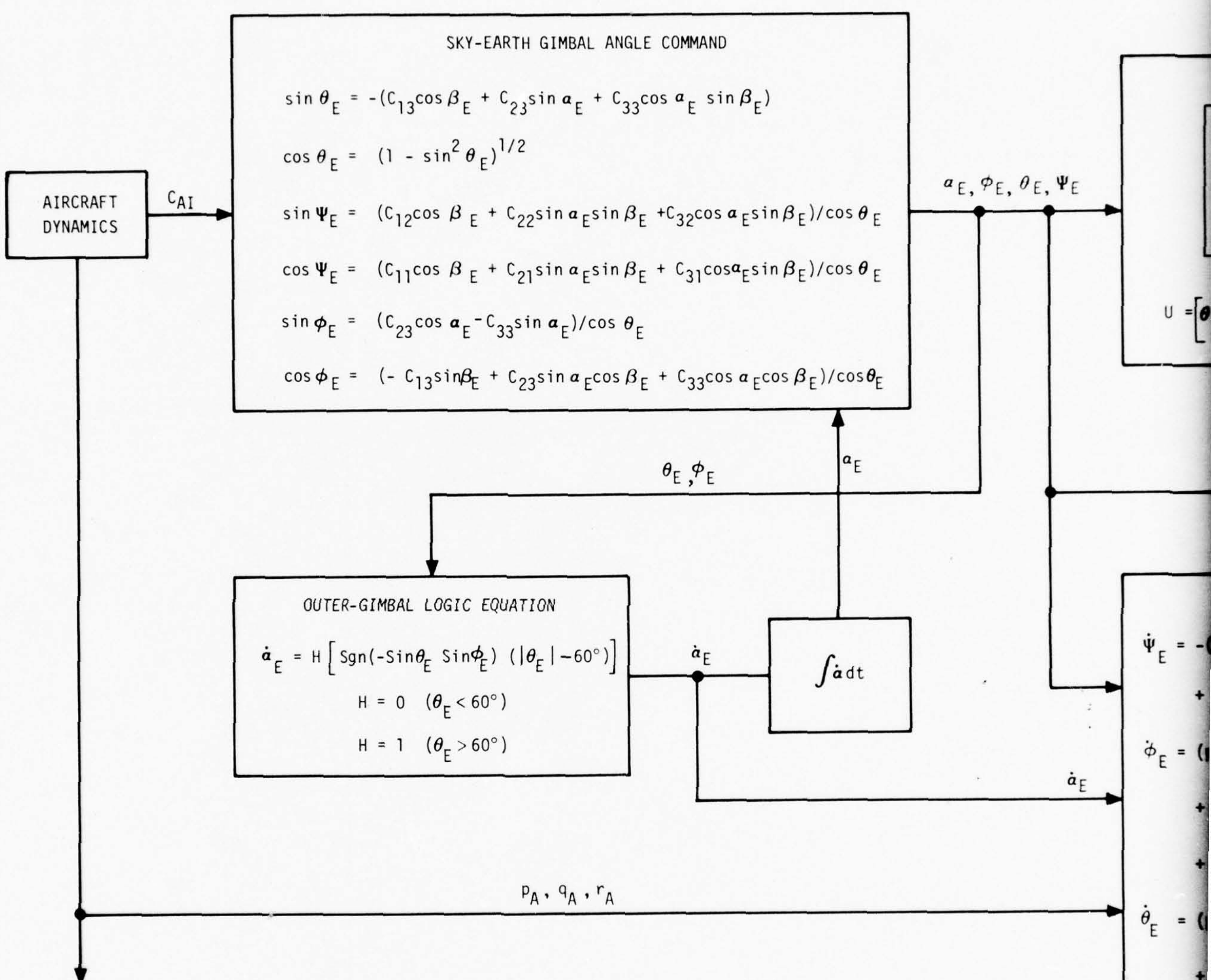
Information derived from NASA Report 1-9115, Adaptive Maneuvering Logic Computer Program for the Simulation of One-on-One Air-to-Air Combat was used as the basis for estimating the storage and speed requirements for the computer synthesized target. A detailed description of the Adaptive Maneuvering Logic (AML) program and subroutines is provided in the NASA report.

A first level flow diagram is provided in Figure 15. Table 3 depicts in simplified form, the sequence in which routines are called by the main simulation program developed by NASA. It also shows which other routines on the left hand side calls the subroutines on the right hand side. Broken and solid lines are used to designate the attacking aircraft and target aircraft respectively. A glossary of routines is also provided.

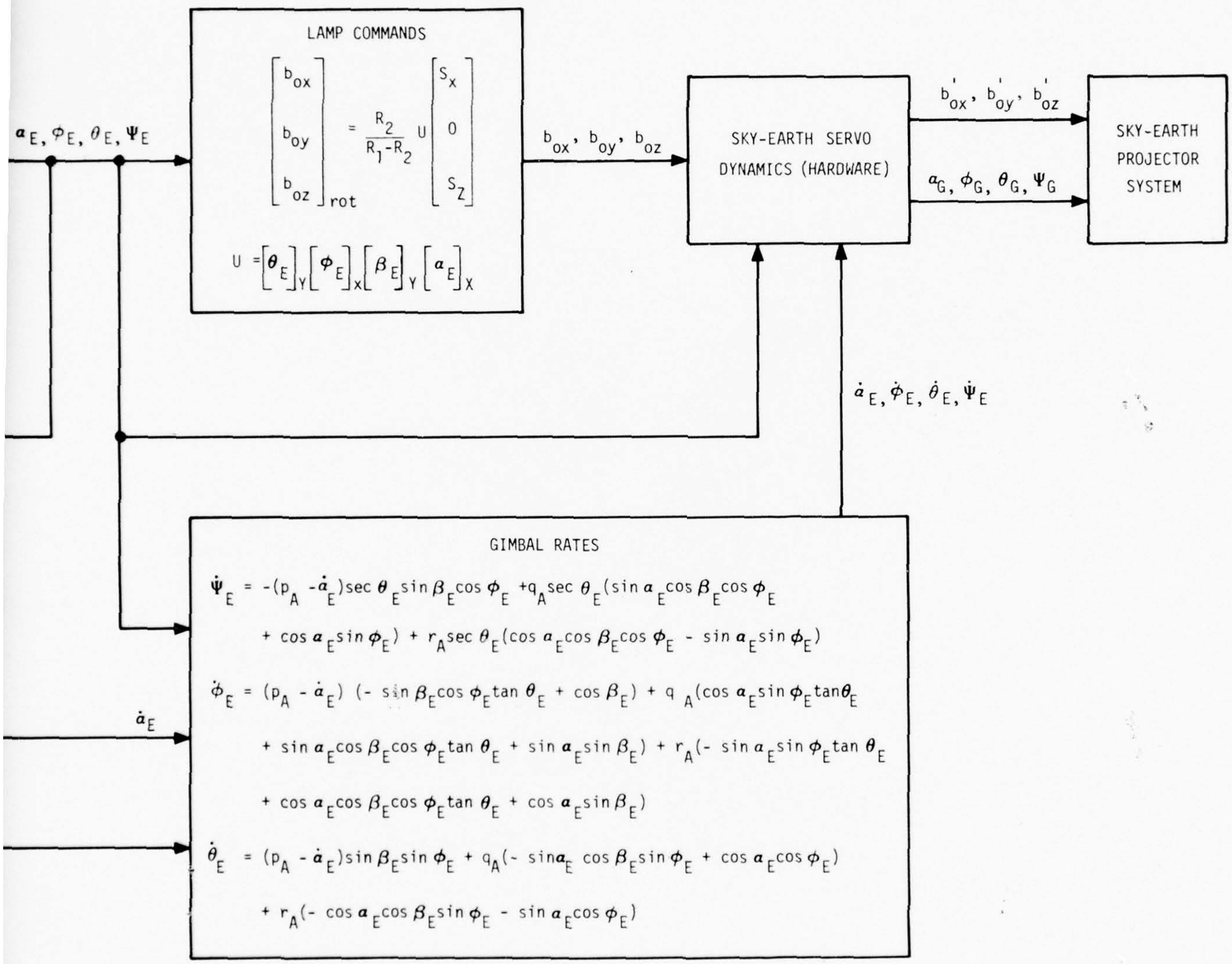
The subroutines are grouped in three levels. In the left column (level 1) are those routines which are called by the main program. They are listed in the sequence in which they are called.

Level two routines are listed in the center column. Subroutines may be listed more than once and in more than one column, if they are called at different levels. For instance, subroutine CLOSS is called directly from the main, but also from level 1 and from level 2 subroutines.

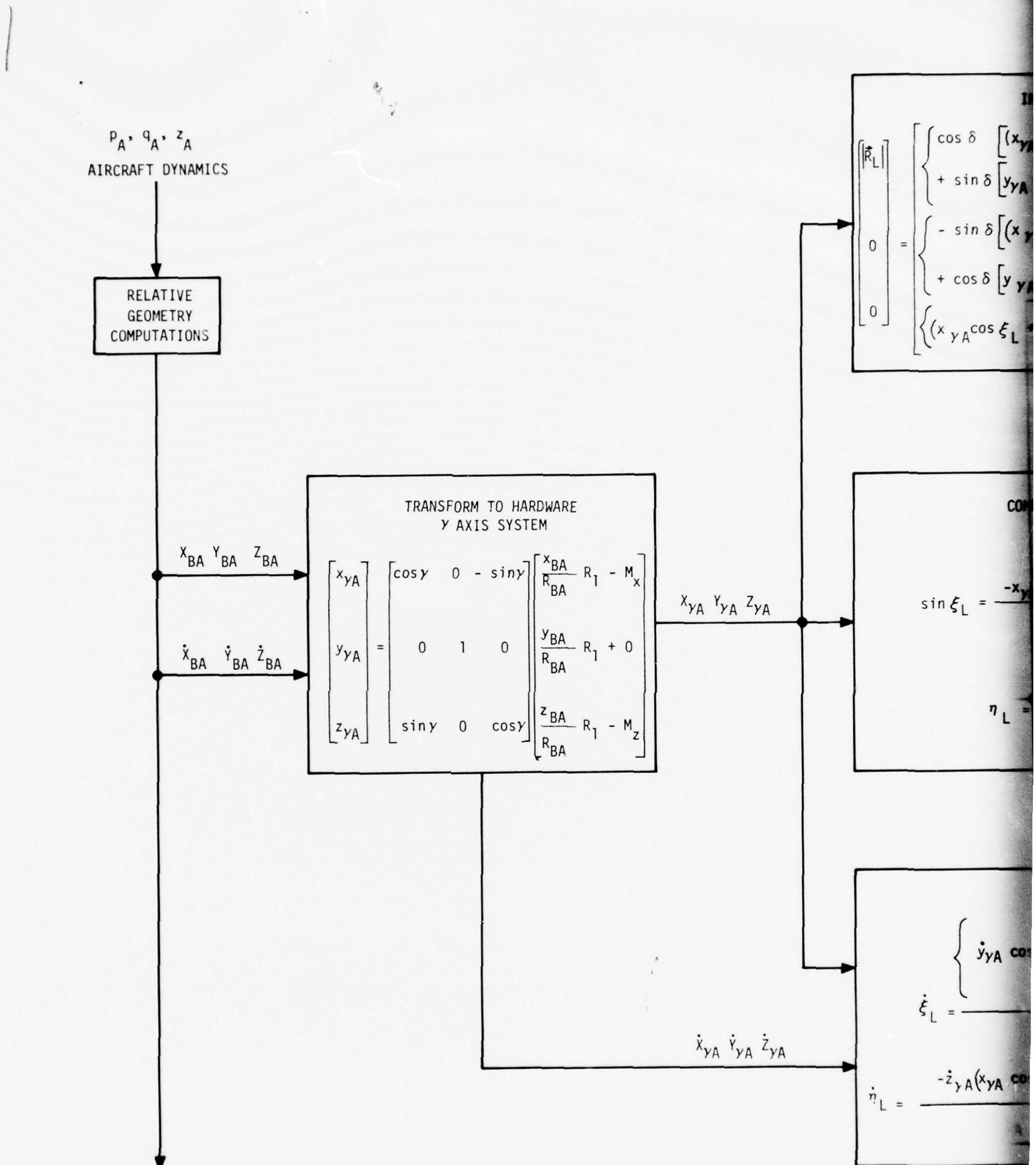
In order to keep the figure from being cluttered, the subroutine CMTRX is omitted. It would appear in level 2, being called by EQMOTA, EQMOTT, REACTA and REACTT and in level 3 being called by TRYNXA, TRYNXT and PRETNW. Pages 55 and 56 list the major AML subroutines with a brief description of each.



AIRCRAFT DYNAMICS
C_AI
SKY-EARTH GIMBAL ANGLE COMMAND
sin θ_E = -(C_13 cos β_E + C_23 sin α_E + C_33 cos α_E sin β_E)
cos θ_E = (1 - sin² θ_E)^1/2
sin Ψ_E = (C_12 cos β_E + C_22 sin α_E sin β_E + C_32 cos α_E sin β_E)/cos θ_E
cos Ψ_E = (C_11 cos β_E + C_21 sin α_E sin β_E + C_31 cos α_E sin β_E)/cos θ_E
sin φ_E = (C_23 cos α_E - C_33 sin α_E)/cos θ_E
cos φ_E = (- C_13 sin β_E + C_23 sin α_E cos β_E + C_33 cos α_E cos β_E)/cos θ_E
α_E, φ_E, θ_E, Ψ_E
α_E
θ_E, φ_E
OUTER-GIMBAL LOGIC EQUATION
α̇_E = H [Sgn(-Sin θ_E Sin φ_E) (|θ_E| - 60°)]
H = 0 (θ_E < 60°)
H = 1 (θ_E > 60°)
α̇_E
∫α̇ dt
α̇_E
p_A, q_A, r_A
U =
Ψ̇_E = -
φ̇_E = (
θ̇_E = (



MATH MODEL FOR SKY-EARTH PROJECTION SYSTEM



p_A, q_A, z_A
AIRCRAFT DYNAMICS
RELATIVE GEOMETRY COMPUTATIONS
X_BA Y_BA Z_BA
Ẋ_BA Ẏ_BA Ż_BA
TRANSFORM TO HARDWARE γ AXIS SYSTEM
[x_γA; y_γA; z_γA] = [cosγ 0 -sinγ; 0 1 0; sinγ 0 cosγ] [x_BA/R_BA R_1 - M_x; y_BA/R_BA R_1 + 0; z_BA/R_BA R_1 - M_z]
X_γA Y_γA Z_γA
Ẋ_γA Ẏ_γA Ż_γA
|R⃗_L|
0
0
cos δ
+ sin δ
- sin δ
+ cos δ
sin ξ_L =
η_L
ξ̇_L =
η̇_L =

2

IMAGE PROJECTION DISTANCE

$$\begin{bmatrix}|\vec{R}_L|\\ 0\\ 0\end{bmatrix} = \begin{bmatrix} \left\{\begin{array}{l}\cos\delta\left[(x_{yA}\cos\xi_L + y_{yA}\sin\xi_L)\cos\eta_L - z_{yA}\sin\eta_L\right]\\ +\sin\delta\left[y_{yA}\cos\xi_L - x_{yA}\sin\xi_L - |\vec{E}|\right]\end{array}\right\} \\ \left\{\begin{array}{l}-\sin\delta\left[(x_{yA}\cos\xi_L + y_{yA}\sin\xi_L)\cos\eta_L - z_{yA}\sin\eta_L\right]\\ +\cos\delta\left[y_{yA}\cos\xi_L - x_{yA}\sin\xi_L - |\vec{E}|\right]\end{array}\right\} \\ \left\{(x_{yA}\cos\xi_L + y_{yA}\sin\xi_L)\sin\eta_L + z_{yA}\cos\eta_L\right\}\end{bmatrix}$$

$|R_L|$ → FOCUS SERVO COMMAND → R_f → FOCUS SERVO DYNAMICS

COMPUTE MIRROR GIMBAL COMMANDS

$$\sin\xi_L = \frac{-x_{yA}|\vec{V}|\cos\chi + y_{yA}\sqrt{x_{yA}^2 + y_{yA}^2 - |\vec{V}|^2\cos^2\chi}}{x_{yA}^2 + y_{yA}^2}$$

$$\eta_L = \tan^{-1}\left(\frac{-z_{yA}}{x_{yA}\cos\xi_L + y_{yA}\sin\xi_L}\right)$$

ξ_L η_L → TARGET-MIRROR SERVO DYNAMICS (HARDWARE) → PROJECTION SYSTEM

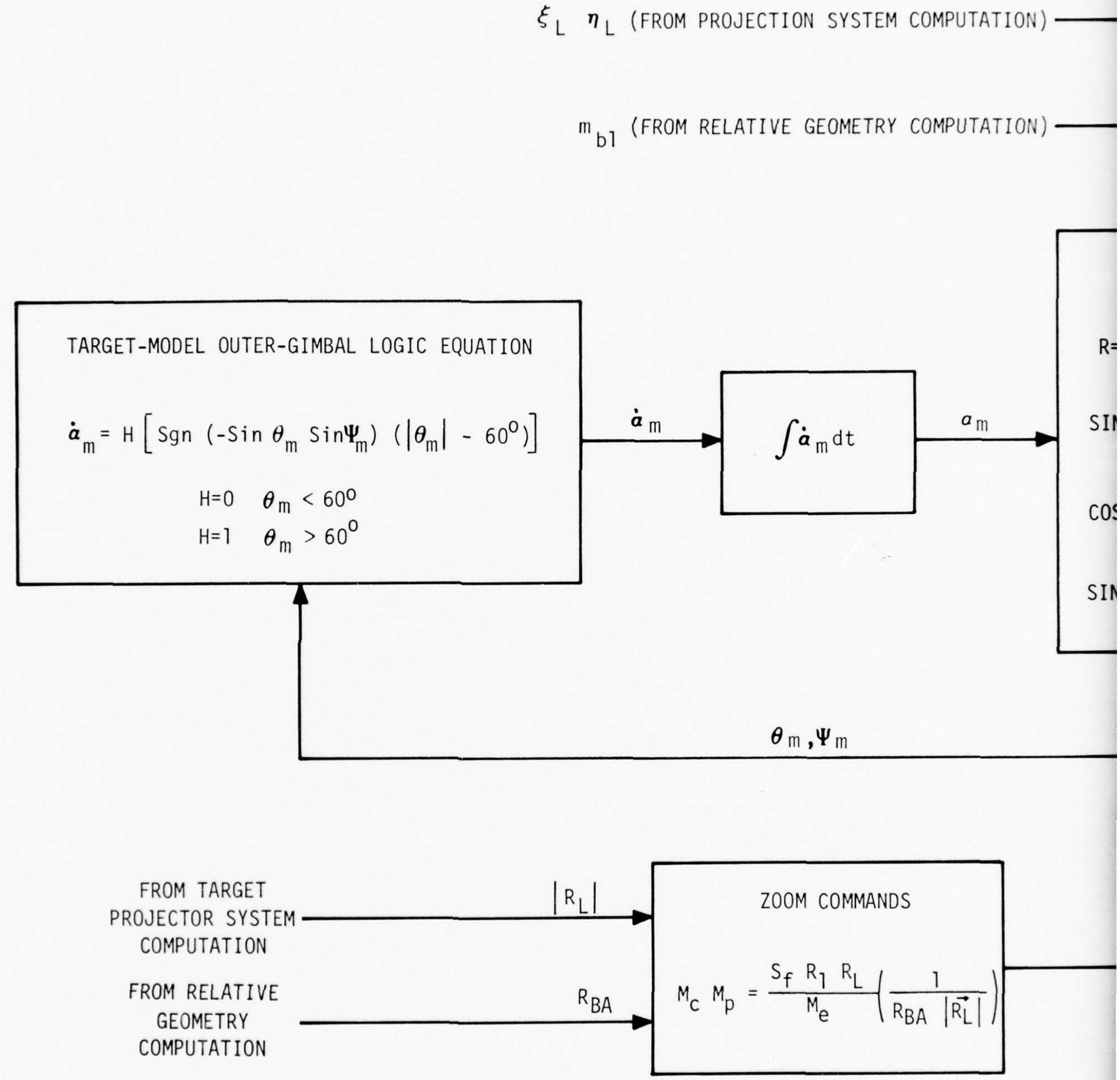
$\dot{\xi}_L$ $\dot{\eta}_L$ → TARGET-MIRROR SERVO DYNAMICS (HARDWARE)

COMPUTE MIRROR GIMBAL RATE COMMANDS

$$\dot{\xi}_L = \frac{\left\{\dot{y}_{yA}\cos\xi_L - \dot{x}_{yA}\sin\xi_L + \dfrac{(x_{yA}\dot{x}_{yA} + y_{yA}\dot{y}_{yA} + z_{yA}\dot{z}_{yA})\cos\left(\frac{\pi}{2} - \delta\right)}{\sqrt{|\vec{V}|^2 - |\vec{E}|^2\left[1 - \cos^2\left(\frac{\pi}{2} - \delta\right)\right]}}\right\}}{x_{yA}\cos\xi_L + y_{yA}\sin\xi_L}$$

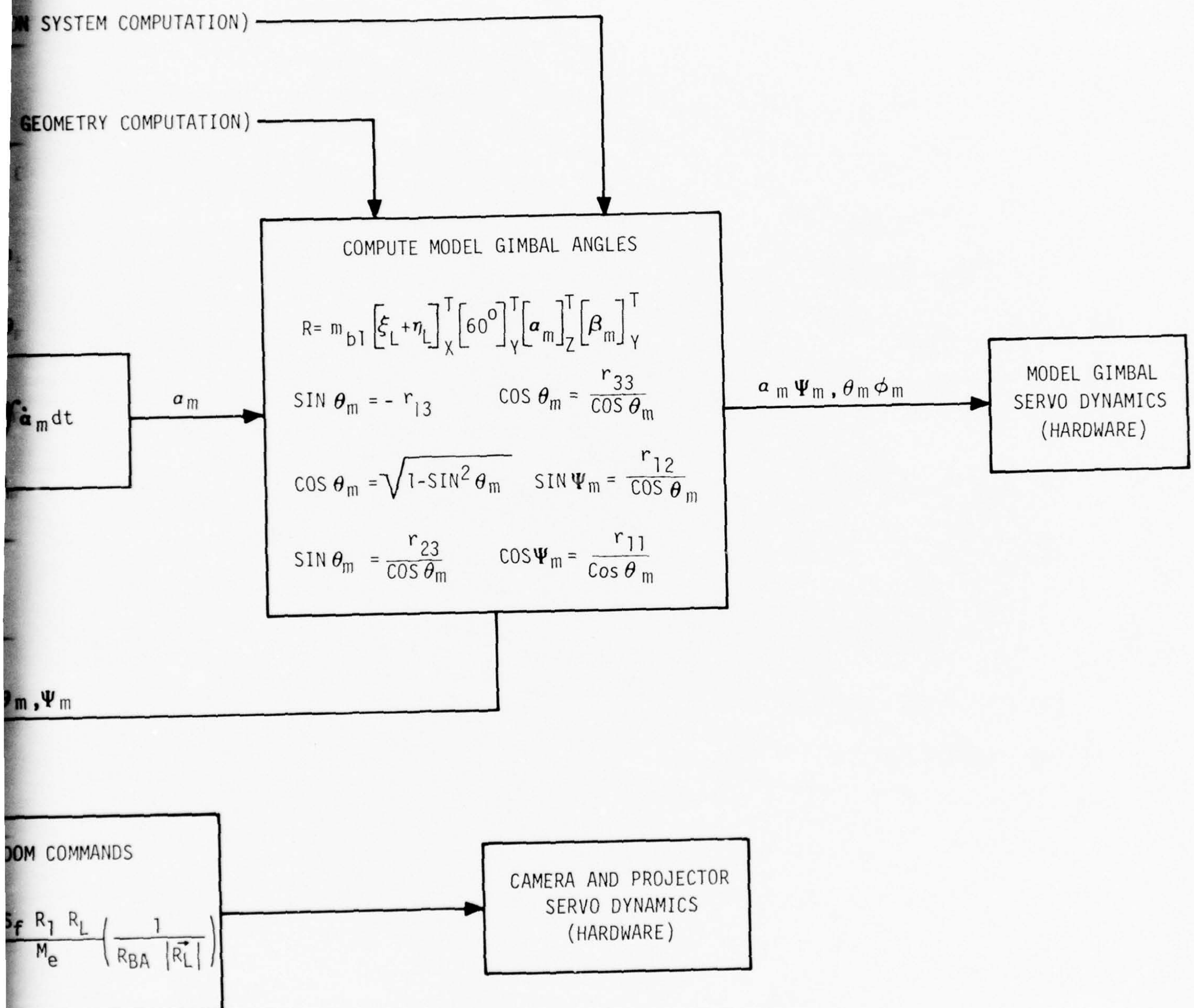
$$\dot{\eta}_L = \frac{-\dot{z}_{yA}(x_{yA}\cos\xi_L + y_{yA}\sin\xi_L) + z_{yA}(\dot{x}_{yA}\cos\xi_L + \dot{y}_{yA}\sin\xi_L) + z_{yA}\dot{\xi}_L\left(y_{yA}\cos\xi_L - x_{yA}\sin\xi_L\right)}{(1 - \cos^2\chi)(x_{yA}^2 + y_{yA}^2 + z_{yA}^2)}$$

TARGET PROJECTION SYSTEM MATH MODEL



ξL ηL (FROM PROJECTION SYSTEM COMPUTATION)
mb1 (FROM RELATIVE GEOMETRY COMPUTATION)
TARGET-MODEL OUTER-GIMBAL LOGIC EQUATION
$\dot{\alpha}_m = H\left[\mathrm{Sgn}\ (-\mathrm{Sin}\ \theta_m\ \mathrm{Sin}\Psi_m)\ (|\theta_m| - 60^o)\right]$
$H=0 \quad \theta_m < 60^o$
$H=1 \quad \theta_m > 60^o$
$\dot{\alpha}_m$
$\int \dot{\alpha}_m dt$
α_m
R=
SI
CO
SI
θ_m, Ψ_m
FROM TARGET PROJECTOR SYSTEM COMPUTATION
$|R_L|$
FROM RELATIVE GEOMETRY COMPUTATION
R_{BA}
ZOOM COMMANDS
$M_c\ M_p = \frac{S_f\ R_1\ R_L}{M_e}\left(\frac{1}{R_{BA}\ |\vec{R_L}|}\right)$

2



MODEL AND AIRCRAFT CAMERA MATH MODEL

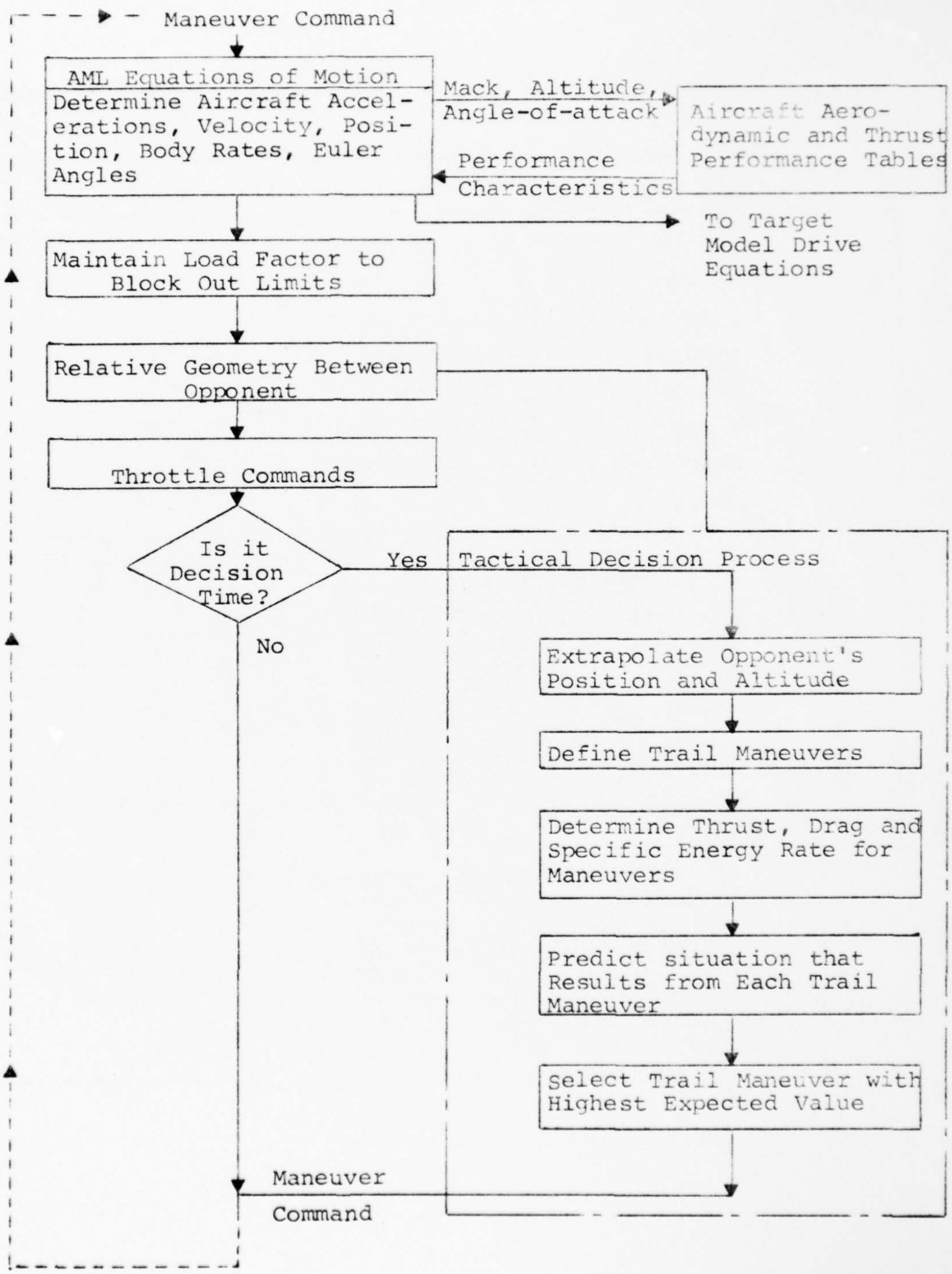
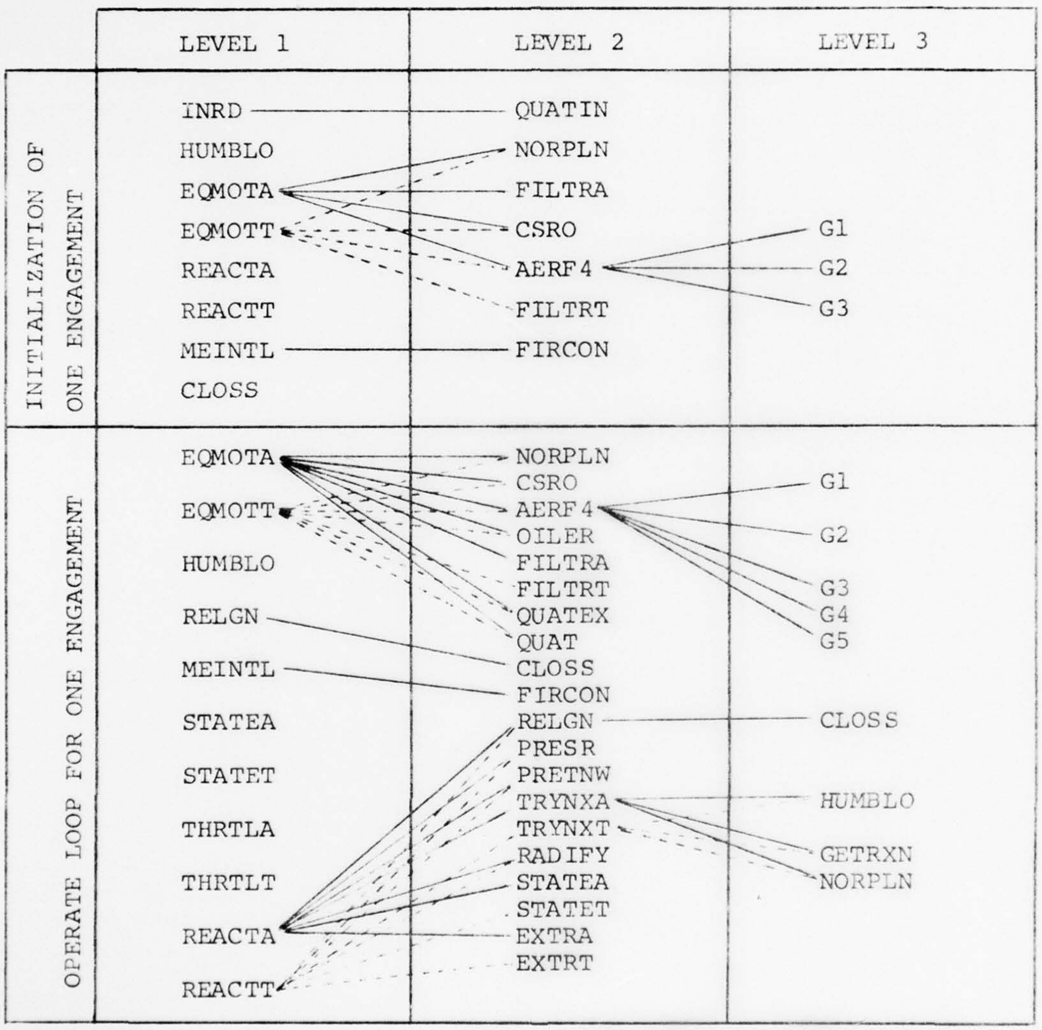


Figure 15. Flow Chart of AML Program

TABLE 3. INFORMATION FLOW BETWEEN MAIN PROGRAM AND SUBROUTINES



LIST OF SUBROUTINES COMPRISING THE AML PROGRAM

AERF (Aerodynamic Coefficients) - Purpose is to obtain aerodynamic coefficients, thrust data, and performance characteristics.

CLOSS (Angle Between Two Vectors) - Purpose is to calculate the angle between two vectors.

CMTRX (Direction Cosine Matrix) - Purpose is to compute the nine elements of a direction cosine matrix.

CSRHO (Speed of Sound) - Purpose is to calculate the speed of sound and atmospheric density for the AML controlled aircraft as a function of altitude.

EQMOT (Equation of Motion) - Purpose is to compute the parameters defining the trajectory and attitude of the AML controlled aircraft.

EXTRT (Extrapolation) - Purpose is to extrapolate the position, velocity, and attitude of the opponent of the AML controlled aircraft.

FILTR (Body Rotational Rate Filter) - Purpose is to smooth the motion of the displayed aircraft by filtering the body rates of the AML controlled aircraft before sending the rates to the model display software.

GETRXN (Get Closest Maneuver Plane) - Purpose is to find the number of maneuver plane rotation increments which will rotate a given maneuver plane closest to some desired rotation angle.

MEINTL (Accumulate Time-in-Envelop) - Purpose is to accumulate the offensive time and weapon delivery time for the AML controlled aircraft.

NORPLN (Normal to Maneuver Plane) - Purpose is to calculate the components in a unit vector normal to a specified maneuver plane.

PRESR (Predict Straight Flight) - Purpose is to predict position, velocity and attitude for straight flight trail maneuvers.

PRETNW (Predict Turning Flight) - Purpose is to predict the position, velocity and attitude for turning flight in a specified maneuver plane.

REACT (Reaction Routine) - Purpose is to determine the most promising tactical maneuver and to set up the parameters required to execute the maneuver.

RELGN (Relative Geometry) - Purpose is to compute the parameters defining the relative geometry between two aircraft.

STATE (State Evaluation) - Purpose is to evaluate the relative situation that exist between the AML controlled aircraft and its opponent.

THRTL (Thrust Control) - Purpose is to determine the desirable throttle position.

TRYNXT (Try Next Maneuver) - Purpose is to define the trail maneuver to be evaluated during the current decision making process.

HUMBLO (Human Pilot Blackout Cues) - Purpose is to provide a simulation of pilot blackout under high g-load conditions.

FIRCON (Fire Cone Determination) - Purpose is to determine whether the subject aircraft is within range and angles to fire one of three kinds of weapons at the opponent.

OILER (Euler Angles) - Purpose is to obtain the Euler angles from a given direction cosine matrix.

QUAT (Quaternion Integration) - Purpose is to present values of quaternions, body axes rotational rates p, q, and r and integration step size.

QUATET (Quaternions to Direction Cosines) - Purpose is to transform the quaternions into the nine direction cosines.

QUATIN (Euler Angles to Quaternions) - Purpose is to calculate the Euler angles corresponding to given quaternions.

RADIFY (Random Perturbation) - Purpose is to introduce randomness in the decision process by randomly perturbing selected variables about their nominal value.

SBDEF (Maximum Speed Brake Deflection) - Purpose is to calculate maximum permissible speed brake deflection as a function of Mach number and altitude.

SLAPDF (Slat/Flap Deflection Limits) - Purpose is to calculate flap/slat deflections as a function of Mach number and altitude.

Figure 11. Display Computations Performed for Two Top Priority Missiles

APPENDIX B

COMPUTER PERFORMANCE REQUIREMENTS

FLIGHT-AERO SIMULATION

The program module size (instruction count) and processing requirements for the flight simulation function were based upon knowledge and information gained from existing training systems having similar simulation requirements, namely Device 2F95-Operational Flight Trainer for F-14 aircraft. The results of the flight simulation computer analysis are summarized in Table 4.

TACTICAL SIMULATION

The program routines, module size (instruction count), and processing requirements for the tactical simulation were based upon experience and data derived from current training devices having similar simulation requirements. The results of the tactical simulation analysis are depicted in Table 5.

VISUAL SYSTEM

The routines, module size (instruction count) and processing requirements for the 2F112 visual system were determined utilizing the procedures described in Appendix A and information derived from the NASA reports. The results of the visual system analysis are provided in Table 6.

SYNTHESIZED TARGET SIMULATION

The routines, module size (instruction count) and processing requirements for the computer synthesized target were determined utilizing the procedures described previously and information derived from the referenced NASA reports. The results of the synthesized target simulation analysis are provided in Table 7.

TABLE 4. COMPUTER PERFORMANCE REQUIREMENTS - FLIGHT-AERO

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
FLIGHT & CONTROLS	.10	4300.	4730.	150.	1350.	6230.	4730.0	32.00000	151360.
FLIGHT & CONTROLS	.10	2000.	2200.	0.	0.	2200.	1870.0	16.00000	29920.
FLIGHT & CONTROLS	.10	3600.	3960.	0.	0.	3960.	2574.0	8.00000	20592.
ENGINES	.10	2500.	2750.	50.	250.	3050.	2475.0	16.00000	39600.
ENGINES	.10	830.	913.	0.	0.	913.	456.5	8.00000	3652.
ACCESSORIES	.10	345.	380.	30.	120.	529.	284.6	16.00000	4554.
ACCESSORIES	.10	400.	440.	0.	0.	440.	374.0	8.00000	2992.
RADIO FACILITIES	.10	750.	825.	30.	70.	925.	825.0	32.00000	26400.
RADIO FACILITIES	.10	360.	396.	0.	0.	396.	396.0	16.00000	6336.
RADIO FACILITIES	.10	500.	550.	200.	1300.	2050.	2612.5	4.00000	10450.
RADIO FACILITIES	.10	1000.	1100.	0.	0.	1100.	2310.0	1.00000	2310.
G-SUIT	.10	800.	880.	50.	150.	1080.	704.0	32.00000	22528.
INDEPENDENT MODE	.10	1200.	1320.	150.	850.	2320.	1056.0	8.00000	8448.
VISUAL DATA INTERFACE	.10	200.	220.	100.	350.	670.	550.0	32.00000	17600.
CRT UPDATE CONTROL	.10	2200.	2420.	100.	600.	3120.	2420.0	8.00000	19360.
CRT UPDATE CONTROL	.10	400.	440.	0.	0.	440.	2310.0	4.00000	9240.
BUFFER CTL & PAGING	.10	350.	385.	50.	100.	535.	231.0	2.00000	462.
KBD INTERPRET & OVERLAY	.10	200.	220.	400.	3600.	4220.	2197.8	2.00000	4396.
MALFUNCTIONS	.10	180.	198.	100.	550.	848.	336.6	1.00000	337.
MODE & FREEZE CONTROL	.10	110.	121.	0.	0.	121.	36.3	32.00000	1162.

TABLE 4. COMPUTER PERFORMANCE REQUIREMENTS - FLIGHT-AERO (Continued)

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
RECORD/PLAYBACK	.10	600.	660.	500.	1500.	2660.	1254.0	32.00000	40128.
SOUND	.10	160.	176.	50.	150.	376.	704.0	16.00000	11264.
SOUND	.10	130.	143.	0.	0.	143.	572.0	8.00000	4576.
EXECUTIVE	.10	1000.	1100.	300.	1000.	2400.	473.0	32.00000	15136.
SUB-TOTALS		24115.	26527.	2260.	11940.	40727.			452802.
REQ. SPARE(25% OF SUB-TOTALS)		6029.	6632.	565.	2985.	10182.			113200.
TOTALS		30144.	33158.	2825.	14925.	50906.			566002.
AVE. INST. EXECUTION TIME REQUIRED BY PROGRAM(MICROSEC)									1.7668

TABLE 5. COMPUTER PERFORMANCE REQUIREMENTS - TACTICS

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
NAV	.10	450.	495.	50.	100.	645.	495.0	32.00000	15840.
NAV	.10	1000.	1100.	0.	0.	1100.	550.0	8.00000	4400.
NAV	.10	500.	550.	0.	0.	550.	1100.0	1.00000	1100.
INS	.10	750.	825.	50.	400.	1275.	783.7	32.00000	25080.
INS	.10	200.	220.	0.	0.	220.	110.0	8.00000	880.
INS	.10	300.	330.	0.	0.	330.	66.0	1.00000	66.
UHF DATA LINK	.10	865.	951.	100.	600.	1652.	951.5	32.00000	30448.
UHF DATA LINK	.10	540.	594.	0.	0.	594.	594.0	16.00000	9504.
UHF DATA LINK	.10	690.	759.	0.	0.	759.	683.1	8.00000	5465.
NAV COMPUTER	.10	3500.	3850.	250.	2000.	6100.	1925.0	32.00000	61600.
MDIG INTERFACE PROG	.10	50.	55.	10.	50.	115.	55.0	32.00000	1760.
MDIG INTERFACE PROG	.10	1000.	1100.	0.	0.	1100.	110.0	16.00000	1760.
RADAR/IR TARGET	.10	450.	495.	100.	3000.	3595.	2212.6	32.00000	70805.
TID BUFFER CONTROL	.10	400.	440.	0.	25.	465.	110.0	1.00000	110.
RADAR INTERFACE	.10	420.	462.	50.	150.	662.	462.0	32.00000	14784.
RADAR INTERFACE	.10	250.	275.	0.	0.	275.	220.0	16.00000	3520.
ARMAMENT	.10	1030.	1133.	100.	1000.	2233.	339.9	32.00000	10877.
WEAPON DELIVERY	.10	1350.	1485.	60.	100.	1645.	1113.8	32.00000	35640.
WEAPON DELIVERY	.10	946.	1041.	0.	0.	1041.	520.3	16.00000	8325.
WEAPON SCORING	.10	2600.	2860.	50.	230.	3140.	1029.6	32.00000	32947.

TABLE 5. COMPUTER PERFORMANCE REQUIREMENTS - TACTICS (Continued)

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
WEAPON SCORING	.10	270.	297.	0.	200.	497.	297.0	16.00000	4752.
5400C INTERFACE	.10	325.	358.	50.	1000.	1408.	125.1	32.00000	4004.
5400C INTERFACE	.10	1500.	1650.	0.	0.	1650.	825.0	16.00000	13200.
5400C INTERFACE	.10	200.	220.	0.	0.	220.	220.0	8.00000	1760.
5400C INTERFACE	.10	1375.	1513.	0.	0.	1513.	1512.5	4.00000	6050.
5400C INTERFACE	.10	150.	165.	0.	0.	165.	206.3	2.00000	413.
5400C INTERFACE	.10	300.	330.	0.	0.	330.	231.0	1.00000	231.
RHAWS	.10	100.	110.	40.	450.	600.	66.0	32.00000	2112.
RHAWS	.10	1000.	1100.	0.	0.	1100.	550.0	8.00000	4400.
RHAWS	.10	800.	880.	0.	0.	880.	1100.0	4.00000	4400.
DECM	.10	50.	55.	50.	300.	405.	55.0	32.00000	1760.
DECM	.10	1000.	1100.	0.	0.	1100.	715.0	4.00000	2860.
ALE-39	.10	500.	550.	20.	100.	670.	55.0	32.00000	1760.
ALE-39	.10	50.	55.	0.	0.	55.	71.5	4.00000	286.
ORLMS X-Y	.10	30.	33.	20.	50.	103.	33.0	32.00000	1056.
ORLMS X-Y	.10	360.	396.	0.	0.	396.	118.8	8.00000	950.
ORLM INTERFACE	.10	250.	275.	10.	30.	315.	275.0	32.00000	8800.
RADAR	.10	50.	55.	50.	250.	355.	55.0	32.00000	1760.
RADAR	.10	1000.	1100.	0.	0.	1100.	660.0	16.00000	10560.
RADAR	.10	800.	880.	0.	0.	880.	572.0	4.00000	2288.

TABLE 5. COMPUTER PERFORMANCE REQUIREMENTS - TACTICS (Continued)

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
RADAR	.10	500.	550.	0.	0.	550.	330.0	2.00000	660.
IR	.10	50.	55.	60.	200.	315.	55.0	32.00000	1760.
IR	.10	500.	550.	0.	0.	550.	330.0	16.00000	5280.
IR	.10	250.	275.	0.	0.	275.	192.5	2.00000	385.
VICIG INTERFACE	.10	50.	55.	30.	60.	145.	55.0	32.00000	1760.
VICIG INTERFACE	.10	500.	550.	0.	0.	550.	275.0	16.00000	4400.
EXEC FUNT	.10	1600.	1760.	280.	1300.	3340.	880.0	32.00000	28160.
SUB-TOTALS		30851.	33936.	1430.	11595.	46961.			450717.
REG. SPARE(25% OF SUB-TOTALS)		7713.	8484.	358.	2899.	11740.			112679.
TOTALS		38564.	42420.	1788.	14494.	58701.			563396.
AVE. INST. EXECUTION TIME REQUIRED BY PROGRAM(MICROSEC)									1.7749

TABLE 6. COMPUTER PERFORMANCE REQUIREMENTS - VISUAL

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
SKY-SEA PROJ	.10	1840.	2024.	100.	350.	2474.	2024.0	32.00000	64768.
MISC	.10	69.	76.	10.	50.	136.	75.9	32.00000	2429.
TARGET PROJ	.10	1713.	1884.	110.	400.	2394.	1884.3	32.00000	60298.
MISC	.10	241.	265.	20.	150.	435.	265.1	32.00000	8483.
INTERACTIVE TARGET PROJ	.10	1713.	1884.	110.	550.	2544.	1884.3	32.00000	60298.
MISC	.10	241.	265.	20.	100.	385.	265.1	32.00000	8483.
MISSILE/GUN PROJ	.10	690.	759.	60.	300.	1119.	759.0	32.00000	24288.
MISC	.10	149.	164.	10.	100.	274.	163.9	32.00000	5245.
CVA	.10	850.	935.	50.	100.	1085.	935.0	8.00000	7480.
CVA	.10	200.	220.	0.	0.	220.	66.0	4.00000	264.
EXECUTIVE & I/O	.10	977.	1075.	150.	1000.	2225.	1074.7	32.00000	34390.
SUB-TOTALS		8683.	9551.	640.	3100.	13291.			276425.
REQ. SPARE(25% OF SUB-TOTALS)		2171.	2388.	160.	775.	3323.			69106.
TOTALS		10854.	11939.	800.	3875.	16614.			345532.
AVE. INST. EXECUTION TIME REQUIRED BY PROGRAM(MICROSEC)									2.8941

TABLE 7. COMPUTER PERFORMANCE REQUIREMENTS - SYNTHETIC TARGET

PROGRAMMED FUNCTION (ROUTINES)	CONT. FACTORS	INSTRUCT. ESTIMATES	TOTAL INSTR ESTIMATES	CONSTANT ESTIMATES	DATA STORE ESTIMATES	TOTAL MEMORY REQUIRED	WORST-CASE INST. PER SOL. CYCLE	SOL. RATE	WORST-CASE INST. EXEC. RATES
EQUATIONS OF MOTION	.10	3289.	3618.	130.	550.	4298.	3617.9	32.00000	115773.
DIRECTION COSINES	.10	69.	76.	30.	100.	206.	75.9	32.00000	2429.
AERO COEFFICIENTS	.10	310.	341.	20.	50.	411.	341.0	32.00000	10912.
EULER ANGLE	.10	253.	278.	5.	40.	323.	278.3	32.00000	8906.
ROTATIONAL FILTER	.10	69.	76.	15.	100.	191.	75.9	32.00000	2429.
QUATERNION TO DIR COSINES	.10	989.	1088.	30.	150.	1268.	1087.9	32.00000	34813.
QUATERNION INTEGRATION	.10	322.	354.	10.	50.	414.	354.2	32.00000	11334.
HUMAN PILOT BLACKOUT	.10	69.	76.	50.	100.	226.	75.9	32.00000	2429.
RELATIVE GEOMETRY	.10	609.	670.	20.	300.	990.	669.9	32.00000	21437.
CLOSEST MANEUVERPLANE	.10	471.	518.	5.	250.	773.	518.1	32.00000	16579.
ACCUMULATION OF WEAPON TIME	.10	57.	63.	15.	50.	128.	62.7	32.00000	2006.
FIRE CONE	.10	138.	152.	10.	150.	312.	151.8	32.00000	4858.
THRUST CONTROL	.10	80.	88.	70.	100.	258.	88.0	32.00000	2816.
REACTION ROUTINE	.10	793.	872.	15.	150.	1037.	872.3	32.00000	27914.
PREDICT TURNING FLIGHT	.10	161.	177.	60.	150.	387.	177.1	32.00000	5667.
RANDOM PERTURBATION	.10	667.	734.	10.	500.	1244.	733.7	32.00000	23478.
STATE EVALUATION	.10	92.	101.	150.	650.	901.	101.2	32.00000	3238.
EXECUTIVE & I/O	.10	977.	1075.	500.	1000.	2575.	1074.7	32.00000	34390.
SUB-TOTALS		9415.	10356.	1145.	4440.	15941.			331407.
REQ. SPARE(25% OF SUB-TOTALS)		2354.	2589.	286.	1110.	3985.			82852.
TOTALS		11769.	12946.	1431.	5550.	19927.			414259.
AVE. INST. EXECUTION TIME REQUIRED BY PROGRAM(MICROSEC)									2.41[illegible]

APPENDIX C

COMPUTER PERFORMANCE ANALYSIS

The instruction mix for the four basic simulation functions was based upon data derived from existing training programs with similar requirements. The method used to determine instruction mix was that described in the percentage instruction mix paragraph in Section III. The execution times for the instruction type listed in the table were obtained from vendor literature. The results of the computer performance analysis for the four major 2F112 simulation functions are provided in Table 8 through 11.

TABLE 8. COMPUTER PERFORMANCE ANALYSIS - FLIGHT-AERO

INSTRUCTION TYPE	% USAGE (1)	8/32 WLAH ** WITH MODIFIED BRANCH OPN. EXECUTION TIME (usec) (2)	8/32 WLAH ** WEIGHTED TIME USED/TYPE (1)(2)=(3)	SEL 32/50 EXECUTION TIME (usec) (2)	SEL 32/50 WEIGHTED TIME USED/TYPE (1)(2)=(3)	XEROX 550 EXECUTION TIME (usec) (2)	XEROX 550 WEIGHTED TIME USED/TYPE (1)(2)=(3)
LOAD	.170	1.25	0.2125	1.20	0.204	1.94	0.3298
STORE	.096	2.00	0.1920	1.20	0.1152	3.01	0.2890
ADD/SUBTRACT	.170	1.25	0.2125	1.20	0.204	1.94	0.3298
MULTIPLY	.060	3.54	0.2124	4.50	0.270	6.23	0.3738
DIVIDE	.006	5.8	0.0348	5.10	0.0306	14.40	0.0864
LOGICAL	.074	1.25	0.0925	1.20	0.0888	1.90	0.1406
SHIFT (5 PLACES)	.160	0.94	0.1504	1.80	0.288	3.17	0.5072
COMPARE	.020	1.25	0.025	1.20	0.024	2.15	0.043
BRANCH	.230	2.00 *	0.460	0.60	0.138	1.72	0.3956
INDEX	-	-	-	-	-	-	-
REG. TO REG. OPNS.	-	-	-	-	-	-	-
I/O (SET-UP TIME PLUS BLOCK OF 10 WORDS)	0.014	5.73	0.0802	0.60	0.0084	14.41	0.2017
TOTALS			1.6723 usec		1.371 usec		2.6969 usec
AVE. INST. EXEC. RATE PER COMPUTER			597,979 IPS		729,395 IPS		370,796 IPS

* AVE. BRANCH AND LINK EXECUTION TIME FOR 8/32 WLAH - BRANCH OUT OF CACHE 37% OF TIME
** BEST CASE EXECUTION TIMES

TABLE 9. COMPUTER PERFORMANCE ANALYSIS - TACTICS

INSTRUCTION TYPE	% USAGE	8/32 WLAH ** WITH MODIFIED BRANCH OPN.		SEL 32/50		XEROX - 550	
		EXECUTION TIME (usec)	WEIGHTED TIME USED/TYPE	EXECUTION TIME (usec)	WEIGHTED TIME USED/TYPE	EXECUTION TIME (usec)	WEIGHTED TIME USED/TYPE
	(1)	(2)	(1)(2)=(3)	(2)	(1)(2)=(3)	(2)	(1)(2)=(3)
LOAD	.224	1.25	0.280	1.20	0.2688	1.94	0.4346
STORE	.133	2.00	0.266	1.20	0.1956	3.01	0.4003
ADD/SUBTRACT	.096	1.25	0.120	1.20	0.1152	1.94	0.1862
MULTIPLY	.068	3.54	0.2407	4.50	0.306	6.23	0.4236
DIVIDE	.007	5.8	0.0406	5.10	0.0357	14.40	0.1008
LOGICAL	.016	1.25	0.020	1.20	0.0192	1.90	0.0304
SHIFT (5 PLACES)	.091	0.94	0.0855	1.80	0.1638	3.17	0.2885
COMPARE	.046	1.25	0.0575	1.20	0.0552	2.15	0.0989
BRANCH	.147	2.00 *	0.294	0.60	0.0882	1.72	0.2528
INDEX	.159	4.78 ***	0.7600	1.20	0.1908	1.72	0.2735
REG. TO REG. OPNS.	-			-	-	-	-
MISCELLANEOUS	-				-	-	-
I/O (SET-UP TIME PLUS BLOCK OF 10 WORDS)	.013	5.73	0.0744	0.600	0.0078	14.41	0.1873
TOTALS			2.2387 usec		1.4103 usec		2.6769 usec
AVE. INST. EXEC. RATE PER COMPUTER			446,689 IPS		709,069 IPS		373,566 IPS

* AVE. BRANCH AND LINK EXECUTION TIME FOR 8/32 WITH LOOKAHEAD (WLAH) - BRANCH OUT OF CACHE 37% OF TIME
** BEST CASE EXECUTION TIMES
*** BRANCH ON INDEX HIGH - BRANCH OUT OF CACHE 37% OF TIME

TABLE 10. COMPUTER PERFORMANCE ANALYSIS - VISUAL

INSTRUCTION TYPE	% USAGE (1)	8/32 WLAH ** WITH MODIFIED BRANCH OPN.		SEL 32/50		XEROX 550	
		EXECUTION TIME(usec) (2)	WEIGHTED TIME USED/TYPE (1)(2)=(3)	EXECUTION TIME(usec) (2)	WEIGHTED TIME USED/TYPE (1)(2)=(3)	EXECUTION TIME(usec) (2)	WEIGHTED TIME USED/TYPE (1)(2)=(3)
LOAD	.287	1.25	0.3588	1.20	0.3444	1.94	0.5568
STORE	.132	2.00	0.264	1.20	0.1584	3.01	0.3973
ADD/SUBTRACT	.170	1.25	0.2125	1.20	0.204	1.94	0.3298
MULTIPLY	.151	3.54	0.5345	4.50	0.6795	6.23	0.9407
DIVIDE	.033	5.8	0.1914	5.10	0.1683	14.40	0.4752
LOGICAL	.013	1.25	0.0163	1.20	0.0156	1.90	0.0247
SHIFT (5PLACES)	.032	0.94	0.0301	1.80	0.0576	3.17	0.1014
COMPARE	.054	1.25	0.0675	1.20	0.0648	2.15	0.1161
BRANCH	.121	2.00 *	0.242	0.60	0.0726	1.72	0.2081
INDEX	.007	4.78 ***	0.0335	1.20	0.0084	1.72	0.0120
REG. TO REG. OPNS.	-	-	-	-	-	-	-
MISCELLANEOUS	-	-	-	-	-	-	-
I/O (SET-UP TIME PLUS BLOCK OF 10 WORDS)	-	5.73	-	0.60	-	14.41	-
TOTALS			1.9506 usec		1.7736 usec		3.1621 usec
AVE. INST. EXEC. RATE PER COMPUTER			512,663 IPS		563,825 IPS		316,246 IPS

* - AVE. BRANCH AND LINK EXECUTION TIME FOR 8/32 WLAH - BRANCH OUT OF CACHE - 37% OF TIME

** - BEST CASE EXECUTION TIMES

*** - BRANCH ON INDEX HIGH - BRANCH OUT OF CACHE 37% OF TIME

TABLE 11. COMPUTER PERFORMANCE ANALYSIS - SYNTHETIC TARGET

INSTRUCTION TYPE	% USAGE (1)	8/32 WLAH ** WITH MODIFIED BRANCH OPN		SEL 32/50		XEROX 550	
		EXECUTION TIME (usec) (2)	WEIGHTED TIME USED/TYPE (1)(2)=(3)	EXECUTION TIME (usec) (2)	WEIGHTED TIME USED/TYPE (1)(2)=(3)	EXECUTION TIME (usec) (2)	WEIGHTED TIME USED/TYPE (1)(2)=(3)
LOAD	.315	1.25	0.3938	1.20	0.378	1.94	0.6111
STORE	.187	2.00	0.374	1.20	0.2244	3.01	0.5629
ADD/SUBTRACT	.110	1.25	0.1375	1.20	0.132	1.94	0.2134
MULTIPLY	.176	3.54	0.6230	4.50	0.792	6.23	1.0965
DIVIDE	.011	5.80	0.0638	5.10	0.0561	14.40	0.1584
LOGICAL	.007	1.25	0.0088	1.20	0.0084	1.90	0.0133
SHIFT (5 PLACES)	.029	0.94	0.0273	1.80	0.0522	3.17	0.0919
COMPARE	.060	1.25	0.075	1.20	0.072	2.15	0.129
BRANCH	.105	2.00 *	0.210	0.60	0.063	1.72	0.1806
INDEX	-	-	-	-	-	-	-
REG. TO REG. OPNS.	-		-	-	-	-	-
MISCELLANEOUS	-		-	-	-	-	-
I/O (SET-UP TIME PLUS BLOCK OF 10 WORDS)	-	5.73	-	0.600	-	14.41	-
TOTALS			1.9132 usec		1.7781 usec		3.0571 usec
AVE. INST. EXEC. RATE PER COMPUTER			522,684 IPS		562,398 IPS		327,107 IPS

* AVE BRANCH AND LINK EXECUTION TIME FOR 8/32 WLAH - BRANCH OUT OF CACHE - 37% OF TIME
** BEST CASE EXECUTION TIMES

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NAVTRAEQUIPCEN IH-262

APPENDIX D

COMPUTER EXECUTION TIMES - TIME FRAME ANALYSIS

Tables 12 through 15 show the worst-case execution times of the 2F112 simulation functions assigned to each of the time frame slots for each processor.

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	FRAME TIME AS CPU - INTERDATA 8/					
		1	2	3	4	5	6
Flight & Controls (32/Sec)	4730	7.910	7.910	7.910	7.910	7.910	7.9
Flight & Controls (16/Sec)	1870	-	3.127	-	3.127	-	3.1
Flight & Controls (8/Sec)	2574	4.305	-	-	-	4.305	-
Engines (16/Sec)	2475	-	4.139	-	4.139	-	4.1
Engines (8/Sec)	457	0.764	-	-	-	0.764	-
Accessories (16/Sec)	285	0.477	-	0.477	-	0.477	-
Accessories (8/Sec)	374	-	0.625	-	-	-	0.6
Radio Facilities (32/Sec)	825	1.380	1.380	1.380	1.380	1.380	1.3
Radio Facilities (16/Sec)	396	-	0.662	-	0.662	-	0.6
Radio Facilities (4/Sec)	2613	-	-	4.370	-	-	-
Radio Facilities (1/Sec)	2310	-	-	-	3.863	-	-
G - Suit (32/Sec)	704	1.177	1.177	1.177	1.177	1.177	1.1
Independent Mode (8/Sec)	1056	1.766	-	-	-	1.766	-
Visual Data Interface (32/Sec)	550	0.920	0.920	0.920	0.920	0.920	0.9
CRT Update Control (8/Sec)	2420	4.047	-	-	-	4.047	-
CRT Update Control (4/Sec)	2310	-	-	3.863	-	-	-
Buffer CTL & Paging (2/Sec)	231	-	0.386	-	-	-	-
KBD Interpret & Overlay (2/Sec)	2198	-	-	-	-	-	-
Malfunction (1/Sec)	337	-	0.564	-	-	-	-
Mode & Freeze Control (32/Sec)	36	0.060	0.060	0.060	0.060	0.060	0.0
Record/Playback (32/Sec)	1254	2.097	2.097	2.097	2.097	2.097	2.0
Sound (16/Sec)	704	1.177	-	1.177	-	1.177	-
Sound (8/Sec)	572	-	-	-	0.957	-	-
Executive (32/Sec)	473	0.791	0.791	0.791	0.791	0.791	0.7
TOTAL TIME PER FRAME		26.871	23.838	24.222	27.083	26.871	22.8

-	4.139	-	4.139	-	4.139	-	4.139	-
0.764	-	-	-	0.764	-	-	-	0.764
0.477	-	0.477	-	0.477	-	0.477	-	0.477
-	0.625	-	-	-	0.625	-	-	-
1.380	1.380	1.380	1.380	1.380	1.380	1.380	1.380	1.380
-	0.662	-	0.662	-	0.662	-	0.662	-
-	-	-	-	-	-	4.370	-	-
-	-	-	-	-	-	-	-	-
1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177
1.766	-	-	-	1.766	-	-	-	1.766
0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920
4.047	-	-	-	4.047	-	-	-	4.047
-	-	-	-	-	-	3.863	-	-
-	-	-	-	-	-	-	-	-
-	-	3.676	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097

0.477	-	0.477	-	0.477	-	0.477
-	-	-	0.625	-	-	-
1.380	1.380	1.380	1.380	1.380	1.380	1.380
-	0.662	-	0.662	-	0.662	-
4.370	-	-	-	-	-	-
-	-	-	-	-	-	-
1.177	1.177	1.177	1.177	1.177	1.177	1.177
-	-	1.766	-	-	-	1.177
0.920	0.920	0.920	0.920	0.920	0.920	0.920
-	-	4.047	-	-	-	4.047
3.863	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	3.676	-	-
-	-	-	-	-	-	-
0.060	0.060	0.060	0.060	0.060	0.060	0.060

TABLE 12. TIME FRAME ANALYSIS - FLIGHT-AERO (INTERDATA 8/32)

1	22	23	24	25	26	27	28	29	30	31	32
910	7.910	7.910	7.910	7.910	7.910	7.910	7.910	7.910	7.910	7.910	7.910
-	3.127	-	3.127	-	3.127	-	3.127	-	3.127	-	3.127
305	-	-	-	4.305	-	-	-	4.305	-	-	-
-	4.139	-	4.139	-	4.139	-	4.139	-	4.139	-	4.139
764	-	-	-	0.764	-	-	-	0.764	-	-	-
477	-	0.477	-	0.477	-	0.477	-	0.477	-	0.477	-
-	0.625	-	-	-	0.625	-	-	-	0.625	-	-
380	1.380	1.380	1.380	1.380	1.380	1.380	1.380	1.380	1.380	1.380	1.380
-	0.662	-	0.662	-	0.662	-	0.662	-	0.662	-	0.662
-	-	-	-	-	-	4.370	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177
766	-	-	-	1.177	-	-	-	1.766	-	-	-
920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920	0.920
047	-	-	-	4.047	-	-	-	4.047	-	-	-
-	-	-	-	-	-	3.863	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	3.676	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097
177	-	1.177	-	1.177	-	1.177	-	1.177	-	1.177	-
-	-	-	0.957	-	-	-	0.957	-	-	-	0.957
791	0.791	0.791	0.791	0.791	0.791	0.791	0.791	0.791	0.791	0.791	0.791
.871	22.888	19.665	23.220	26.871	22.888	24.222	23.220	26.871	22.888	15.989	23.220

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	FLIGH… FRAME TIME ASSIGNMENT A… CPU - SEL 32/55					
		1	2	3	4	5	6
Flight & Controls (32/Sec)	4730	6.485	6.485	6.485	6.485	6.485	6.485
Flight & Controls (16/Sec)	1870	-	2.564	-	2.564	-	2.564
Flight & Controls (8/Sec)	2574	3.529	-	-	-	3.529	-
Engines (16/Sec)	2475	-	3.393	-	3.393	-	3.393
Engines (8/Sec)	457	0.626	-	-	-	0.626	-
Accessories (16/Sec)	285	0.391	-	0.391	-	0.391	-
Accessories (8/Sec)	374	-	0.513	-	-	-	0.513
Radio Facilities (32/Sec)	825	1.131	1.131	1.131	1.131	1.131	1.131
Radio Facilities (16/Sec)	396	-	0.543	-	0.543	-	0.543
Radio Facilities (4/Sec)	2613	-	-	3.582	-	-	-
Radio Facilities (1/Sec)	2310	-	-	-	3.167	-	-
G-Seat (32/Sec)	704	0.965	0.965	0.965	0.965	0.965	0.965
Independent Mode (8/Sec)	1056	1.448	-	-	-	1.448	-
Visual Data Interface (32/Sec)	550	0.754	0.754	0.754	0.754	0.754	0.754
CRT Update Control (8/Sec)	2420	3.318	-	-	-	3.318	-
CRT Update Control (4/Sec)	2310	-	-	3.167	-	-	-
Buffer CTL & Paging (2/Sec)	231	-	0.317	-	-	-	-
KBD Interpret & Overlay (2/Sec)	2198	-	-	-	-	-	-
Malfunctions (1/Sec)	337	-	0.462	-	-	-	-
Mode & Freeze Control (32/Sec)	36	0.049	0.049	0.049	0.049	0.049	0.049
Record/Playback (32/Sec)	1254	1.719	1.719	1.719	1.719	1.719	1.719
Sound (16/Sec)	704	0.965	-	0.965	-	0.965	-
Sound (8/Sec)	572	-	-	-	0.784	-	-
Executive (32/Sec)	473	0.648	0.648	0.648	0.648	0.648	0.648
TOTAL TIME PER FRAME		22.028	19.543	19.856	22.[illegible]02	22.028	18.764

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FLIGHT SIMULATION
ENT AND EXECUTION TIME (MILLISECONDS)
AIET - 1.371 MICROSECONDS

	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.48
4	-	2.564	-	2.564	-	2.564	-	2.564	-	2.564	-	2.564	-	2.56
	-	-	3.529	-	-	-	3.529	-	-	-	3.529	-	-	-
3	-	3.393	-	3.393	-	3.393	-	3.393	-	3.393	-	3.393	-	3.39
	-	-	0.626	-	-	-	0.626	-	-	-	0.626	-	-	-
	0.391	-	0.391	-	0.391	-	0.391	-	0.391	-	0.391	-	0.391	-
3	-	-	-	0.513	-	-	-	0.513	-	-	-	0.513	-	-
1	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.13
3	-	0.543	-	0.543	-	0.543	-	0.543	-	0.543	-	0.543	-	0.54
	-	-	-	-	3.582	-	-	-	-	-	-	-	3.582	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.96
	-	-	1.448	-	-	-	1.448	-	-	-	1.448	-	-	-
4	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.75
	-	-	3.318	-	-	-	3.318	-	-	-	3.318	-	-	-
	-	-	-	-	3.167	-	-	-	-	-	-	-	3.167	-
	-	-	-	-	-	-	-	-	-	-	-	0.317	-	-
	3.013	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.04
9	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.71
	0.965	-	0.965	-	0.965	-	0.965	-	0.965	-	0.965	-	0.965	-
	-	0.784	-	-	-	0.784	-	-	-	0.784	-	-	-	0.78
8	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.64

TABLE 13. TIME FRAME ANALYSIS - FLIGHT-AERO (SEL 32/55)

19	20	21	22	23	24	25	26	27	28	29	30	31	32
.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485	6.485
-	2.564	-	2.564	-	2.564	-	2.564	-	2.564	-	2.564	-	2.564
-	-	3.529	-	-	-	3.529	-	-	-	3.529	-	-	-
-	3.393	-	3.393	-	3.393	-	3.393	-	3.393	-	3.393	-	3.393
-	-	0.626	-	-	-	0.626	-	-	-	0.626	-	-	-
.391	-	0.391	-	0.391	-	0.391	-	0.391	-	0.391	-	0.391	-
-	-	-	0.513	-	-	-	0.513	-	-	-	0.513	-	-
.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131
-	0.543	-	0.543	-	0.543	-	0.543	-	0.543	-	0.543	-	0.543
.582	-	-	-	-	-	-	-	3.582	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965
-	-	1.448	-	-	-	1.448	-	-	-	1.448	-	-	-
.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754
-	-	3.318	-	-	-	3.318	-	-	-	3.318	-	-	-
.167	-	-	-	-	-	-	-	3.167	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	3.013	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719	1.719
.965	-	0.965	-	0.965	-	0.965	-	0.965	-	0.965	-	0.965	-
-	0.784	-	-	-	0.784	-	-	-	0.784	-	-	-	0.784
.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648
.856	19.035	22.028	18.764	16.120	19.035	22.028	18.764	19.856	19.035	22.028	18.764	13.107	19.035

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	FLIGHT FRAME TIME ASSIGNMENT A CPU - XEROX 550						
		1	2	3	4	5	6	
Flight & Controls (32/Sec)	4370	12.756	12.756	12.756	12.756	12.756	12.756	12
Flight & Controls (16/Sec)	1870	-	5.043	-	5.043	-	5.043	
Flight & Controls (8/Sec)	2574	6.942	-	-	-	6.942	-	
Engines (16/Sec)	2475	-	6.675	-	6.675	-	6.675	
Engines (8/Sec)	457	1.232	-	-	-	1.232	-	
Accessories (16/Sec)	285	0.769	-	0.769	-	0.769	-	(
Accessories (8/Sec)	374	-	1.009	-	-	-	1.009	
Radio Facilities (32/Sec)	825	2.225	2.225	2.225	2.225	2.225	2.225	2
Radio Facilities (16/Sec)	396	-	1.068	-	1.068	-	1.068	
Radio Facilities (4/Sec)	2613	-	-	-	7.047	-	-	
Radio Facilities (1/Sec)	2310	-	-	6.230	-	-	-	
G-Suit (32/Sec)	704	1.899	1.899	1.899	1.899	1.899	1.899	1
Independent Mode (8/Sec)	1056	2.848	-	-	-	2.848	-	
Visual Data Interface (32/Sec)	550	1.483	1.483	1.483	1.483	1.483	1.483	1
CRT Update Control (8/Sec)	2420	6.526	-	-	-	6.526	-	
CRT Update Control (4/Sec)	2310	-	-	6.230	-	-	-	
Buffer CTL & Paging (2/Sec)	231	-	0.623	-	-	-	-	
KBD Interpret & Overlay (2/Sec)	2198	-	-	-	-	-	-	5
Malfunctions (1/Sec)	337	-	0.909	-	-	-	-	
Mode & Freeze Control (32/Sec)	36	0.097	0.097	0.097	0.097	0.097	0.097	(
Record/Playback (32/Sec)	1254	3.382	3.382	3.382	3.382	3.382	3.382	3
Sound (16/Sec)	704	1.899	-	1.899	-	1.899	-	1
Sound (8/Sec)	572	-	-	-	1.543	-	-	
Executive (32/Sec)	473	1.276	1.276	1.276	1.276	1.276	1.276	1
TOTAL TIME PER FRAME		43.334	38.445	38.246	44.494	43.334	36.913	3

1.009	-	-	-	1.009	-	-
2.225	2.225	2.225	2.225	2.225	2.225	2.225
1.068	-	1.068	-	1.068	-	1.068
-	-	7.047	-	-	-	-
-	-	-	-	-	-	-
1.899	1.899	1.899	1.899	1.899	1.899	1.899
-	-	-	2.848	-	-	-
1.483	1.483	1.483	1.483	1.483	1.483	1.483
-	-	-	6.526	-	-	-
-	6.230	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
0.097	0.097	0.097	0.097	0.097	0.097	0.097

TABLE 14. TIME FRAME ANALYSIS - FLIGHT-AI
(XEROX 550)

	19	20	21	22	23	24	25	26	27	28	29	30	31	3
6	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.756	12.
3	-	5.043	-	5.043	-	5.043	-	5.043	-	5.043	-	5.043	-	5.
	-	-	6.942	-	-	-	6.942	-	-	-	6.942	-	-	
75	-	6.675	-	6.675	-	6.675	-	6.675	-	6.675	-	6.675	-	6.
	-	-	1.232	-	-	-	1.232	-	-	-	1.232	-	-	
	0.769	-	0.769	-	0.769	-	0.769	-	0.769	-	0.769	-	0.769	
09	-	-	-	1.009	-	-	-	1.009	-	-	-	1.009	-	-
25	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.225	2.
58	-	1.068	-	1.068	-	1.068	-	1.068	-	1.068	-	1.068	-	1.
	-	7.047	-	-	-	-	-	-	-	7.047	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	
99	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.899	1.
	-	-	2.848	-	-	-	2.848	-	-	-	2.848	-	-	
33	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.483	1.
	-	-	6.526	-	-	-	6.526	-	-	-	6.526	-	-	
	6.230	-	-	-	-	-	-	-	6.230	-	-	-	-	
32	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	5.928	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	
97	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.
82	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.382	3.
	1.899	-	1.899	-	1.899	-	1.899	-	1.899	-	1.899	-	1.899	
	-	1.543	-	-	-	1.543	-	-	-	1.543	-	-	-	1.
6	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.276	1.
6	32.016	44.494	43.334	36.913	31.714	37.447	43.334	36.913	32.016	44.494	43.334	36.913	25.786	37.

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	TACTICAL EN FRA E TIME ASSIGNMEN CPU - INTERDATA						
		1	2	3	4	5	6	
RHAWS (4/Sec)	1100	-	2.463	-	-	-	2.463	
DECM (32/Sec)	55	0.123	0.123	0.123	0.123	0.123	0.123	
DECM (4/Sec)	715	1.601	-	-	-	1.601	-	
ALE - 39 (32/Sec)	55	0.123	0.123	0.123	0.123	0.123	0.123	
ALE - 39 (4/Sec)	72	-	-	0.161	-	-	-	
DRLMS (32/Sec)	33	0.074	0.074	0.074	0.074	0.074	0.074	
DRLMS X-Y (8/Sec)	119	-	-	0.266	-	-	-	
DRLM Interface (32/Sec)	275	0.615	0.615	0.615	0.615	0.615	0.615	
Radar (32/Sec)	55	0.123	0.123	0.123	0.123	0.123	0.123	
Radar (16/Sec)	660	1.478	-	1.478	-	1.478	-	
Radar (4/Sec)	572	-	-	-	1.281	-	-	
Radar (2/Sec)	330	-	-	-	-	-	-	
IR (32/Sec)	55	0.123	0.123	0.123	0.123	0.123	0.123	
IR (16/Sec)	330	-	0.739	-	0.739	-	0.739	
IR (2/Sec)	193	-	-	0.432	-	-	-	
VIDIG (32/Sec)	55	0.123	0.123	0.123	0.123	0.123	0.123	
VIDIG (16/Sec)	275	-	0.616	-	0.616	-	0.616	
Executive (32/Sec)	880	1.970	1.970	1.970	1.970	1.970	1.970	
TOTAL TIME PER FRAME		30.983	33.625	31.345	33.399	29.234	31.679	3

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ENVIRONMENT SIMULATION
IENT AND EXECUTION TIME (MILLISECONDS)
ATA 8/32 W/LKAHD AIET - 2.2387 MICROSECONDS

	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	-	-	-	2.463	-	-	-	1.108	1.108	1.108	1.108	1.108	1.108	1.1
	0.123	0.123	0.123	0.123	0.123	0.123	0.123	-	-	-	1.231	-	-	-
	-	-	1.601	-	-	-	1.601	-	-	-	-	-	-	-
	0.123	0.123	0.123	0.123	0.123	0.123	0.123	1.755	1.755	1.755	1.755	1.755	1.755	1.75
	-	-	-	-	0.161	-	-	-	0.246	-	-	-	0.246	-
	0.074	0.074	0.074	0.074	0.074	0.074	0.074	-	-	-	-	-	-	-
	0.266	-	-	-	0.266	-	-	2.131	2.131	2.131	2.131	2.131	2.131	2.13
	0.615	0.615	0.615	0.615	0.615	0.615	0.615	1.330	-	1.330	-	1.330	-	1.33
	0.123	0.123	0.123	0.123	0.123	0.123	0.123	-	1.530	-	1.530	-	1.530	-
	1.478	-	1.478	-	1.478	-	1.478	4.310	4.310	4.310	4.310	4.310	4.310	4.31
	-	-	-	-	-	1.281	-	0.123	0.123	0.123	0.123	0.123	0.123	0.12
	0.739	-	-	-	-	-	-	0.246	-	0.246	-	0.246	-	0.24
	0.123	0.123	0.123	0.123	0.123	0.123	0.123	4.954	4.954	4.954	4.954	4.954	4.954	4.95
	-	0.739	-	0.739	-	0.739	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	1.034	1.034	1.034	1.034	1.034	1.034	1.03
	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.493	-	0.493	-	0.493	-	0.49
	-	0.616	-	0.616	-	0.616	-	0.761	0.761	0.761	0.761	0.761	0.761	0.76
	1.970	1.970	1.970	1.970	1.970	1.970	1.970	2.494	2.494	2.494	2.494	2.494	2.494	2.49
								1.164	-	1.164	-	1.164	-	1.16
								2.306	2.306	2.306	2.306	2.306	2.306	2.30
								0.665	-	0.665	-	0.665	-	0.66
								0.280	0.280	0.280	0.280	0.280	0.280	0.28
								-	1.847	-	1.847	-	1.847	-
								-	-	0.493	-	-	-	0.49
								-	-	1.694	-	-	-	1.69
								-	-	-	-	-	0.461	-
								-	-	-	-	-	-	-
								0.148	0.148	0.148	0.148	0.148	0.148	0.14
	32.015	32.734	31.450	33.625	30.206	33.399	29.234	1.231	-	-	-	1.231	-	-

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TABLE 15. TIME FRAME ANALYSIS - TACTICS (INTERDATA 8/32)

19	20	21	22	23	24	25	26	27	28	29	30	31	32
.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108	1.108
-	-	1.231	-	-	-	1.231	-	-	-	1.231	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755	1.755
.246	-	-	-	0.246	-	-	-	0.246	-	-	-	0.246	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131	2.131
-	1.330	-	1.330	-	1.330	-	1.330	-	1.330	-	1.330	-	1.330
.530	-	1.530	-	1.530	-	1.530	-	1.530	-	1.530	-	1.530	-
.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310	4.310
.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
-	0.246	-	0.246	-	0.246	-	0.246	-	0.246	-	0.246	-	0.246
.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954	4.954
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034	1.034
-	0.493	-	0.493	-	0.493	-	0.493	-	0.493	-	0.493	-	0.493
.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.761
.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494	2.494
-	1.164	-	1.164	-	1.164	-	1.164	-	1.164	-	1.164	-	1.164
.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306	2.306
-	0.665	-	0.665	-	0.665	-	0.665	-	0.665	-	0.665	-	0.665
.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
.847	-	1.847	-	1.847	-	1.847	-	1.847	-	1.847	-	1.847	-
-	0.493	-	-	-	0.493	-	-	-	0.493	-	-	-	0.493
-	1.694	-	-	-	1.694	-	-	-	1.694	-	-	-	1.694
.461	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
-	-	-	1.231	-	-	-	1.231	-	-	-	1.231	-	-

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	TACTICAL ENVIRONME FRAME TIME ASSIGNMENT AN CPU - INTERDATA 8/32 W/LK						
		1	2	3	4	5	6	7
Navigation (32/Sec)	495	1.108	1.108	1.108	1.108	1.108	1.108	1.10
Navigation (8/Sec)	550	1.231	-	-	-	1.231	-	-
Navigation (1/Sec)	1100	-	-	-	-	-	-	1.23
Inertial Nav Sys (32/Sec)	784	1.755	1.755	1.755	1.755	1.755	1.755	1.75
Inertial Nav Sys (8/Sec)	110	-	-	0.246	-	-	-	0.24
Inertial Nav Sys (1/Sec)	66	0.148	-	-	-	-	-	-
UHF Data Link (32/Sec)	952	2.131	2.131	2.131	2.131	2.131	2.131	2.13
UHF Data Link (16/Sec)	594	-	1.330	-	1.330	-	1.330	-
UHF Data Link (8/Sec)	683	-	-	1.530	-	-	-	1.53
Nav Computer (32/Sec)	1925	4.310	4.310	4.310	4.310	4.310	4.310	4.31
MDIG Interface Program (32/Sec)	55	0.123	0.123	0.123	0.123	0.123	0.123	0.12
MDIG Interface Program (16/Sec)	110	-	0.246	-	0.246	-	0.246	-
Radar/IR Target (32/Sec)	2213	4.954	4.954	4.954	4.954	4.054	4.954	4.95
TID Buffer Control (1/Sec)	110	-	-	0.246	-	-	-	-
Radar Interface (32/Sec)	462	1.034	1.034	1.034	1.034	1.034	1.034	1.03
Radar Interface (16/Sec)	220	-	0.493	-	0.493	-	0.493	-
Armament (32/Sec)	340	0.761	0.761	0.761	0.761	0.761	0.761	0.76
Weapon Delivery (32/Sec)	1114	2.494	2.494	2.494	2.494	2.494	2.494	2.49
Weapon Delivery (16/Sec)	520	-	1.164	-	1.164	-	1.164	-
Weapon Scoring (32/Sec)	1030	2.306	2.306	2.306	2.306	2.306	2.306	2.30
Weapon Scoring (16/Sec)	297	-	0.665	-	0.665	-	0.665	-
5400 Interface (32/Sec)	125	0.280	0.280	0.280	0.280	0.280	0.280	0.28
5400 Interface (16/Sec)	825	1.847	-	1.847	-	1.847	-	1.84
5400 Interface (8/Sec)	220	-	-	-	0.493	-	-	-
5400 Interface (4/Sec)	1513	-	-	-	1.694	-	-	-
5400 Interface (2/Sec)	206	-	-	0.461	-	-	-	-
5400 Interface (1/Sec)	231	-	-	-	-	-	0.517	-
RHAWS (32/Sec)	66	0.148	0.148	0.148	0.148	0.148	0.148	0.1
RHAWS (8/Sec)	550	-	1.231	-	-	-	1.231	-

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NVIRONMENT SIMULATION
MENT AND EXECUTION TIME (MILLISECONDS)
/32 W/LKAHD AIET - 2.2387 MICROSECONDS

	7	8	9	10	11	12	13	14	15	16	17	18	19	2(
B	1.108	1.108	1.108	1.108	1.108	1.108	1.108	2.463	-	-	-	2.463	-	-
	-	-	1.231	-	-	-	1.231	0.123	0.123	0.123	0.123	0.123	0.123	0.1
	1.231	0.616	0.615	-	-	-	-	-	-	-	1.601	-	-	-
5	1.755	1.755	1.755	1.755	1.755	1.755	1.755	0.123	0.123	0.123	0.123	0.123	0.123	0.1
	0.246	-	-	-	0.246	-	-	-	-	-	-	-	0.161	-
	-	-	-	-	-	-	-	0.074	0.074	0.074	0.074	0.074	0.074	0.0
1	2.131	2.131	2.131	2.131	2.131	2.131	2.131	-	0.266	-	-	-	0.266	-
0	-	1.330	-	1.330	-	1.330	-	0.615	0.615	0.615	0.615	0.615	0.615	0.6
	1.530	-	-	-	1.530	-	-	0.123	0.123	0.123	0.123	0.123	0.123	0.1
0	4.310	4.310	4.310	4.310	4.310	4.310	4.310	-	1.478	-	1.478	-	1.478	-
3	0.123	0.123	0.123	0.123	0.123	0.123	0.123	-	-	-	-	-	-	1.2
6	-	0.246	-	0.246	-	0.246	-	-	-	-	-	-	-	-
4	4.954	4.954	4.954	4.954	4.954	4.954	4.954	0.123	0.123	0.123	0.123	0.123	0.123	0.1
	-	-	-	-	-	-	-	0.739	-	0.739	-	0.739	-	0.7
4	1.034	1.034	1.034	1.034	1.034	1.034	1.034	-	-	-	-	-	0.432	-
3	-	0.493	-	0.493	-	0.493	-	0.123	0.123	0.123	0.123	0.123	0.123	0.1
1	0.761	0.761	0.761	0.761	0.761	0.761	0.761	0.616	-	0.616	-	0.616	-	0.6
4	2.494	2.494	2.494	2.494	2.494	2.494	2.494	1.970	1.970	1.970	1.970	1.970	1.970	1.9
4	-	1.164	-	1.164	-	1.164	-							
6	2.306	2.306	2.306	2.306	2.306	2.306	2.306							
5	-	0.665	-	0.665	-	0.665	-							
0	0.280	0.280	0.280	0.280	0.280	0.280	0.280							
	1.847	-	1.847	-	1.847	-	1.847							
	-	0.493	-	-	-	0.493	-							
	-	1.694	-	-	-	1.694	-							
	-	-	-	-	-	-	-							
17	-	-	-	-	-	-	-							
8	0.148	0.148	0.148	0.148	0.148	0.148	0.148							
1	-	-	-	1.231	-	-	-	31.162	30.045	32.118	30.835	33.625	31.099	33.

-	-	-	2.463	-	-	-	2.463	-	-	-	2.463
0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
-	-	1.601	-	-	-	1.601	-	-	-	1.601	-
0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
0.161	-	-	-	-	-	-	-	0.161	-	-	-
0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
0.266	-	-	-	0.266	-	-	-	0.266	-	-	-
0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
1.478	-	1.478	-	1.478	-	1.478	-	1.478	-	1.478	-
-	1.281	-	-	-	-	-	-	-	1.281	-	-
-	-	-	-	0.739	-	-	-	-	-	-	-
0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
-	0.739	-	0.739	-	0.739	-	0.739	-	0.739	-	0.739
0.432	-	-	-	-	-	-	-	-	-	-	-
0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
-	0.616	-	0.616	-	0.616	-	0.616	-	0.616	-	0.616
1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	TACTI FRAME TIME ASS CPU - SEL 32/					
		1	2	3	4	5	6
Navigation (32/Sec)	495	0.698	0.698	0.698	0.698	0.698	0.698
Navigation (8/Sec)	550	0.776	-	-	-	0.776	-
Navigation (1/Sec)	1100	-	-	-	-	-	-
Inertial Nav Sys (32/Sec)	784	1.106	1.106	1.106	1.106	1.106	1.106
Inertial Nav Sys (8/Sec)	110	-	-	0.155	-	-	-
Inertial Nav Sys (1/Sec)	66	0.093	-	-	-	-	-
UHF Data Link (32/Sec)	952	1.343	1.343	1.343	1.343	1.343	1.343
UHF Data Link (16/Sec)	594	-	0.838	-	0.838	-	0.838
UHF Data Link (8/Sec)	683	-	-	0.963	-	-	-
Nav Computer (32/Sec)	1925	2.715	2.715	2.715	2.715	2.715	2.715
Mdig Interface Prog (32/Sec)	55	0.078	0.078	0.078	0.078	0.078	0.078
Mdig Interface Prog (16/Sec)	110	-	0.155	-	0.155	-	0.155
Radar/IR Target (32/Sec)	2213	3.121	3.121	3.121	3.121	3.121	3.121
TID Buffer Control (1/Sec)	110	-	-	0.155	-	-	-
Radar Interface (32/Sec)	462	0.652	0.652	0.652	0.652	0.652	0.652
Radar Interface (16/Sec)	220	-	0.310	-	0.310	-	0.310
Armament (32/Sec)	340	0.480	0.480	0.480	0.480	0.480	0.480
Weapon Delivery (32/Sec)	1114	1.571	1.571	1.571	1.571	1.571	1.571
Weapon Delivery (16/Sec)	520	-	0.733	-	0.733	-	0.733
Weapon Scoring (32/Sec)	1030	1.453	1.453	1.453	1.453	1.453	1.453
Weapon Scoring (16/Sec)	297	-	0.419	-	0.419	-	0.419
5400 Interface (32/Sec)	125	0.716	0.716	0.716	0.716	0.716	0.716
5400 Interface (16/Sec)	825	1.163	-	1.163	-	1.163	-
5400 Interface (8/Sec)	220	-	-	-	0.310	-	-
5400 Interface (4/Sec)	1513	-	-	-	2.134	-	-
5400 Interface (2/Sec)	206	-	-	0.291	-	-	-
5400 Interface (1/Sec)	231	-	-	-	-	-	0.326
RHAWS (32/Sec)	66	0.093	0.093	0.093	0.093	0.093	0.093
RHAWS (8/Sec)	550	-	0.776	-	-	-	0.776

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TACTICAL ENVIRONMENT SIMULATION
ME ASSIGNMENT AND EXECUTION TIME (MILLISECONDS)
SEL 32/55 AIET - 1.4103 MICROSECONDS

6	7	8	9	10	11	12	13	14	15	16	17	18	19
0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698
-	-	-	0.776	-	-	-	0.776	-	-	-	0.776	-	-
-	0.776	0.387	0.388	-	-	-	-	-	-	-	-	-	-
1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106
-	0.155	-	-	-	0.155	-	-	-	0.155	-	-	-	0.155
-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343
0.838	-	0.838	-	0.838	-	0.838	-	0.838	-	0.838	-	0.838	-
-	0.963	-	-	-	0.963	-	-	-	0.963	-	-	-	0.963
2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
0.155	-	0.155	-	0.155	-	0.155	-	0.155	-	0.155	-	0.155	-
3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121
-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652
0.310	-	0.310	-	0.310	-	0.310	-	0.310	-	0.310	-	0.310	-
0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571
0.733	-	0.733	-	0.733	-	0.733	-	0.733	-	0.733	-	0.733	-
1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453

0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698
0.776	-	-	-	0.776	-	-	-	0.776	-	-
-	-	-	-	-	-	-	-	-	-	-
1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106	1.106
-	-	0.155	-	-	-	0.155	-	-	-	0.155
-	-	-	-	-	-	-	-	-	-	-
1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343	1.343
-	0.838	-	0.838	-	0.838	-	0.838	-	0.838	-
-	-	0.963	-	-	-	0.963	-	-	-	0.963
2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715	2.715
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
-	0.155	-	0.155	-	0.155	-	0.155	-	0.155	-
3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121	3.121
-	-	-	-	-	-	-	-	-	-	-
0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652
-	0.310	-	0.310	-	0.310	-	0.310	-	0.310	-
0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571
-	0.733	-	0.733	-	0.733	-	0.733	-	0.733	-
1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453	1.453
-	0.419	-	0.419	-	0.419	-	0.419	-	0.419	-

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	TACTICAL E… FRAME TIME ASSIGN… CPU - SEL 32/5…						
		1	2	3	4	5	6	
RHAWS (4/Sec)	1100	-	1.551	-	-	-	1.551	
DECM (32/Sec)	55	0.078	0.078	0.078	0.078	0.078	0.078	0
DECM (4/Sec)	715	1.008	-	-	-	1.008	-	
ALE-39 (32/Sec)	55	0.078	0.078	0.078	0.078	0.078	0.078	0
ALE-39 (4/Sec)	72	-	-	0.102	-	-	-	
DRLMS X-Y (32/Sec)	33	0.047	0.047	0.047	0.047	0.047	0.047	0
DRLMS X-Y (8/Sec)	119	-	-	0.168	-	-	-	0
DRLM Interface (32/Sec)	275	0.388	0.388	0.388	0.388	0.388	0.388	0
Radar (32/Sec)	55	0.078	0.078	0.078	0.078	0.078	0.078	0
Radar (16/Sec)	660	0.931	-	0.931	-	0.931	-	0
Radar (4/Sec)	572	-	-	-	0.807	-	-	
Radar (2/Sec)	330	-	-	-	-	-	-	0
IR (32/Sec)	55	0.078	0.078	0.078	0.078	0.078	0.078	0
IR (16/Sec)	330	-	0.465	-	0.465	-	0.465	
IR (2/Sec)	193	-	-	0.272	-	-	-	
VIDIG (32/Sec)	55	0.078	0.078	0.078	0.078	0.078	0.078	0
VIDIG (16/Sec)	275	0.388	-	0.388	-	0.388	-	0
Executive (32/Sec)	880	1.241	1.241	1.241	1.241	1.241	1.241	1
TOTAL TIME PER FRAME		19.911	20.799	20.140	21.723	19.818	21.125	

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TACTICAL ENVIRONMENT SIMULATION
TIME ASSIGNMENT AND EXECUTION TIME (MILLISECONDS)
- SEL 32/55 AIET - 1.4103 MICROSECONDS

	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	1.551	-	-	-	1.551	-	-	-	1.551	-	-	-	1.551	-
	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
	-	-	-	1.008	-	-	-	1.008	-	-	-	1.008	-	-
	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
	-	-	-	-	-	0.102	-	-	-	-	-	-	-	0.102
	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
	-	0.168	-	-	-	0.168	-	-	-	0.168	-	-	-	0.168
	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388
	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
	-	0.931	-	0.931	-	0.931	-	0.931	-	0.931	-	0.931	-	0.931
	-	-	-	-	-	-	0.807	-	-	-	-	-	-	-
	-	0.465	-	-	-	-	-	-	-	-	-	-	-	-
	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
	0.465	-	0.465	-	0.465	-	0.465	-	0.465	-	0.465	-	0.465	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.073	0.078	0.078	0.078	0.078	0.078	0.078
	-	0.388	-	0.388	-	0.388	-	0.388	-	0.388	-	0.388	-	0.388
	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241
3	21.125	20.561	21.303	20.206	20.799	19.422	21.723	19.818	20.799	19.320	20.916	19.818	20.799	19.71

21	22	23	24	25	26	27	28	29	30	31
-	1.551	-	-	-	1.551	-	-	-	1.551	-
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
1.008	-	-	-	1.008	-	-	-	1.008	-	-
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
-	-	-	-	-	-	0.102	-	-	-	-
0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
-	-	0.168	-	-	-	0.168	-	-	-	0.168
0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388	0.388
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
0.931	-	0.931	-	0.931	-	0.931	-	0.931	-	0.931
-	-	-	-	-	-	-	0.807	-	-	-
-	-	0.465	-	-	-	-	-	-	-	-
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
-	0.465	-	0.465	-	0.465	-	0.465	-	0.465	-
-	-	-	-	-	-	-	-	-	-	-
0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
0.388	-	0.388	-	0.388	-	0.388	-	0.388	-	0.388
1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241	1.241

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	TACTICAL FRAME TIME ASSIGNMENT CPU- XEROX 550					
		1	2	3	4	5	6
Navigation (32/Sec)	495	1.325	1.325	1.325	1.325	1.325	1.325
Navigation (8/Sec)	550	1.472	-	-	-	1.472	-
Navigation (1/Sec)	1100	-	-	-	-	-	-
Inertial Nav (32/Sec)	784	2.099	2.099	2.099	2.099	2.099	2.099
Inertial Nav Sys (8/Sec)	110	-	-	0.294	-	-	-
Inertial Nav Sys (1/Sec)	66	0.177	-	-	-	-	-
UHF Data Link (32/Sec)	952	2.548	2.548	2.548	2.548	2.548	2.548
UHF Data Link (16/Sec)	594	-	1.590	-	1.590	-	1.590
UHF Data Link (8/Sec)	683	-	-	1.828	-	-	-
Nav Computer (32/Sec)	1925	5.153	5.153	5.153	5.153	5.153	5.153
MDIG Interface Program (32/Sec)	55	0.147	0.147	0.147	0.147	0.147	0.147
MDIG Interface Program (16/Sec)	110	-	0.294	-	0.294	-	0.294
Radar/IR (32/Sec)	2213	5.924	5.924	5.924	5.924	5.924	5.924
TID Buffer Control (1/Sec)	110	-	-	0.294	-	-	-
Radar Interface (32/Sec)	462	1.237	1.237	1.237	1.237	1.237	1.237
Radar Interface (16/Sec)	220	-	0.589	-	0.589	-	0.589
Armament (32/Sec)	340	0.910	0.910	0.910	0.910	0.910	0.910
Weapon Delivery (32/Sec)	1114	2.982	2.982	2.982	2.982	2.982	2.982
Weapon Delivery (16/Sec)	520	-	1.392	-	1.392	-	1.392
Weapon Scoring (32/Sec)	1030	2.757	2.757	2.757	2.757	2.757	2.757
Weapon Scoring (16/Sec)	297	-	0.795	-	0.795	-	0.795
5400 Interface (32/Sec)	125	0.335	0.335	0.335	0.335	0.335	0.335
5400 Interface (16/Sec)	825	2.208	-	2.208	-	2.208	-
5400 Interface (8/Sec)	220	-	-	-	0.589	-	-
5400 Interface (4/Sec)	1513	-	-	-	4.050	-	-
5400 Interface (2/Sec)	206	-	-	0.551	-	-	-
5400 Interface (1/Sec)	231	-	-	-	-	-	0.618
RHAWS (32/Sec)	66	0.177	0.177	0.177	0.177	0.177	0.177
RHAWS (8/Sec)	550	-	1.472	-	-	-	1.472

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ACTICAL ENVIRONMENT SIMULATION
GNMENT AND EXECUTION TIME (MILLISECONDS)
AIET - 2.6769 MICROSECONDS

6	7	8	9	10	11	12	13	14	15	16	17	18	19
.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325
-	-	-	1.472	-	-	-	1.472	-	-	-	1.472	-	-
-	1.472	0.736	0.736	-	-	-	-	-	-	-	-	-	-
.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099
-	0.294	-	-	-	0.294	-	-	-	0.294	-	-	-	0.294
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548
.590	-	1.590	-	1.590	-	1.590	-	1.590	-	1.590	-	1.590	-
-	1.828	-	-	-	1.828	-	-	-	1.828	-	-	-	1.828
.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153
.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
.294	-	0.294	-	0.294	-	0.294	-	0.294	-	0.294	-	0.294	-
.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924
-	-	-	-	-	-	-	-	-	-	-	-	-	-
.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237
.589	-	0.580	-	0.589	-	0.589	-	0.589	-	0.589	-	0.589	-
.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910
.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982
.392	-	1.392	-	1.392	-	1.392	-	1.392	-	1.392	-	1.392	-
.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757
.795	-	0.795	-	0.795	-	0.795	-	0.795	-	0.795	-	0.795	-
.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
-	2.208	-	2.208	-	2.208	-	2.208	-	2.208	-	2.208	-	2.208
-	-	0.589	-	-	-	0.589	-	-	-	0.589	-	-	-
-	-	-	-	-	-	4.050	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	0.551
.618	-	-	-	-	-	-	-	-	-	-	-	-	-
.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177
.472	-	-	-	1.472	-	-	-	1.472	-	-	-	1.472	-

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TABLE 17. TIME SLOT ANALYSIS - TACTICS
(XEROX 550)

19	20	21	22	23	24	25	26	27	28	29	30	31	32
1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325	1.325
-	-	1.472	-	-	-	1.472	-	-	-	1.472	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099	2.099
0.294	-	-	-	0.294	-	-	-	0.294	-	-	-	0.294	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548	2.548
-	1.590	-	1.590	-	1.590	-	1.590	-	1.590	-	1.590	-	1.590
1.828	-	-	-	1.828	-	-	-	1.828	-	-	-	1.828	-
5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153	5.153
0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	0.294	-	0.294	-	0.294	-	0.294	-	0.294	-	0.294	-	0.294
5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924	5.924
-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237	1.237
-	0.589	-	0.589	-	0.589	-	0.589	-	0.589	-	0.589	-	0.589
0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910
2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982	2.982
-	1.392	-	1.392	-	1.392	-	1.392	-	1.392	-	1.392	-	1.392
2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757
-	0.795	-	0.795	-	0.795	-	0.795	-	0.795	-	0.795	-	0.795
0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
2.208	-	2.208	-	2.208	-	2.208	-	2.208	-	2.208	-	2.208	-
-	0.589	-	-	-	0.589	-	-	-	0.589	-	-	-	0.589
-	4.050	-	-	-	-	-	-	-	4.050	-	-	-	-
0.551	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	[illegible]
-	-	-	1.472	-	-	-	1.472	-	-	-	1.472	[illegible]	[illegible]

AD-A043 578 NAVAL TRAINING EQUIPMENT CENTER ORLANDO FLA F/G 9/2
COMPUTER SYSTEM REQUIREMENTS ANALYSIS DEVICE 2F112, F-14 WEAPON--ETC(U)
APR 77 C F SUMMER, G A WYNDLE, D E DANIEL

UNCLASSIFIED NAVTRAEQUIPC-IH-262 NL

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PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	TACTICAL ENV FRAME TIME ASSIGNME CPU - XEROX 550						
		1	2	3	4	5	6	7
RHAWS (4/Sec)	1100	-	2.945	-	-	-	2.945	-
DECM (32/Sec)	55	0.147	0.147	0.147	0.147	0.147	0.147	0.1
DECM (4/Sec)	715	0.957	-	-	-	0.957	-	-
ALE-39 (32/Sec)	55	0.147	0.147	0.147	0.147	0.147	0.147	0.1
ALE-39 (4/Sec)	72	-	-	0.193	-	-	-	0.1
DRLMS X-Y (32/Sec)	33	0.088	0.088	0.088	0.088	0.088	0.088	0.0
DRLMS X-Y (8/Sec)	119	-	-	0.319	-	-	-	0.3
DRLM Interface (32/Sec)	275	0.736	0.736	0.736	0.736	0.736	0.736	0.7
RADAR (32/Sec)	55	0.147	0.147	0.147	0.147	0.147	0.147	0.1
RADAR (16/Sec)	660	1.767	-	1.767	-	1.767	-	1.7
RADAR (4/Sec)	572	-	-	-	1.531	-	-	-
RADAR (2/Sec)	330	-	-	-	-	-	-	0.8
IR (32/Sec)	55	0.147	0.147	0.147	0.147	0.147	0.147	0.1
IR (16/Sec)	330	-	0.883	-	0.883	-	0.883	-
IR (2/Sec)	193	-	-	0.517	-	-	-	-
VIDIG (32/Sec)	55	0.147	0.147	0.147	0.147	0.147	0.147	0.1
VIDIG (16/Sec)	275	0.736	-	0.736	-	0.736	-	0.7
EXECUTIVE FUNT (32/Sec)	880	2.356	2.356	2.356	2.356	2.356	2.356	2.3
TOTAL TIME PER FRAME		36.826	39.469	38.216	41.222	36.649	37.142	39.

2

TICAL ENVIRONMENT SIMULATION
ASSIGNMENT AND EXECUTION TIME (MILLISECONDS)
ROX 550 AIET - 2.6769 MICROSECONDS

	7	8	9	10	11	12	13	14	15	16	17	18	19
945	-	-	-	2.945	-	-	-	2.945	-	-	-	2.945	-
147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	-	-	0.957	-	-	-	0.957	-	-	-	0.957	-	-
147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	0.193	-	-	-	0.193	-	-	-	0.193	-	-	-	0.193
088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088
-	0.319	-	-	-	0.319	-	-	-	0.319	-	-	-	0.319
736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736
147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	1.767	-	1.767	-	1.767	-	1.767	-	1.767	-	1.767	-	1.767
-	-	-	-	-	-	1.531	-	-	-	-	-	-	-
-	0.883	-	-	-	-	-	-	-	-	-	-	-	-
147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
883	-	0.883	-	0.883	-	0.883	-	0.883	-	0.883	-	0.883	-
-	-	-	-	-	-	-	-	-	-	-	-	-	0.517
147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	0.736	-	0.736	-	0.736	-	0.736	-	0.736	-	0.736	-	0.736
356	2.356	2.356	2.356	2.356	2.356	2.356	2.356	2.356	2.356	2.356	2.356	2.356	2.356

-	0.319	-	-	-	0.319	-
0.736	0.736	0.736	0.736	0.736	0.736	0.736
0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	1.767	-	1.767	-	1.767	-
-	-	-	-	-	-	1.531
-	0.883	-	-	-	-	-
0.147	0.147	0.147	0.147	0.147	0.147	0.147
0.883	-	0.883	-	0.883	-	0.883
-	-	-	-	-	-	-
0.147	0.147	0.147	0.147	0.147	0.147	0.147
-	0.736	-	0.736	-	0.736	-
2.356	2.356	2.356	2.356	2.356	2.356	2.356

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	VIS FRAME TIME ASSIGNMENT CPU - INTERDATA						
		1	2	3	4	5	6	7
Sky-Sea Projector (32/Sec)	2024	3.948	3.948	3.948	3.948	3.948	3.948	3.9
Miscellaneous (32/Sec)	76	0.148	0.148	0.148	0.148	0.148	0.148	0.1
Target Projector (32/Sec)	1884	3.675	3.675	3.675	3.675	3.675	3.675	3.6
Miscellaneous (32/Sec)	265	0.517	0.517	0.517	0.517	0.517	0.517	0.5
Interactive Target Projector (32/Sec	1884	3.675	3.675	3.675	3.675	3.675	3.675	3.6
Miscellaneous (32/Sec)	265	0.517	0.517	0.517	0.517	0.517	0.517	0.5
Missile/Gun Projector (32/Sec)	759	1.481	1.481	1.481	1.481	1.481	1.481	1.4
Miscellaneous (32/Sec)	164	0.320	0.320	0.320	0.320	0.320	0.320	0.3
CVA (8/Sec)	935	1.824	-	-	-	1.824	-	-
CVA (4/Sec)	66	-	-	0.129	-	-	-	-
Executive and I/O (32/Sec)	1075	2.097	2.097	2.097	2.097	2.097	2.097	2.0
TOTAL TIME PER FRAME		18.202	16.378	16.507	16.378	18.202	16.378	16

2

VISUAL SIMULATION
NMENT AND EXECUTION TIME (MILLISECONDS)
ERDATA 8/32 WLKHD AIET - 1.9506 MICROSECONDS

	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.948	3.9
8	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.1
5	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.6
7	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.5
5	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.675	3.6
7	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.5
1	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.4
0	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.3
	-	-	1.824	-	-	-	1.824	-	-	-	1.824	-	-	-
	-	-	-	-	0.129	-	-	-	-	-	-	-	0.129	-
7	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.0
78	16.378	16.378	18.202	16.378	16.507	16.378	18.202	16.378	16.378	16.378	18.202	16.378	16.507	16.3

1.481	1.481	1.481	1.481	1.481	1.481	1.481
0.320	0.320	0.320	0.320	0.320	0.320	0.320
-	-	1.824	-	-	-	1.824
-	-	-	-	0.129	-	-
2.097	2.097	2.097	2.097	2.097	2.097	2.097

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	VISUAL FRAME TIME ASSIGNMENTS A CPU - SEL 32/55						
		1	2	3	4	5	6	
Sky-Sea Projector (32/Sec)	2024	3.590	3.590	3.590	3.590	3.590	3.590	3.
Miscellaneous (32/Sec)	76	0.135	0.135	0.135	0.135	0.135	0.135	0.
Target Projector (32/Sec)	1884	3.341	3.341	3.341	3.341	3.341	3.341	3.
Miscellaneous (32/Sec)	265	0.470	0.470	0.470	0.470	0.470	0.470	0.
Interactive Target Projector (32/Sec)	1884	3.341	3.341	3.341	3.341	3.341	3.341	3.
Miscellaneous (32/Sec)	265	0.470	0.470	0.470	0.470	0.470	0.470	0.
Missile/Gun Projector (32/Sec)	759	1.346	1.346	1.346	1.346	1.346	1.346	1.
Miscellaneous (32/Sec)	160	0.284	0.284	0.284	0.284	0.284	0.284	0.
CVA (8/Sec)	935	1.658	-	-	-	1.658	-	
CVA (4/Sec)	66	-	-	0.117	-	-	-	
Executive and I/O (32/Sec)	1075	1.907	1.907	1.907	1.907	1.907	1.907	1.
TOTAL TIME PER FRAME		16.542	14.884	15.001	14.884	16.542	14.884	14.

2

VISUAL SIMULATION
MENTS AND EXECUTION TIME (MILLISECONDS)
/55 AIET - 1.7736 MICROSECONDS

;	7	8	9	10	11	12	13	14	15	16	17	18	19
90	3.590	3.590	3.590	3.590	3.590	3.590	3.590	3.590	3.590	3.590	3.590	3.590	3.590
35	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
41	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341
70	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
41	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341
70	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
46	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346
84	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284
-	-	-	1.658	-	-	-	1.658	-	-	-	1.658	-	-
-	-	-	-	-	0.117	-	-	-	-	-	-	-	0.117
07	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907

3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341	3.341
0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.47
1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.34
0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.28
-	-	1.658	-	-	-	1.658	-	-	-	1.658	-	-	-
0.117	-	-	-	-	-	-	-	0.117	-	-	-	-	-
1.907	1[illegible]	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.907	1.90

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	VISUAL SI FRAME TIME ASSIGNMENT AND EXEC CPU - XEROX 550 A						
		1	2	3	4	5	6	7
Sky-Sea Projector (32/Sec)	2024	6.400	6.400	6.400	6.400	6.400	6.400	6.40
Miscellaneous (32/Sec)	76	0.240	0.240	0.240	0.240	0.240	0.240	0.24
Target Projector (32/Sec)	1884	5.957	5.957	5.957	5.957	5.957	5.957	5.95
Miscellaneous (32/Sec)	265	0.838	0.838	0.838	0.838	0.838	0.838	0.83
Interactive Target Projector (32/Sec)	1884	5.957	5.957	5.957	5.957	5.957	5.957	5.95
Miscellaneous (32/Sec)	265	0.838	0.838	0.838	0.838	0.838	0.838	0.83
Missile/Gun Projector (32/Sec)	759	2.400	2.400	2.400	2.400	2.400	2.400	2.40
Miscellaneous (32/Sec)	164	0.519	0.519	0.519	0.519	0.519	0.519	0.51
CVA (8/Sec)	935	2.957	-	-	-	2.957	-	-
CVA (4/Sec)	66	-	-	0.209	-	-	-	-
Executive and I/O (32/Sec)	1075	3.399	3.399	3.399	3.399	3.399	3.399	3.39
TOTAL TIME PER FRAME		29.505	26.548	26.757	26.548	29.505	26.548	26.5

5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957
0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838
5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957
0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838
2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400
0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519
-	-	2.957	-	-	-	2.957	-	-	-	2.957	-	-	-
-	-	-	-	0.209	-	-	-	-	-	-	-	0.209	-
3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399
26.548	26.548	29.505	26.548	26.757	26.548	29.505	26.548	26.548	26.548	29.505	26.548	26.757	26.548

TABLE 20. TIME FRAME ANALYSIS - VISUAL (XEROX 550)

19	20	21	22	23	24	25	26	27	28	29	30	31	32
400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400
240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240
957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957
838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838
957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957	5.957
838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838	0.838
400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400
519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519	0.519
-	-	2.957	-	-	-	2.957	-	-	-	2.957	-	-	-
209	-	-	-	-	-	-	-	0.209	-	-	-	-	-
399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399	3.399
.757	26.548	29.505	26.548	26.548	26.548	29.505	26.548	26.757	26.548	29.505	26.548	26.548	26.548

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	SYNTHETIC TARG FRAME TIME ASSIGNMENT AN CPU - INTERDATA 8/32						
		1	2	3	4	5	6	
Equation of Motion (32/Sec)	3618	6.922	6.922	6.922	6.922	6.922	6.922	6
Direction Cosines (32/Sec)	76	0.145	0.145	0.145	0.145	0.145	0.145	0
Aero Coefficients (32/Sec)	341	0.652	0.652	0.652	0.652	0.652	0.652	0
Euler Angle (32/Sec)	278	0.532	0.532	0.532	0.532	0.532	0.532	0
Rotational Filter (32/Sec)	76	0.145	0.145	0.145	0.145	0.145	0.145	0
Quaternion to Dir. Cosine (32/Sec)	1088	2.082	2.082	2.082	2.082	2.082	2.082	2
Quaternion Integration (32/Sec)	354	0.677	0.677	0.677	0.677	0.677	0.677	0
Human Pilot Blackout (32/Sec)	76	0.145	0.145	0.145	0.145	0.145	0.145	0
Relative Geometry (32/Sec)	670	1.282	1.282	1.282	1.282	1.282	1.282	1
Closest Maneuverplane (32/Sec)	518	0.991	0.991	0.991	0.991	0.991	0.991	0
Accumulation of Weapon Time (32/Sec)	63	0.121	0.121	0.121	0.121	0.121	0.121	0
Fire Cone (32/Sec)	152	0.291	0.291	0.291	0.291	0.291	0.291	0
Thrust Control (32/Sec)	88	0.168	0.168	0.168	0.168	0.168	0.168	0
Reaction Routine (32/Sec)	872	1.668	1.668	1.668	1.668	1.668	1.668	1
Predict Turning Flight (32/Sec)	177	0.339	0.339	0.339	0.339	0.339	0.339	0
Random Perturbation (32/Sec)	733	1.402	1.402	1.402	1.402	1.402	1.402	1
State Evaluation (32/Sec)	101	0.193	0.193	0.193	0.193	0.193	0.193	0
Executive and I/O (32/Sec)	1075	2.057	2.057	2.057	2.057	2.057	2.057	2
TOTAL TIME PER FRAME		19.812	19.812	19.812	19.812	19.812	19.812	1

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IC TARGET SIMULATION
MENT AND EXECUTION TIME (MILLISECONDS)
8/32 WLKHD AIET - 1.9132 MICROSECONDS

6	7	8	9	10	11	12	13	14	15	16	17	18	19	
922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	
145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	
652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	
532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	
145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	
082	2.082	2.082	0.082	0.082	0.082	0.082	0.082	2.082	2.082	2.082	2.082	2.082	2.082	
677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	
145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	
.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	
.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	
.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	
.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	
.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	
.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	
.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	
.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	
.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	
.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	
.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	

TABLE 21. TIME FRAME ANALYSIS - SYNTHETIC TARGET (INTERDATA 8/32)

	20	21	22	23	24	25	26	27	28	29	30	31	32
.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922	6.922
.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652	0.652
.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532
.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082	2.082
.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677
.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282
.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991
.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291
.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168
.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668	1.668
.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339	0.339
.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402
.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193
.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057
.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812	19.812

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	SYNTHETIC TA FRAME TIME ASSIGNMEN CPU - SEL 32/55						
		1	2	3	4	5	6	
Equation of Motion (32/Sec)	3618	6.433	6.433	6.433	6.433	6.433	6.433	6
Direction Cosines (32/Sec)	76	0.135	0.135	0.135	0.135	0.135	0.135	0
Aero Coefficients (32/Sec)	341	0.606	0.606	0.606	0.606	0.606	0.606	0
Euler Angle (32/Sec)	278	0.494	0.494	0.494	0.494	0.494	0.494	0
Rotational Filter (32/Sec)	76	0.135	0.135	0.135	0.135	0.135	0.135	0
Quaternion to Dir. Cosine (32/Sec)	1088	1.934	1.934	1.934	1.934	1.934	1.934	1
Quaternion Integration (32/Sec)	354	0.629	0.629	0.629	0.629	0.629	0.629	0
Human Pilot Blackout (32/Sec)	76	0.135	0.135	0.135	0.135	0.135	0.135	0
Relative Geometry (32/Sec)	670	1.191	1.191	1.191	1.191	1.191	1.191	1
Closest Maneuverplane (32/Sec	518	0.921	0.921	0.921	0.921	0.921	0.921	0
Accumulation of Weapon Time (32/Sec)	63	0.112	0.112	0.112	0.112	0.112	0.112	0
Fire Cone (32/Sec)	152	0.270	0.270	0.270	0.270	0.270	0.270	0
Thrust Control (32/Sec)	88	0.156	0.156	0.156	0.156	0.156	0.156	0
Reaction Routine (32/Sec)	872	1.550	1.550	1.550	1.550	1.550	1.550	1
Predict Turning Flight (32/Sec)	177	0.315	0.315	0.315	0.315	0.315	0.315	0
Random Perturbation (32/Sec)	733	1.303	1.303	1.303	1.303	1.303	1.303	1
State Evaluation (32/Sec)	101	0.180	1.080	1.080	1.080	1.080	1.080	1
Executive and I/O (32/Sec)	1075	1.911	1.911	1.911	1.911	1.911	1.911	1
TOTAL TIME PER FRAME		18.410	18.410	18.410	18.410	18.410	18.410	1

0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494
0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934
0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629
0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191
0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921
0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112
0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550
0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303
1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	0.180	0.180	0.180	0.180	0.180	0.180
1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911
18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410

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TABLE 22. TIME FRAME ANALYSIS - SYNTHETIC TARGET (SEL 32/55)

19	20	21	22	23	24	25	26	27	28	29	30	31	32
6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433	6.433
0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606
0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494	0.494
0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934	1.934
0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629
0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191	1.191
0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921	0.921
0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112
0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550
0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303	1.303
0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911	1.911
18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410	18.410

PROGRAM MODULE	ESTIMATED WORST-CASE INSTRUCTION EXECUTED	SYNTHETIC TA FRAME TIME ASSIGNMEN CPU - XEROX 550						
		1	2	3	4	5	6	
Equation of Motion (32/Sec)	3618	11.060	11.060	11.060	11.060	11.060	11.060	11.
Direction Cosines (32/Sec)	76	0.232	0.232	0.232	0.232	0.232	0.232	0.
Aero Coefficients (32/Sec)	341	1.042	1.042	1.042	1.042	1.042	1.042	1.
Euler Angle (32/Sec)	278	0.850	0.850	0.850	0.850	0.850	0.850	0.
Rotation Filter (32/Sec)	76	0.232	0.232	0.232	0.232	0.232	0.232	0.
Quaternion to Dir. Cosine (32/Sec)	1088	3.326	3.326	3.326	3.326	3.326	3.326	3.
Quaternion Integration (32/Sec)	354	1.082	1.082	1.082	1.082	1.082	1.082	1.
Human Pilot Blackout (32/Sec)	76	0.232	0.232	0.232	0.232	0.232	0.232	0.
Relative Geometry (32/Sec)	670	2.048	2.048	2.048	2.048	2.048	2.048	2.
Closest Maneuverplane (32/Sec)	518	1.584	1.584	1.584	1.584	1.584	1.584	1.
Accumulation of Weapon Time (32/Sec)	63	0.193	0.193	0.193	0.193	0.193	0.193	0.
Fire Cone (32/Sec)	152	0.465	0.465	0.465	0.465	0.465	0.465	0.
Thrust Control (32/Sec)	88	0.269	0.269	0.269	0.269	0.269	0.269	0.
Reaction Routine (32/Sec)	872	2.666	2.666	2.666	2.666	2.666	2.666	2.
Predict Turning Flight (32/Sec)	177	0.541	0.541	0.541	0.541	0.541	0.541	0.
Random Perturbation (32/Sec)	733	2.241	2.241	2.241	2.241	2.241	2.241	2.
State Evaluation (32/Sec)	101	0.309	0.309	0.309	0.309	0.309	0.309	0.
Executive and I/O (32/Sec)	1075	3.286	3.286	3.286	3.286	3.286	3.286	3.
TOTAL TIME PER FRAME		31.658	31.658	31.658	31.658	31.658	31.658	31

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HETIC TARGET SIMULATION
SSIGNMENT AND EXECUTION TIME (MILLISECONDS)
550 AIET - 3.0571 MICROSECONDS

6	7	8	9	10	11	12	13	14	15	16	17	18	19
.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060
.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042
.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850
.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326
.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082
.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048
.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584
0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193
0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465
0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666
0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541
2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241
0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309
3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286
1.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658

TABLE 23. TIME FRAME ANALYSIS - SYNTHETIC TARGET (XEROX 550)

	20	21	22	23	24	25	26	27	28	29	30	31	32
0	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060	11.060
2	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
2	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042
0	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850
2	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
6	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326	3.326
2	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082	1.082
2	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
8	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048
4	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584	1.584
3	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193
5	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465	0.465
9	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
6	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666	2.666
1	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541
1	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241	2.241
9	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309
6	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286	3.286
8	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658	31.658

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