MICROPROCESSOR SOFTWARE APPLICATIONS FOR FLIGHT TRAINING SIMULATORS

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Microcomputer distributed processing may be the answer to modifications and improvements for overloaded computer systems of training simulators. Top down functional design is a very useful tool for software implementation, and the same concept can be applied to a multiple processor computer system. The grouping of many independent functions into one large, software module leads to confusion, overhead, and inefficiency; the same is true when many large mainframe computers are grouped into one system.

G-cueing is one of the many functions of a pilot training simulator system and a unique candidate for the application of distributed computation techniques. The G-cueing system must respond to the aircraft six-degree-of-freedom (DOF) equations of motion to provide static and dynamic stimuli to the student pilot's proprioceptive, tactile, and visual (with respect to eyepoint) sensors. The cues provided by the system must include onset cues as well as sustained acceleration cues.

A G-cueing system has been developed as a strap-on attachment to the F-15 operational flight training simulator, utilizing a microprocessor computation system. Hydraulic actuators produce the onset cues while pressure control of AIRMAT pneumatic cushion cells produces seat hardness, softness, and contouring to provide for sustained cues. An active lap belt and G-suit is also provided to reproduce those sensations experienced in the actual aircraft.

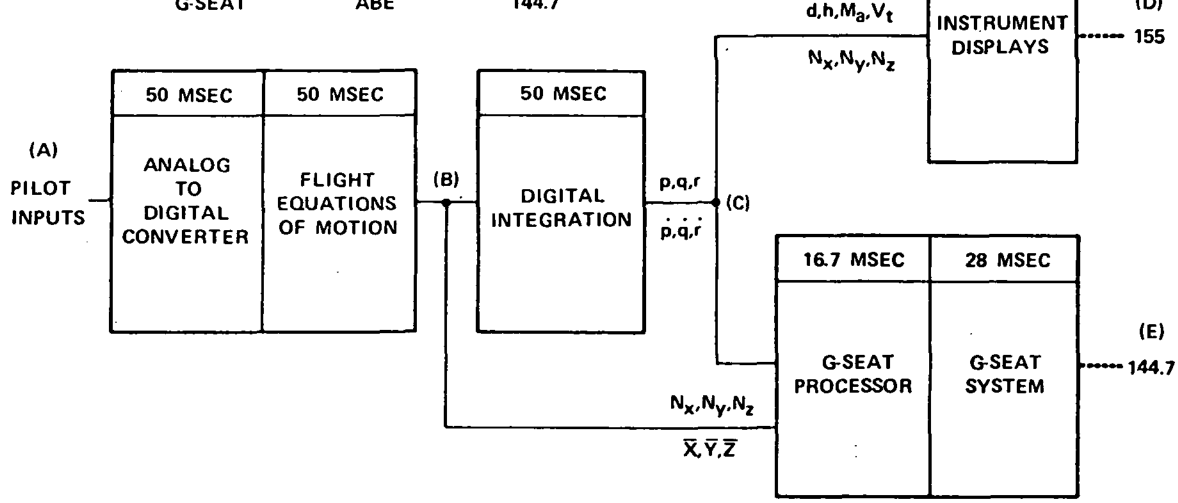
The interface between the G-cueing system software and the software of other simulator systems is very simple: minimal amount of data exchange. However, in itself the G-cueing system is a complex system which requires a significant amount of computer power. This paper presents the G-cueing system software design ann implementation in the dual microprocessor system of the F-15 operational flight training simulator G-cueing system. The software is structured in the two micro-computers such that one serves as a controller performing all logical functions and interface with the host computer system while the other serves as an arith-metic unit performing all mathematical functions.

WHY DISTRIBUTED COMPUTATION ?

- OFFLOAD THE HOST COMPUTER SYSTEM
- REAL-TIME CONSIDERATIONS
- COST ADVANTAGES
- MODULAR HARDWARE (PLUG-IN UNIT)
- INDEPENDENT DEVELOPMENT (SCHEDULE ADVANTAGES)

SYSTEM TIME LAG DIAGRAM

SYSTEM	PATH	TOTAL TIME LAG (MSEC)
INSTRUMENTS	ABCD	155.0
G-SEAT	ABE	144.7



G-CUING A SELF CONTAINED SYSTEM

HOST PROVIDES:

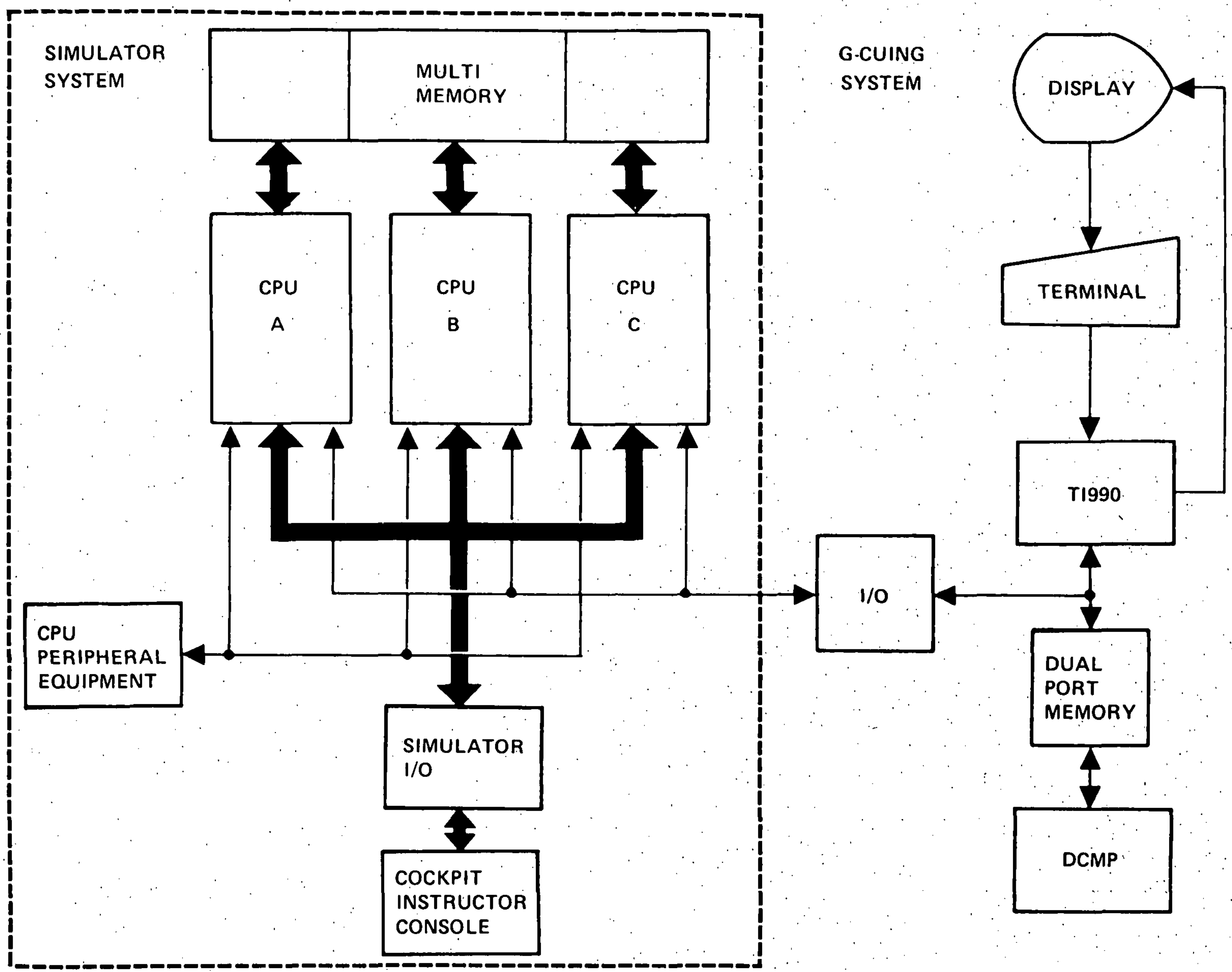
- FRAME SYNCHRONIZATION
- AERODYNAMIC STIMULI
- TRAINER MODE

G-CUING A SELF CONTAINED SYSTEM (CONTD)

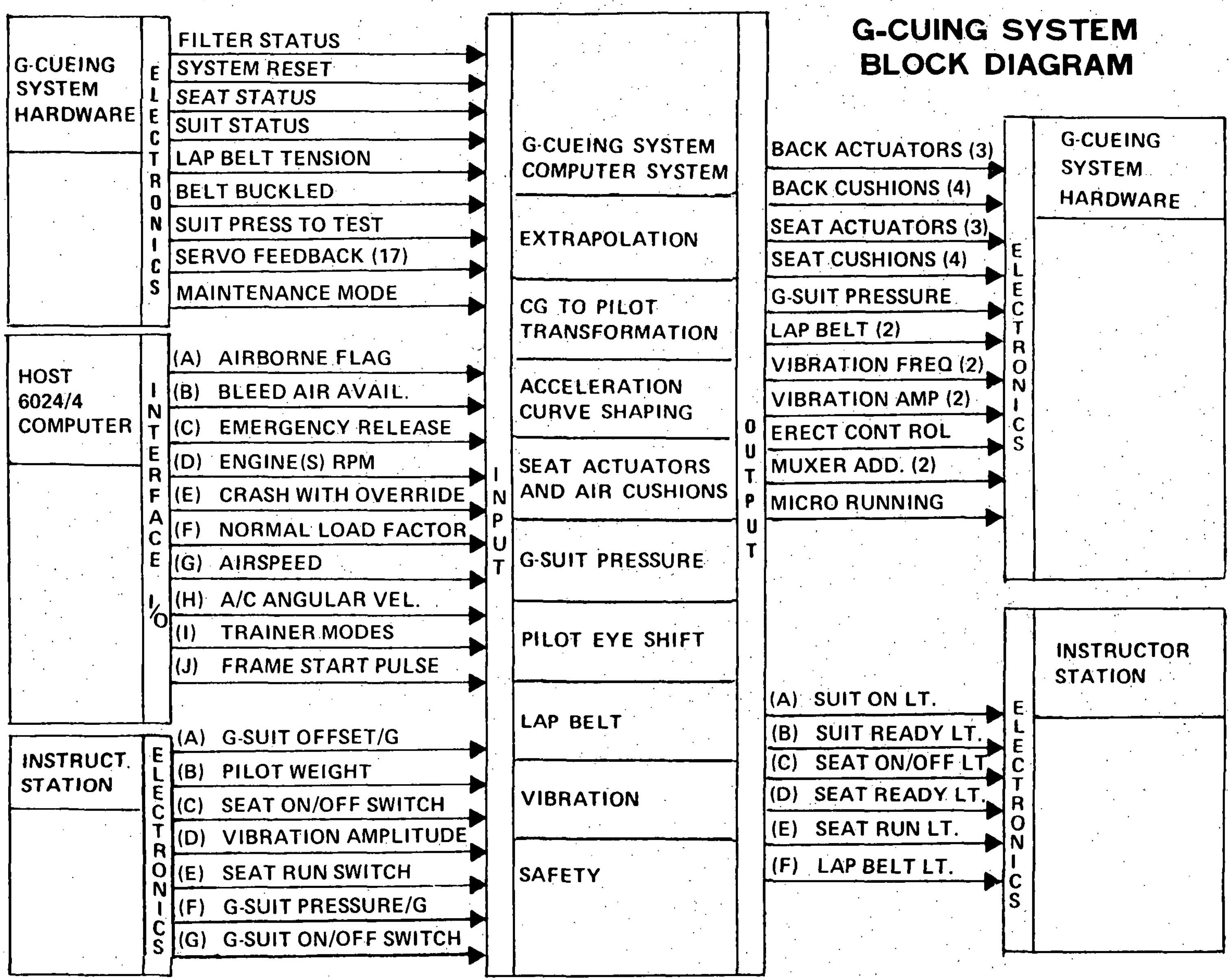
G-CUING SYSTEM PROVIDES:

- ONSET CUES
- SUSTAINED CUES
- BUFFET/VIBRATION CUES
- G-SUIT CUES
- SAFETY MONITORING
- CUE SYNCHRONIZATION
- SELF TEST

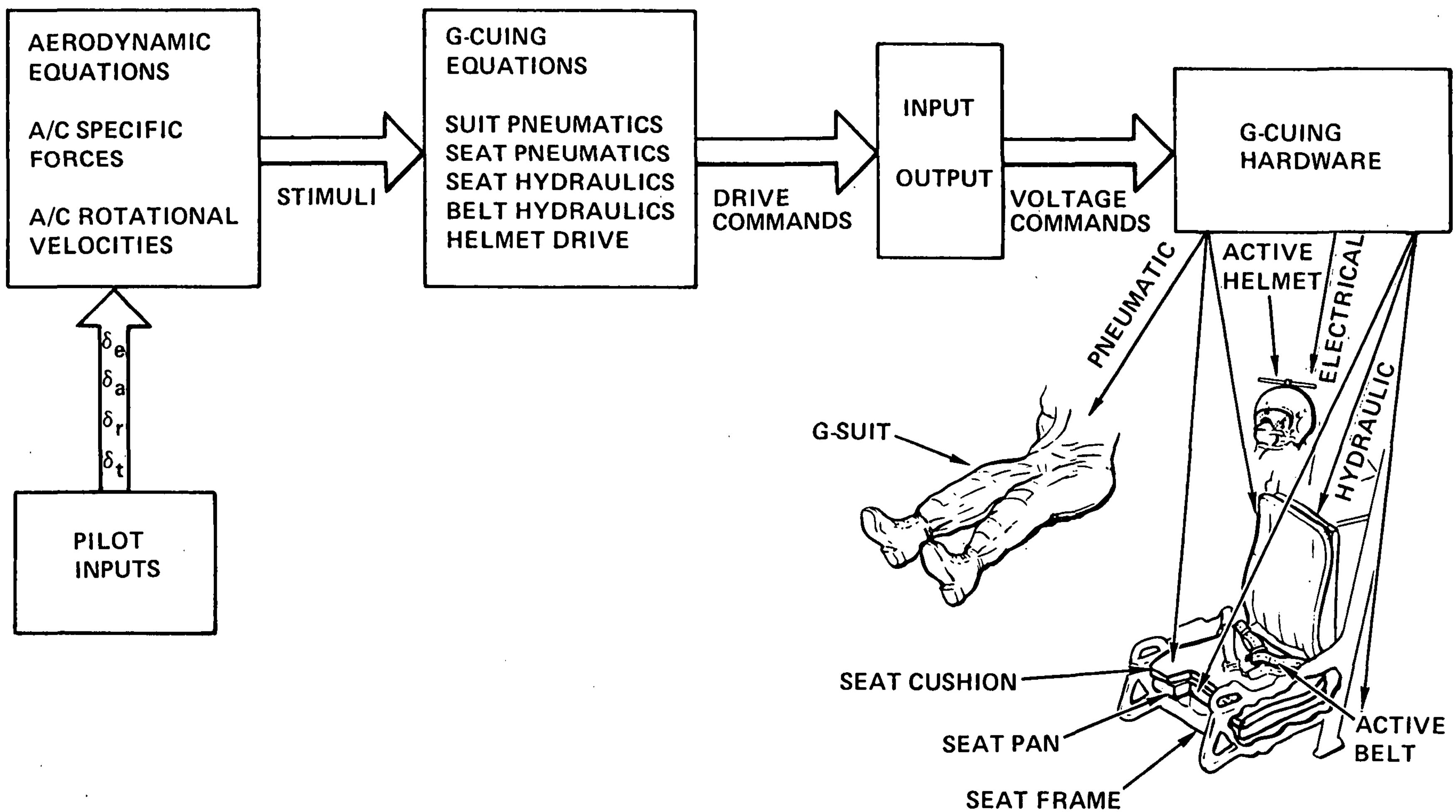
COMPUTATIONAL SYSTEM



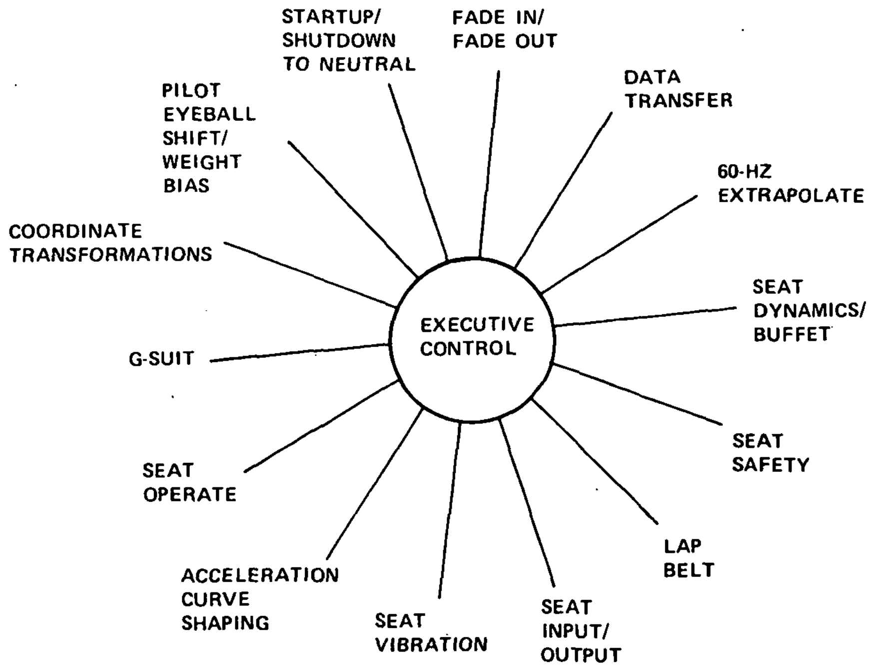
G-CUING SYSTEM BLOCK DIAGRAM



G-CUING SYSTEM DIAGRAM



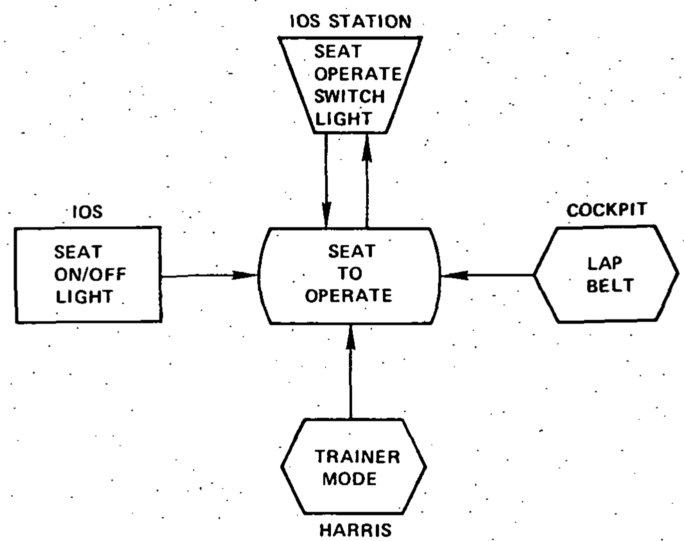
FUNCTIONAL DESCRIPTION OF SOFTWARE



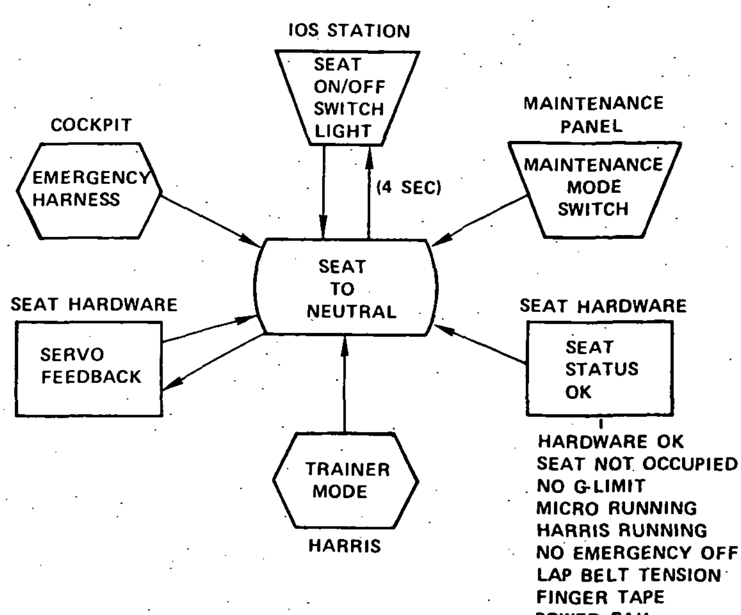
G-CUING SYSTEM SOFTWARE APPORTIONMENT

T I 9900 PROCESSOR	SCRATCH PAD MEMORY	D C M P PROCESSOR
8 K ROM MEMORY 1) SELF TEST 1) EXECUTIVE 2) FADE IN/OUT 3) DATA TRANSFER 4) SEAT SAFETY 5) SEAT I/O 6) SEAT OPERATE 7) START UP/SHUT DOWN 4 K RAM MEMORY SCRATCH PAD	4 K RAM MEMORY 1) TEMPORARY VARIABLES 2) DMCP MODULE ADDRESSES 3) VARIABLE GAIN ADDRESSES	2 K ROM MEMORY 1) 60 HZ EXTRAPOLATOR 2) SEAT DYNAMICS 3) LAP BELT 4) ACCELERATION CURVE SHAPING 5) G-SEAT 6) COORDINATE TRANSFORMATION 7) PILOT WEIGHT BIAS 8) SEAT VIBRATION
3 K MEMORY USED	1 K MEMORY USED	0.9 K MEMORY USED

FUNCTIONAL DESCRIPTION OF G-SEAT TO OPERATE



FUNCTIONAL DESCRIPTION OF G-SEAT STARTUP/SHUTDOWN



SEAT EQUATIONS OF MOTION

- PILOT COORDINATES

$$\ddot{X}_P = N_X + PQY_{CG} + P\gamma Z_{CG} - Q^2X_{CG} - \gamma^2X_{CG} + \dot{Q}Z_{CG} - \dot{\gamma}Y_{CG}$$

$$\ddot{Y}_P = N_Y + QPX_{CG} + Q\gamma Z_{CG} - P^2Y_{CG} - \gamma^2Y_{CG} + \dot{\gamma}X_{CG} - \dot{P}Z_{CG}$$

$$\ddot{Z}_P = N_Z + \gamma PX_{CG} + \gamma QY_{CG} - P^2Z_{CG} - Q^2Z_{CG} - \dot{P}Y_{CG} - \dot{Q}X_{CG}$$

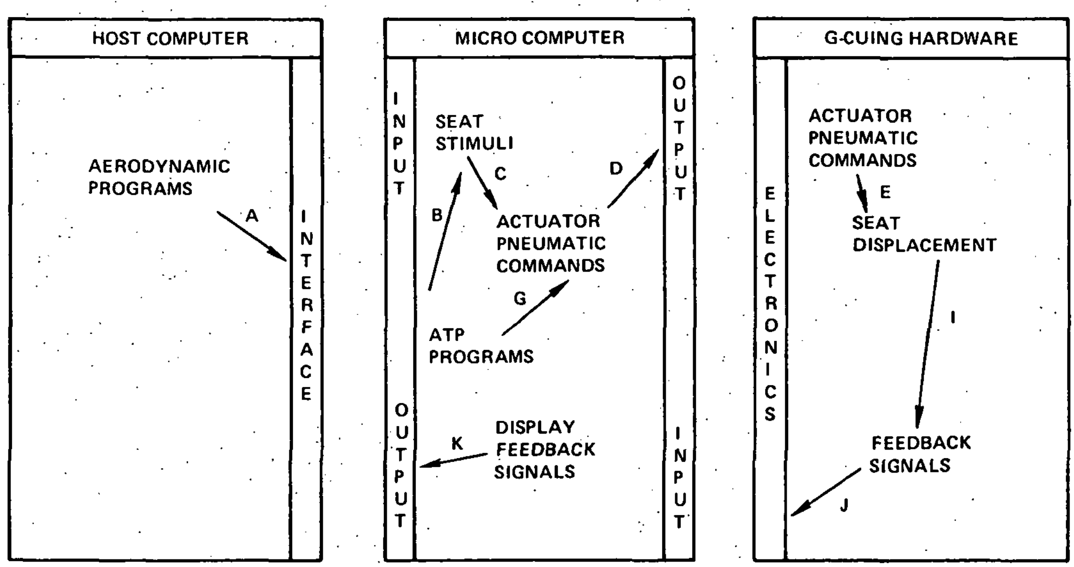
- SEAT ANGLE EFFECTS

$$\ddot{X}_{SP} = \ddot{X}_P \text{ COS } a - Z_P \text{ SIN } a$$

- SEAT ELEMENT COORDINATES

$$ELE_{C,A} = S\left(-W_1\ddot{X}_{SP} - W_2\ddot{Z}_{SP} - W_3\ddot{Y}_{SP}\right) - PWB$$

AUTOMATED ATP OPERATION



OPERATIONAL TRAINING MODE – ABCDE

INTEGRATED ATP MODE – BCDE

HARDWARE ATP MODE -- GDE

ATP SIGNAL RETURN PATH – IJK