

**SIMNET
COMPUTER
IMAGE
GENERATION
SYSTEM**

1987

MICHAEL L. CYRUS

OVERVIEW

- SIMNET CIG SYSTEM
 - 6 U CHASSIS
 - Central Processing Unit
 - Active Area Memory
 - Traversal Processor and DMA
 - 9 U CHASSIS
 - Polygon Processor
 - Tiling Process
 - Pixel Processor Memory
- SIMNET OBJECT TYPES
- SIMNET SAMPLE IMAGERY



Current SimNet M1/M2 CIG Packaging

Front View

Rear View

POWER
DISTRIBUTION
PANEL

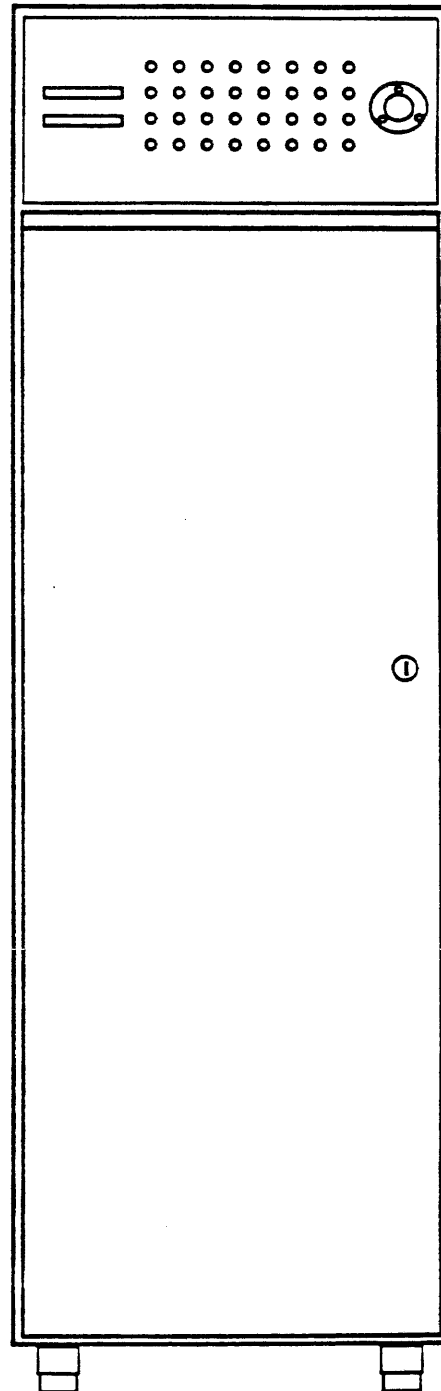
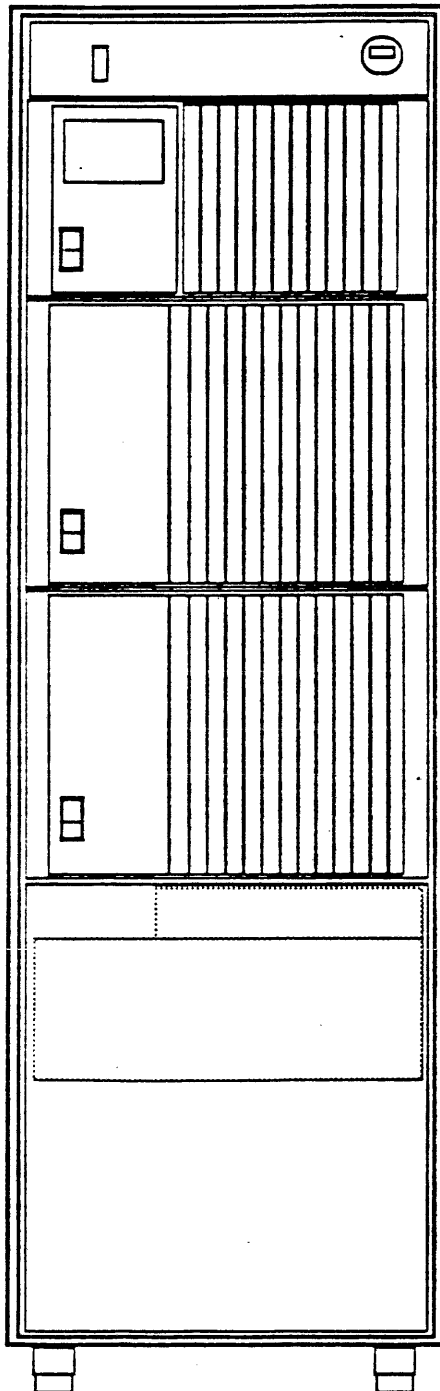
IMAGE
GENERATOR
HOST
SUBSYSTEM

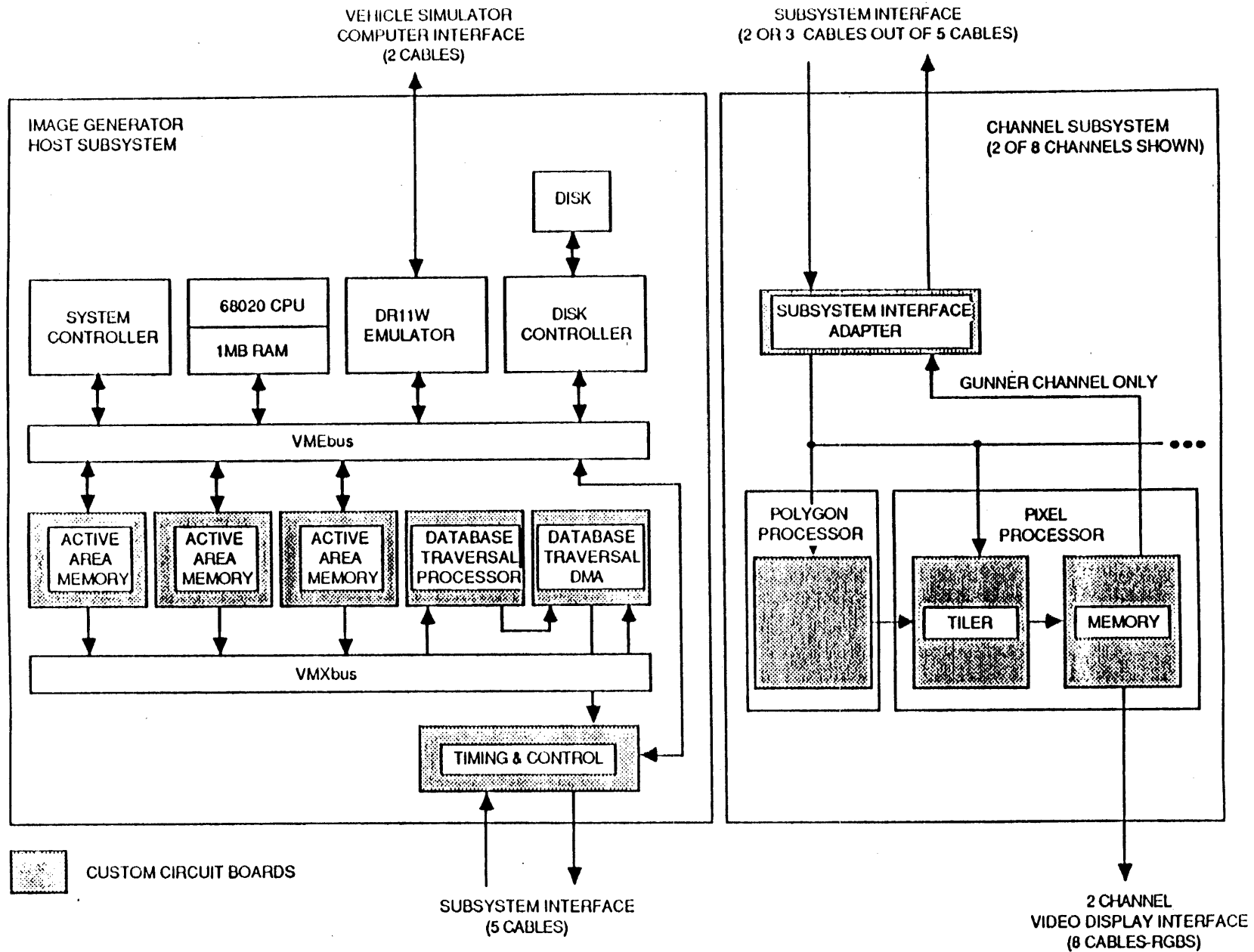
CHANNEL
SUBSYSTEM 2

CHANNEL
SUBSYSTEM 1

LOWER
SUBSYSTEM

SYSTEM I/O
PANEL

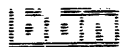




BBN Delta Graphics, Inc.

DELTA SimNet CIG System Performance Parameters

<u>PARAMETER</u>	<u>CIG SYSTEM</u>
Independent Viewing Channels	Up to 8
Occluding Levels	524,288
Frame Update Rate	15 per second per channel 30 Hz optional with 4 channels
Computational Delay (at 15 Hz)	<90 milliseconds
Computed Screen Resolution	320 x 128, 200 x 200
Displayed Screen Resolution	640 x 256, 400 x 400
Video Format	RS-170 RGB
Field-of-View (FOV)	Frame to frame Selectable
Potentially Visible Polygons per Frame	1000 polygons/channel 2000 optional
Online Database Storage Capacity	70 million bytes
Active Area Memory	1.5 million bytes
Terrain Grid Spacing	Selectable
Depth Complexity	3.8 at 15Hz.
Color Resolution	4096 colors
Anti-aliasing	Yes
Distance Fading	Yes
Texture Generation With Transparency	Yes, 16 transparency levels per color
Stamp and Perspective Texturing	Yes
Model Level-of-Detail Control	Yes
Moving Models Per Gaming Area	50
Texture Patterns	Up to 256
Laser Range Finding	Yes
Collision Detection	Yes
Database Size	Up to 3.75 million polygons



CENTRAL PROCESSING UNIT

FUNCTIONS

- Simulation Host Interface
- Moving Model and Special Effects Handling
- Vehicle Position Handling
- Local Terrain Message Assembly
- Active Area Memory Management
- Ballistic Calculations

IMPLEMENTATION

- MC68020 CPU.
- MC68881 Floating Point Coprocessor

SPECIFICATIONS

- 1 MByte RAM
- VME Bus Compatible.



ACTIVE AREA MEMORY

FUNCTIONS

- 8 KILOMETER SQUARE OF ACTIVE AREA MEMORY
- VEHICLE POSITION INFORMATION IN DOUBLE BUFFERED MEMORY
- GENERIC OBJECT DATA STORAGE

IMPLEMENTATION

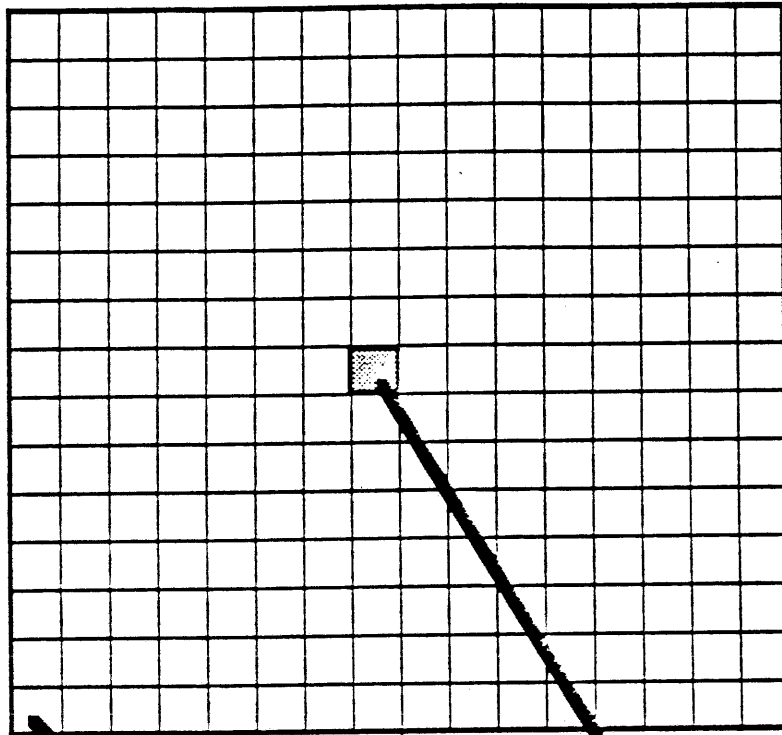
- HALF MBYTE OF STATIC RAM PER BOARD (3 BOARDS)
- DUAL PORTED VME AND VMX BUS INTERFACE

SPECIFICATIONS

- 200 NANOSECOND ACCESS TIME

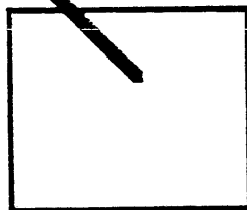


← 16 REGIONS 8KM →



↑
16 Regions
8 km
↓

TERRAIN
REGION



.5KM

.5KM

MY VEHICLE IS IN THE
CENTER TERRAIN REGION



TRAVERSAL PROCESSOR AND DMA

FUNCTIONS

- TRAVERSE DATABASE FOR ALL CHANNELS PER FRAME
- PERFORM FIELD OF VIEW TESTING
- SEND PROPER DATA TO EACH CHANNEL
- PERFORM LOD PROCESSING
- DATA POINTER MANAGEMENT
- CONTROL DATA OUTPUT TO POLY PROCESSORS

IMPLEMENTATION

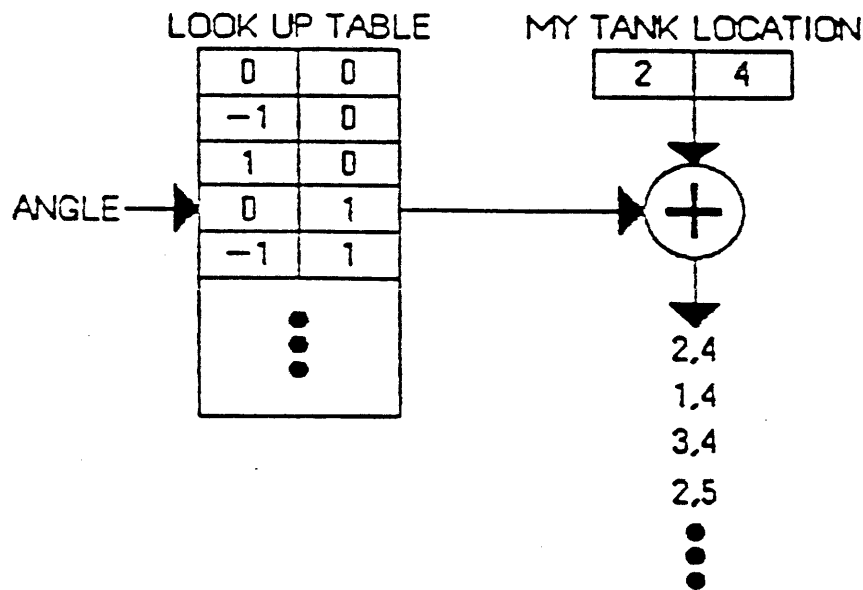
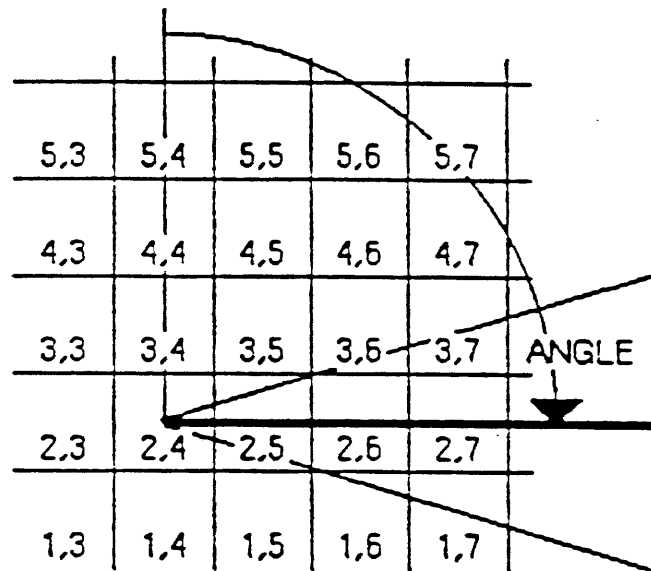
- MICRO CODED PROCESSOR
- FIXED POINT AND FLOATING POINT ALU'S

SPECIFICATIONS

- 8 MIPS FIXED POINT PROCESSING
- 2 MFLOPS FLOATING POINT PROCESSING
- 4K WORDS OF POINTER BUFFER



PRELIMINARY FIELD OF VIEW TEST

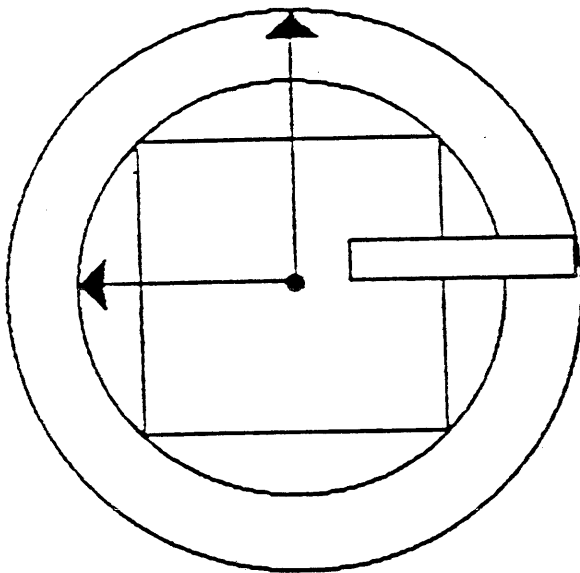


- ORDERS TERRAIN REGIONS FRONT TO BACK
- REDUCES THE NUMBER OF DETAILED FIELD OF VIEW TESTS REQUIRED



DETAILED FIELD OF VIEW TEST

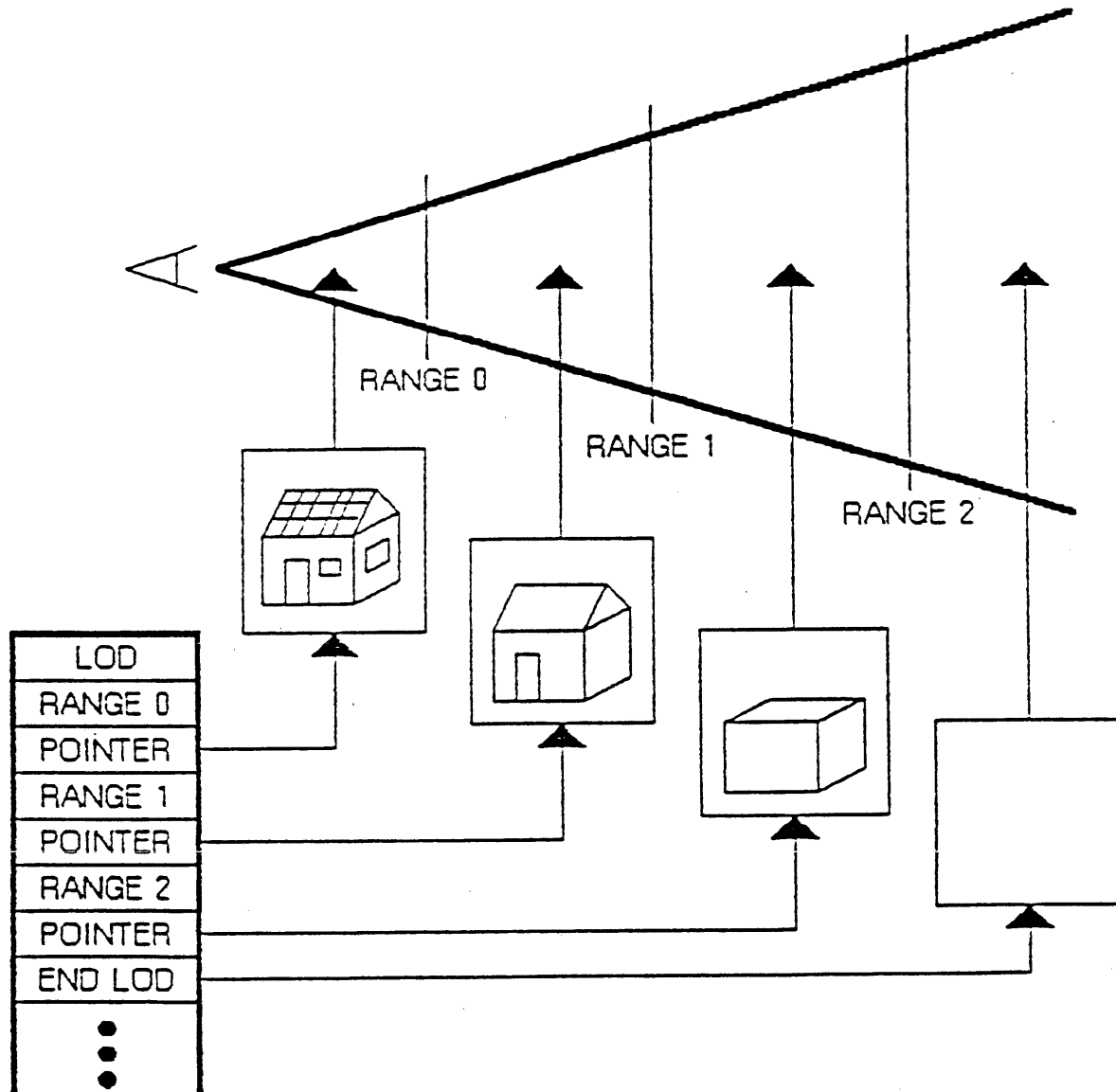
- CLASSIC CENTROID AND RADIUS DOT PRODUCT TEST



EXPAND RADIUS TO
INCLUDE ALL OBJECTS
ASSIGNED TO THE
TERRAIN REGION



LEVEL OF DETAIL PROCESSING



- ALLOWS SCENE DETAIL TO BE CONCENTRATED CLOSE TO THE VIEWPOINT



POLYGON PROCESSOR

FUNCTIONS

- MATRIX MANIPULATIONS
- VIEWSPACE TRANSFORMATIONS
- ELIMINATE BACKFACING POLYGONS
- CLIP POLYGONS TO VIEWING PYRAMID
- SCREEN SPACE PERSPECTIVE PROJECTIONS
- PREPARE POLYGON FOR TILER BOARD
- SETUP TEXTURED AND FACE SHADED POLYGONS
- PROCESS TERRAIN GRIDS AND ROTATED STAMPS

IMPLEMENTATION

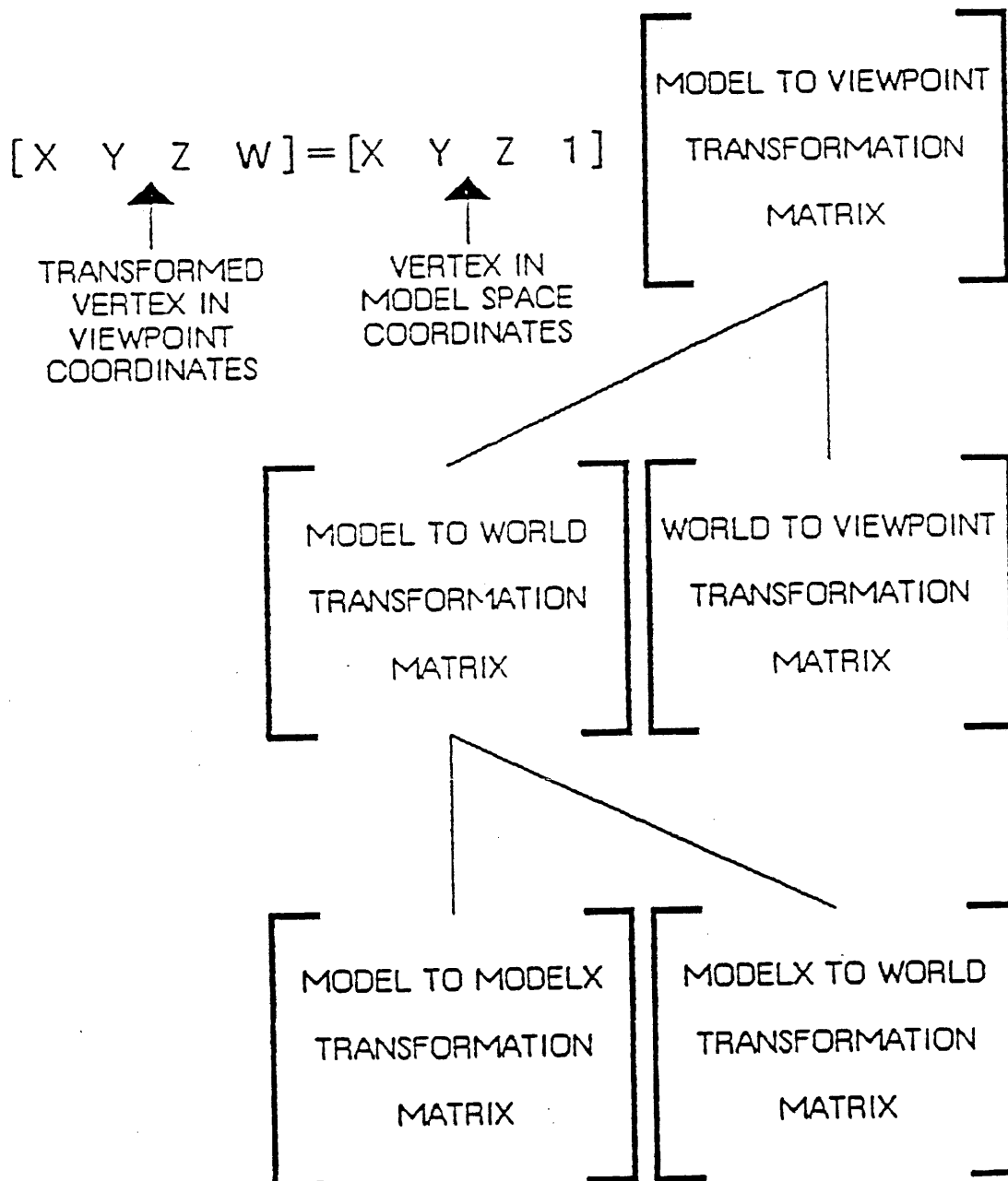
- PIPELINED FLOATING POINT MICROCODED ENGINES
- 4K OF 128 BIT WORDS OF MICROCODE SPACE
- CUSTOM CLIPPING HARDWARE
- ON BOARD DATA RAM.

SPECIFICATIONS

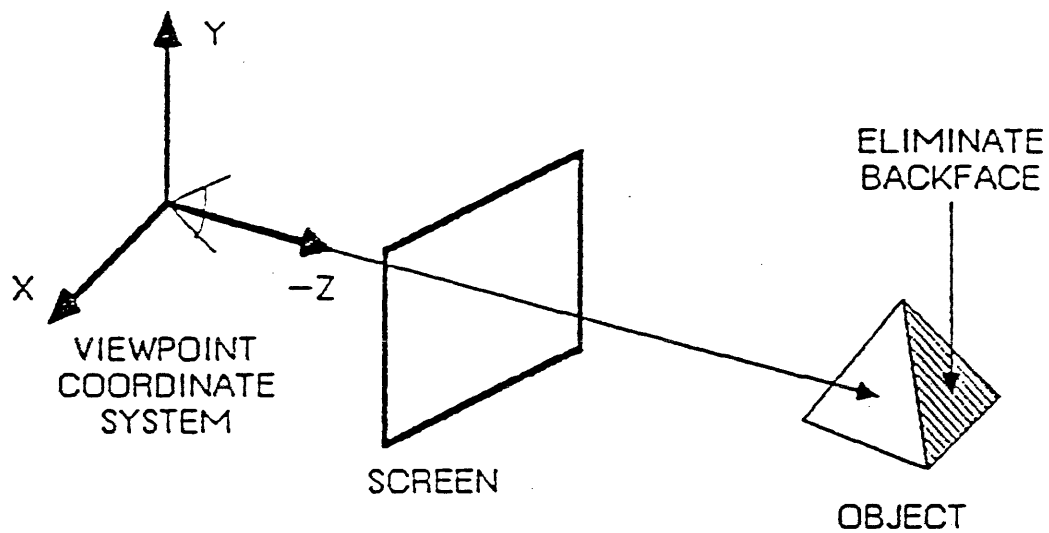
- 30,000 POTENTIALLY VISIBLE 4 SIDED TEXTURED POLYGONS PER SECOND
- 40 MFLOPS TOTAL PROCESSING POWER



VIEWPOINT TRANSFORMATION

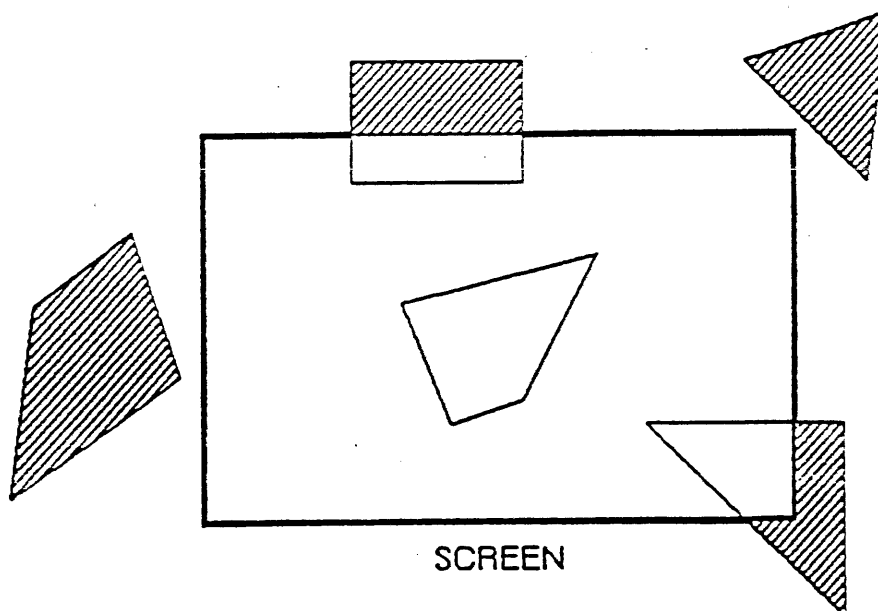
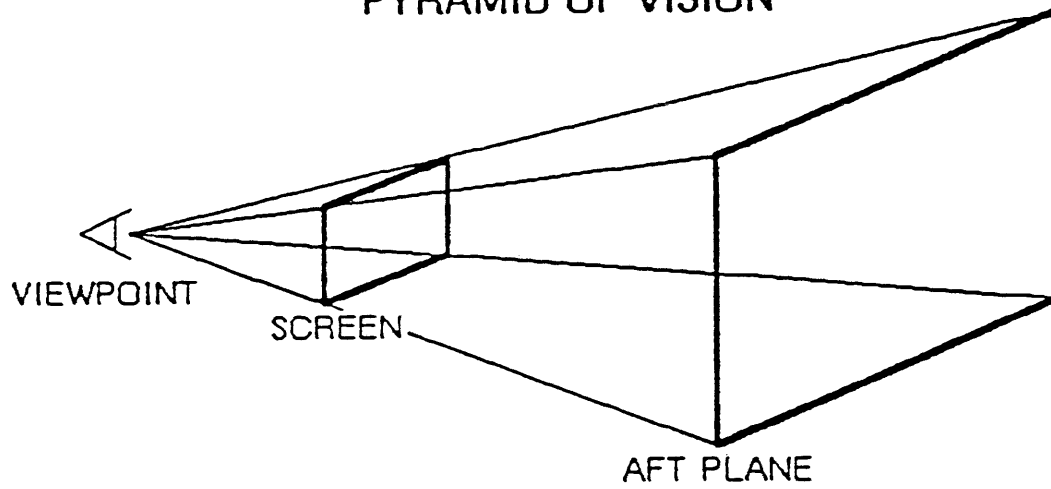


BACKFACE ELIMINATION & VIEWPOINT TRANSFORMATION

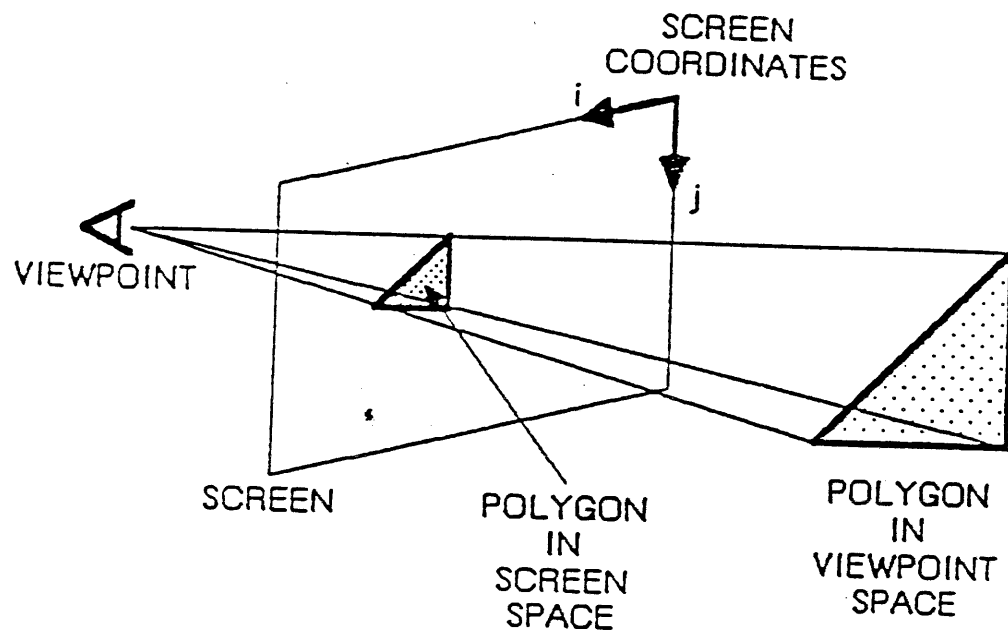


CLIPPING

PYRAMID OF VISION



PROJECTION TO SCREEN COORDINATES



TILING PROCESS

Functions

- Polygon Fill
- Assign polygon color via texture lookup
- Anti-alias polygon edges
- Calculate true perspective depth at each pixel
- Add programmed distance fading
- Assign RGB or intensity texture maps with dynamic LOD control

Implementation

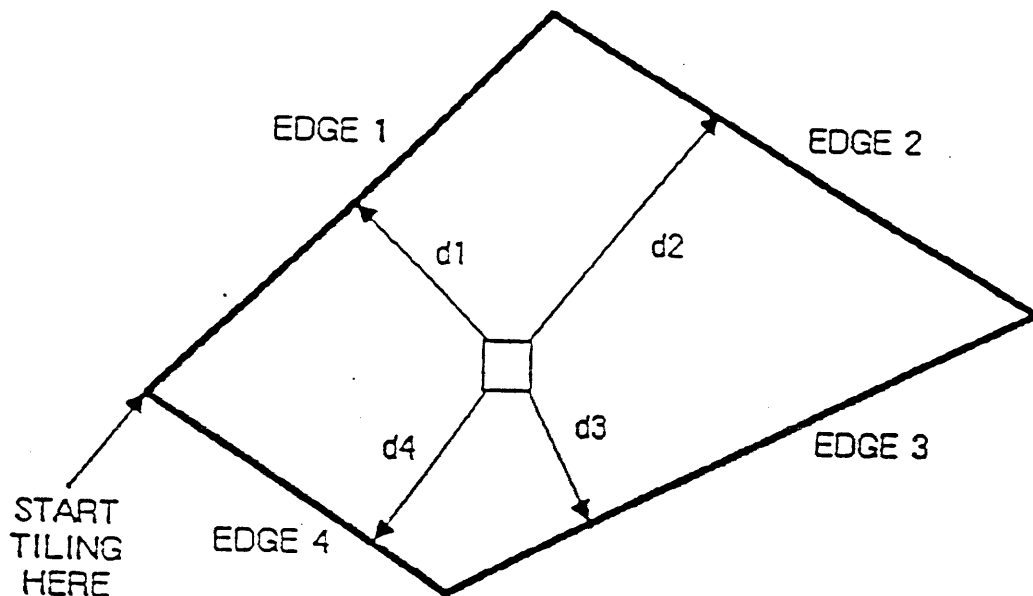
- 2 custom CMOS gate array designs (13 total arrays)
- MSI and LSI-TTL circuitry
- Programmable lookup tables for all color calculations

Specifications

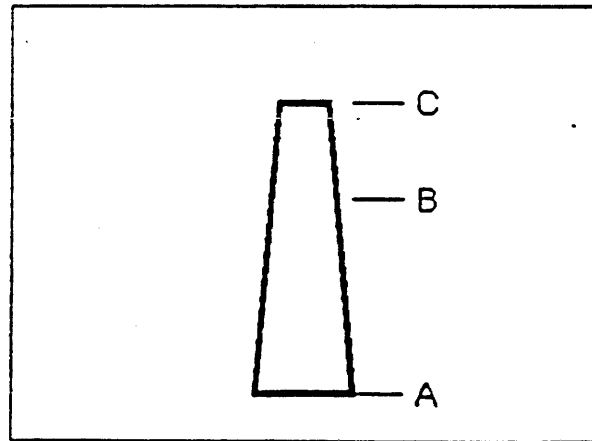
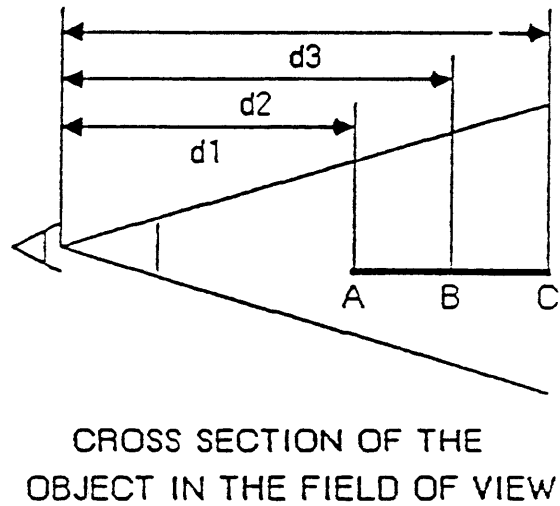
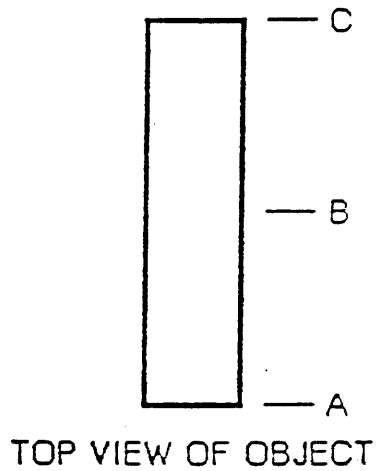
- 160 Kbytes of texture map storage
- 5.5 million pixels per second



TILING



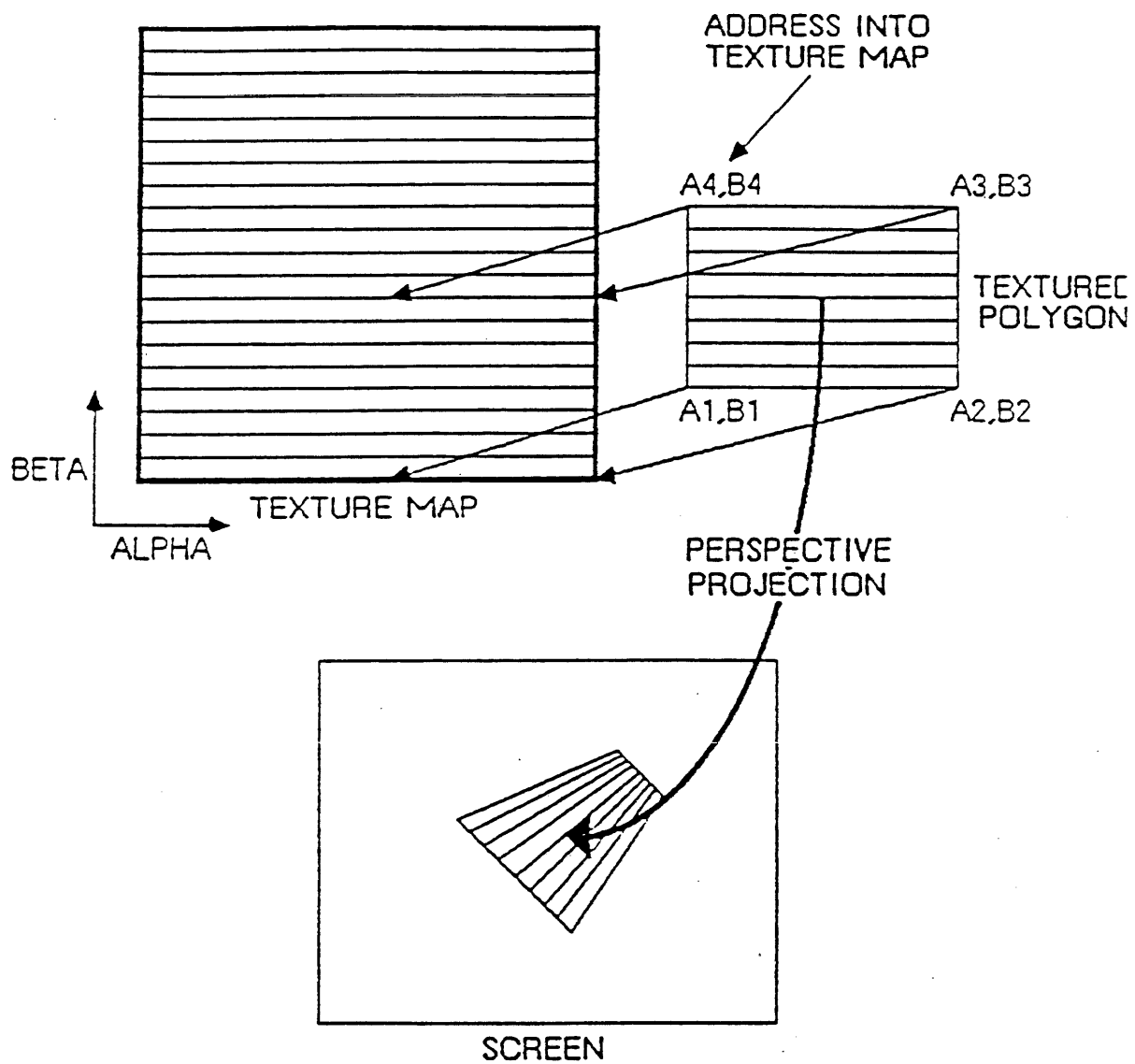
TILING & DEPTH LINEARITY



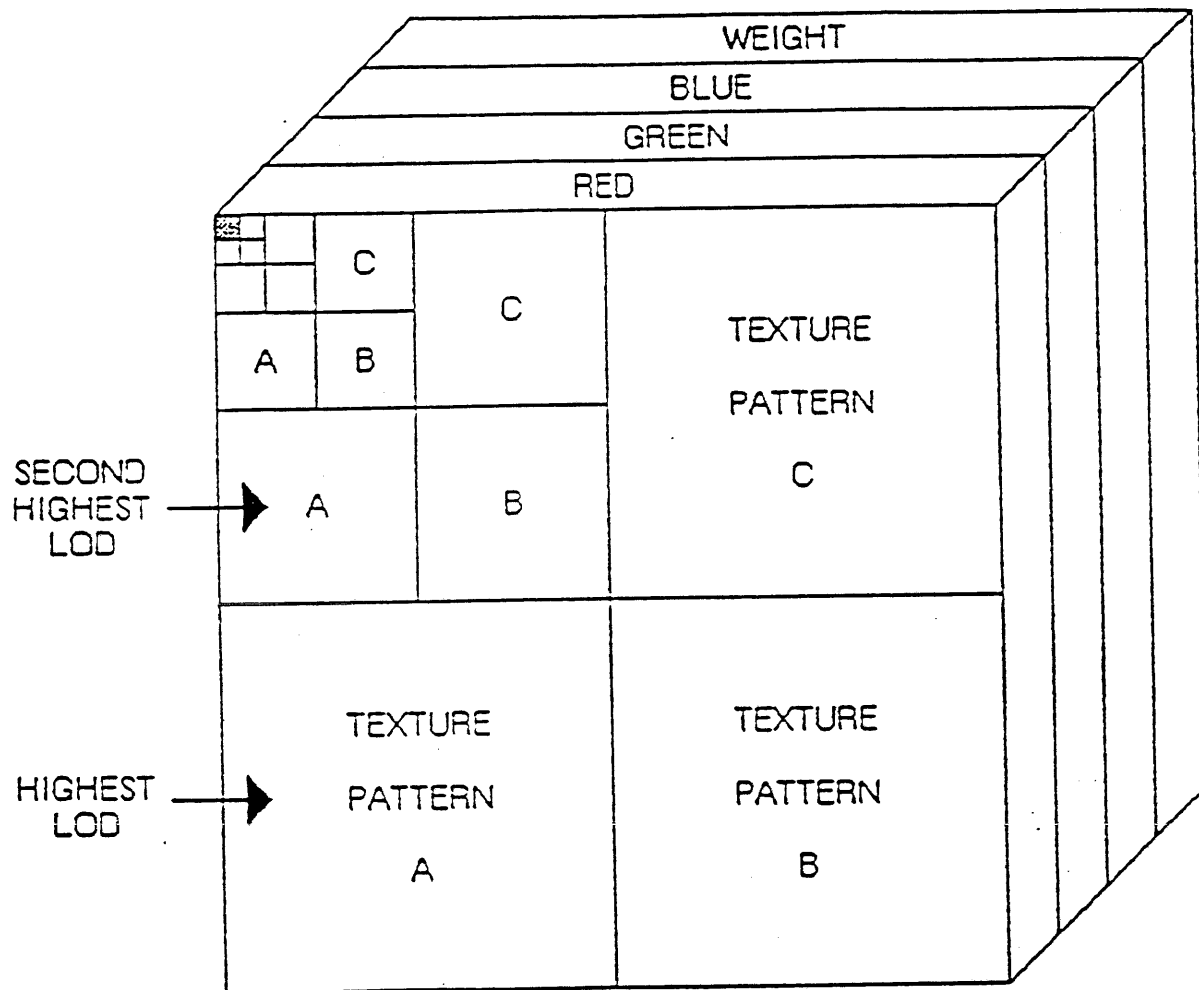
OBJECT IN SCREEN SPACE



PERSPECTIVE TEXTURING



TEXTURE STORAGE & LEVEL OF DETAIL



- ALL TEXTURES ARE PREFILTERED TO REDUCE ALIASING EFFECTS
- LOWER LEVEL OF DETAIL TEXTURES ARE FORMED BY DOWN FILTERING THE HIGHEST LEVEL OF DETAIL TEXTURE



Pixel Processor Memory

Functions

- Hidden surface elimination via hybrid depth buffer
- Color blending for Antialiasing and Transparency
- Sky coloring
- Video output control

Implementation

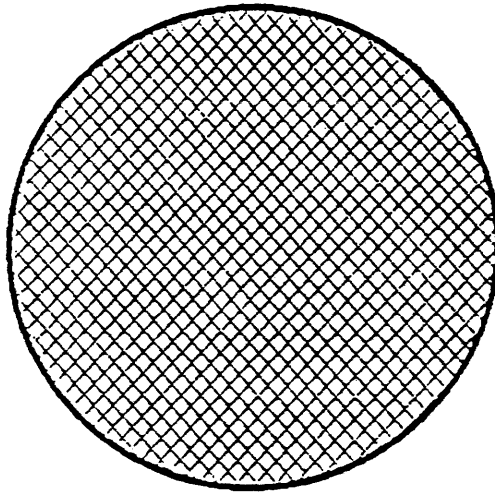
- Double Buffered Frame Stores
- 672 KBytes of Static RAM memory

Specifications

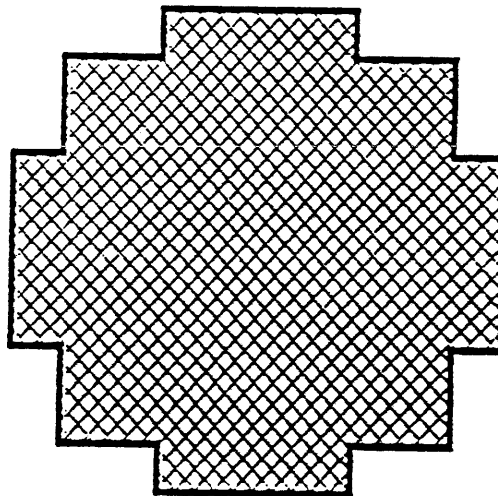
- RS 170 compatible



ALIASING EFFECTS DISCRETE SAMPLING



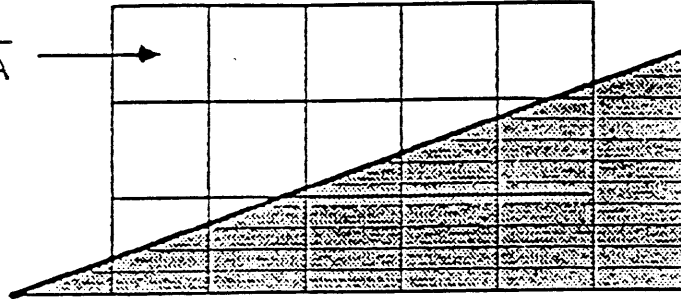
OBJECT WITHOUT ALIASING EFFECTS



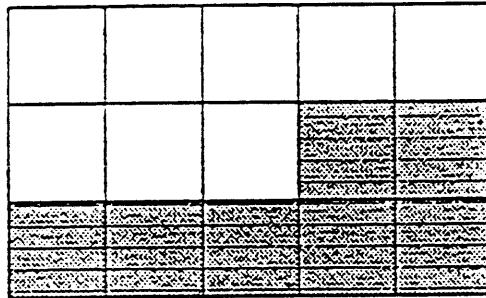
OBJECT SHOWING THE DISCRETE SAMPLING EFFECT

ANTIALIASING

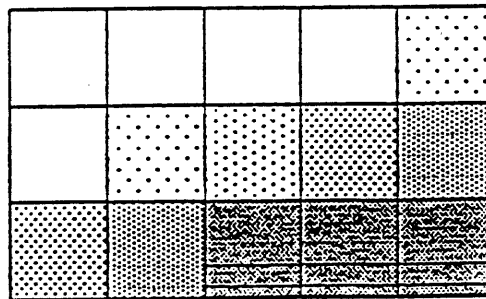
PIXEL
AREA



ACTUAL EDGE CROSSING



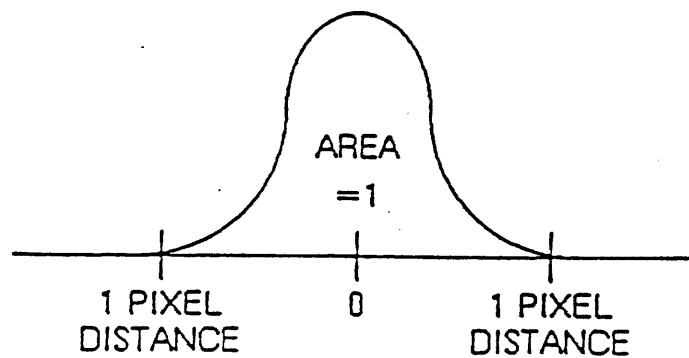
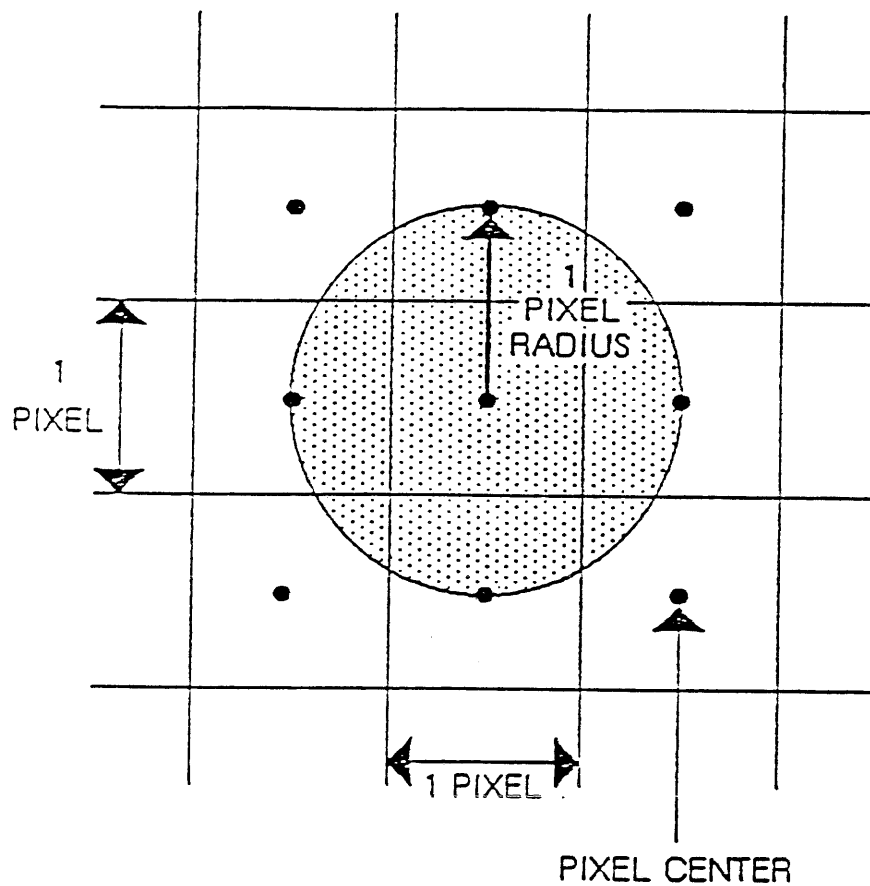
EDGE WITH NO ANTIALIASING



EDGE WITH ANTIALIASING



ANTIALIASING FILTER

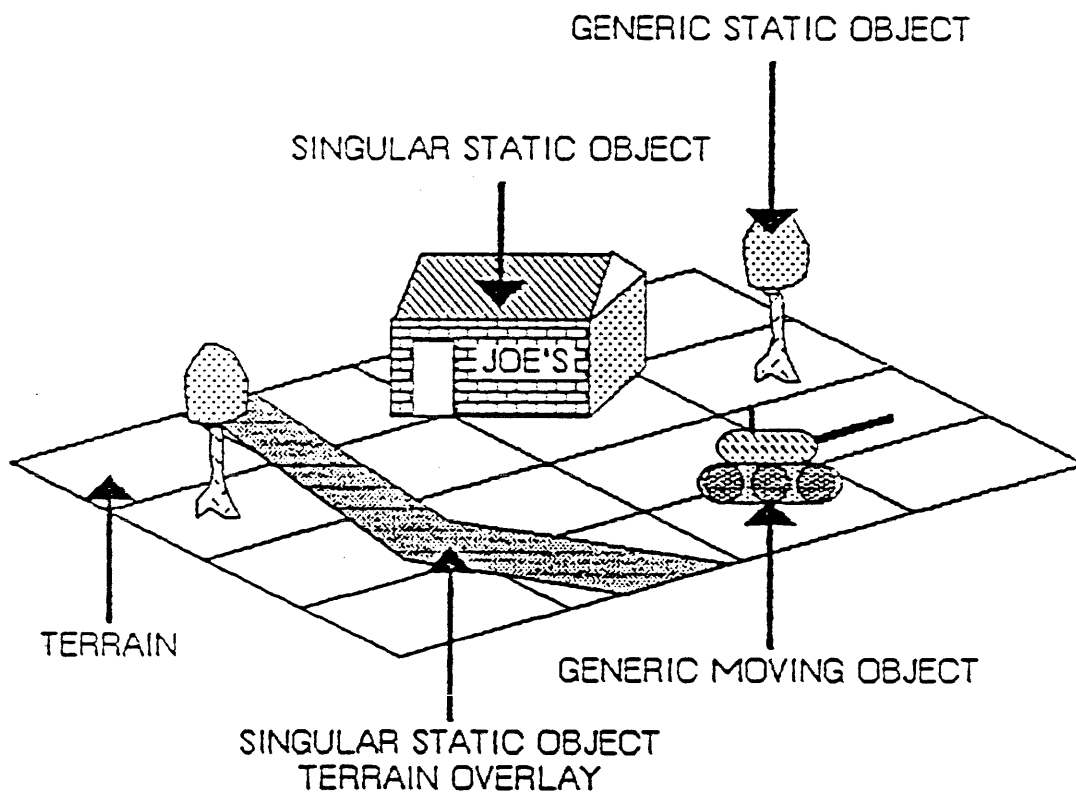


SIMNET OBJECT TYPES

- REAL WORLD TERRAIN GRIDS.
- GENERIC STATIC OBJECTS.
- SINGULAR STATIC OBJECTS.
- TERRAIN OVERLAYS.
- MOVING OBJECTS.
- ROTATED STAMPS.

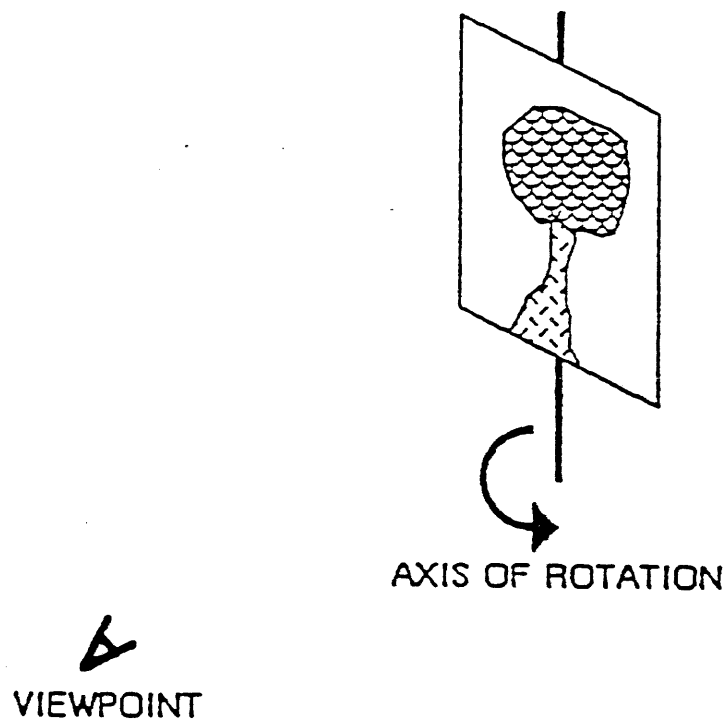


OBJECT DEFINITIONS



STAMPS

- A TEXTURED SURFACE THAT ROTATES TO FACE THE VIEWPOINT



- REDUCES POLYGON COUNT
- ADDS REALISM TO THE SCENE



OBJECTIVES OF DATABASE CONSTRUCTION

- LOWER LIFE CYCLE COSTS
- PROVIDE BROAD UTILIZATION OF SIMULATION SYSTEM
- PROVIDE MAXIMUM IMAGE QUALITY, SCREEN COMPLEXITY AND REALISM ALLOWED BY THE CIG PROCESSOR



CHALLENGES IN DATABASE CONSTRUCTION

- COMBINING DATA OF VARIOUS TYPES AND FORMATS
- MATCHING GAMING AREA DATA TO REAL WORLD COORDINATES
- WORKING WITH LARGE QUANTITIES OF DIVERSE DATA
- MODIFICATION AND ENHANCEMENT OF GAMING AREAS
- COMPRESSING AND FORMATTING DATA TO BUILD
COMPACT RUN-TIME DATABASES



KEY TASKS

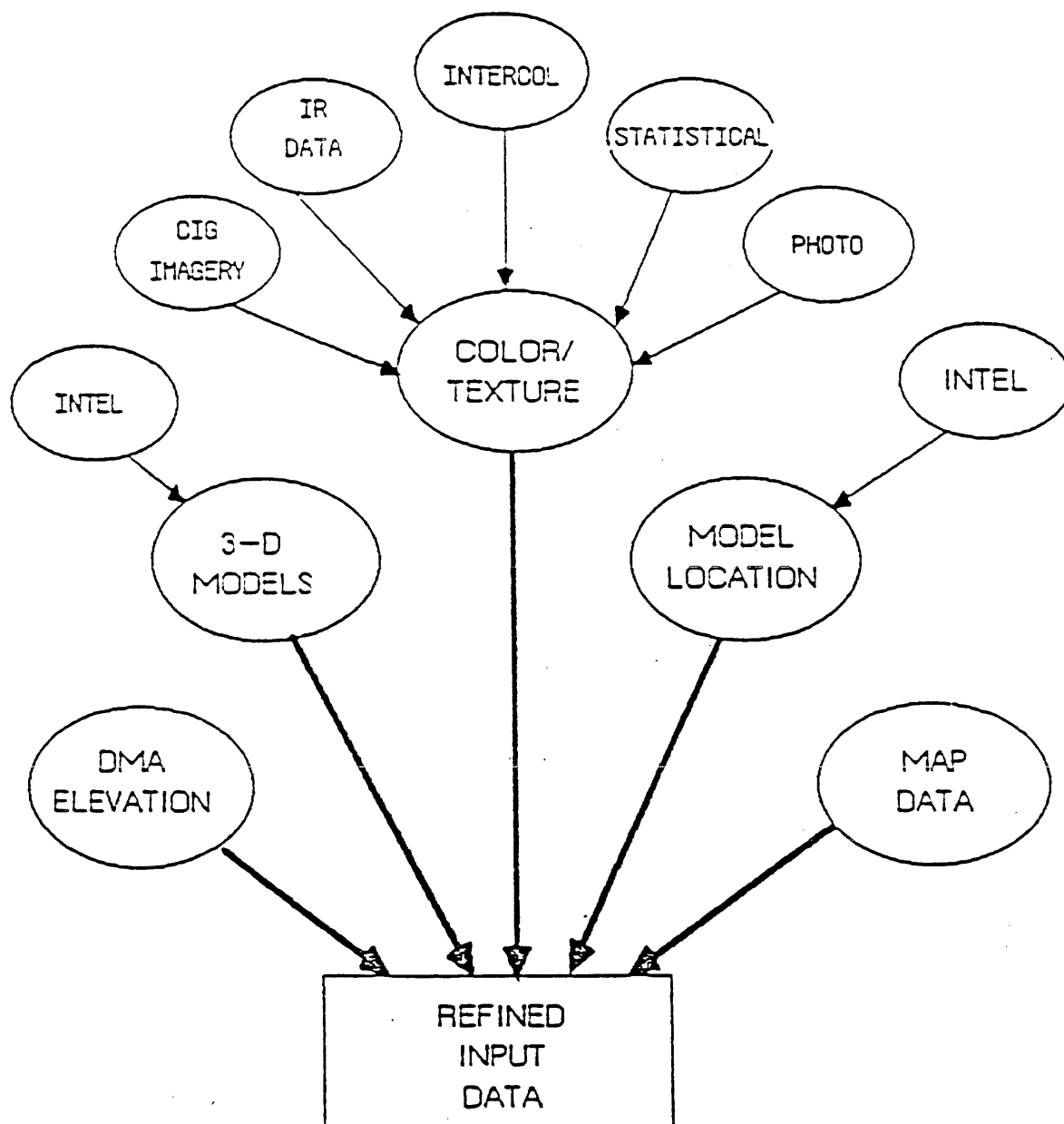
MULTISOURCE DATA INPUT

GAMING AREA CONSTRUCTION

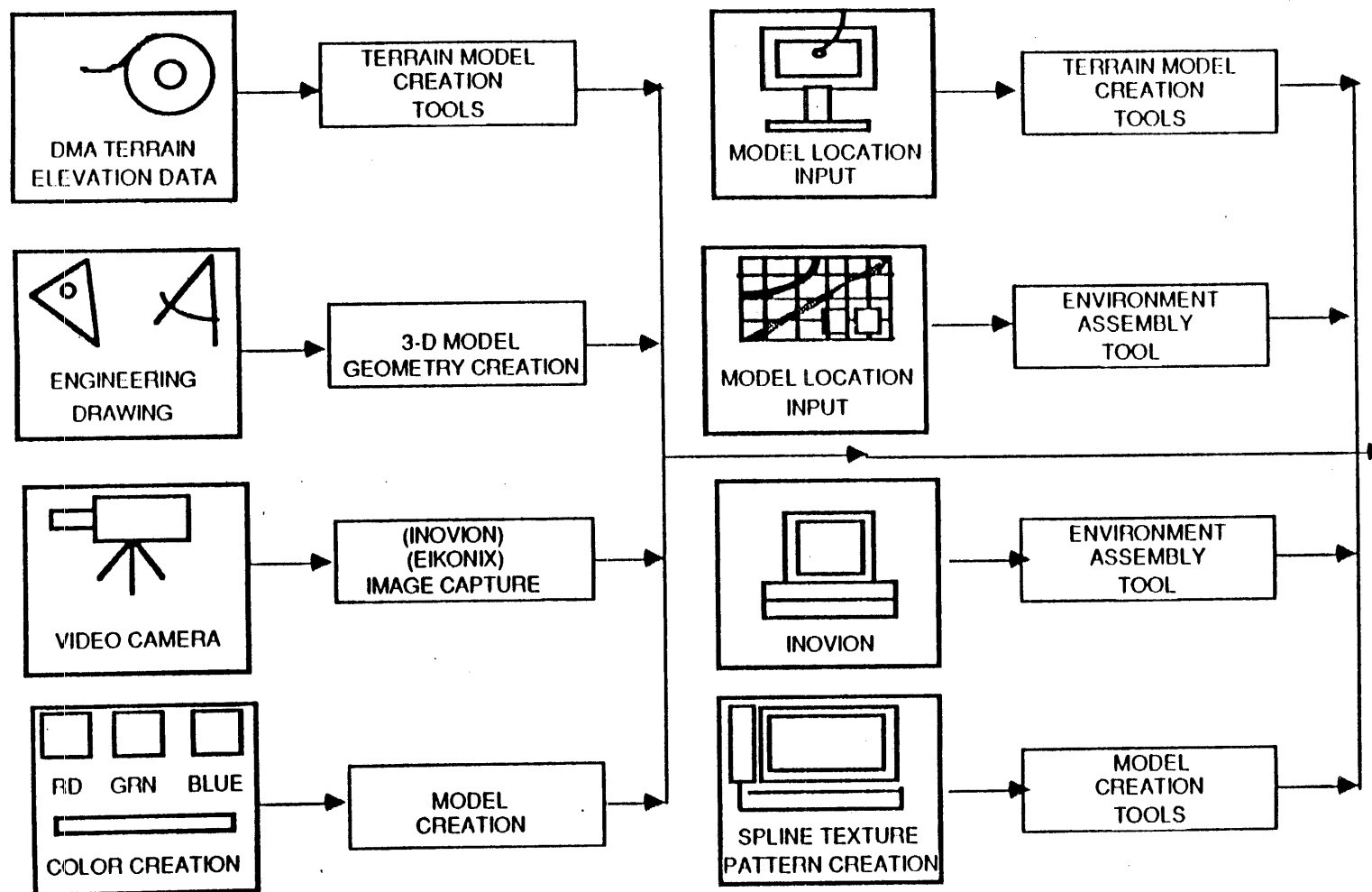
LOAD MODULE CONSTRUCTION



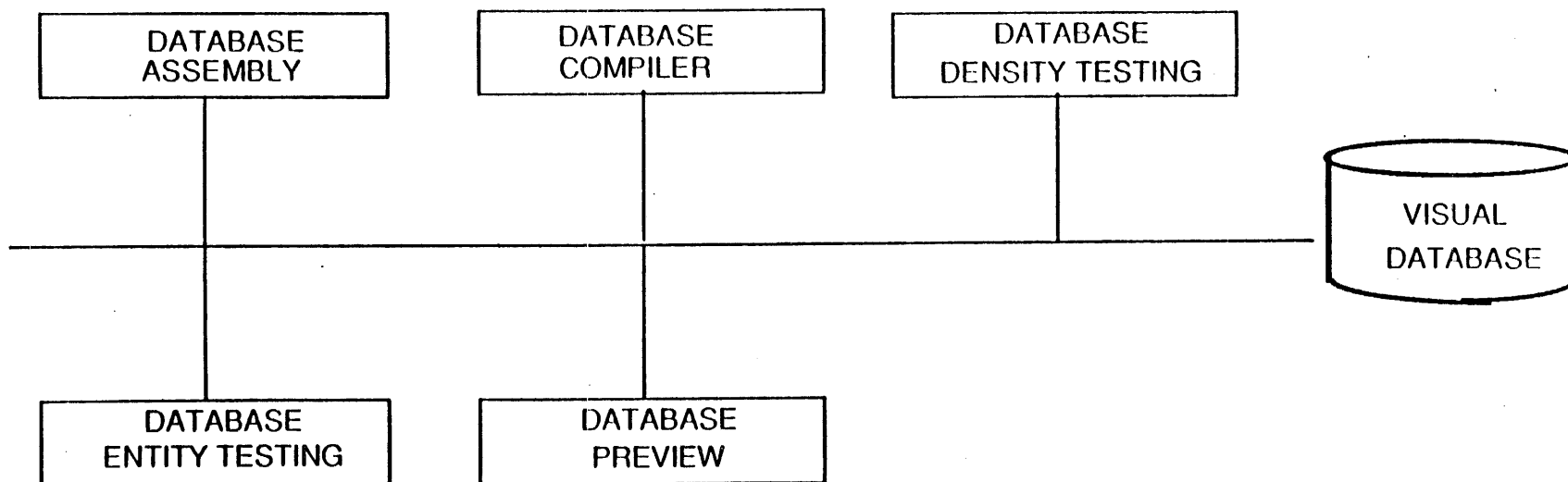
MULTISOURCE DATA INPUT



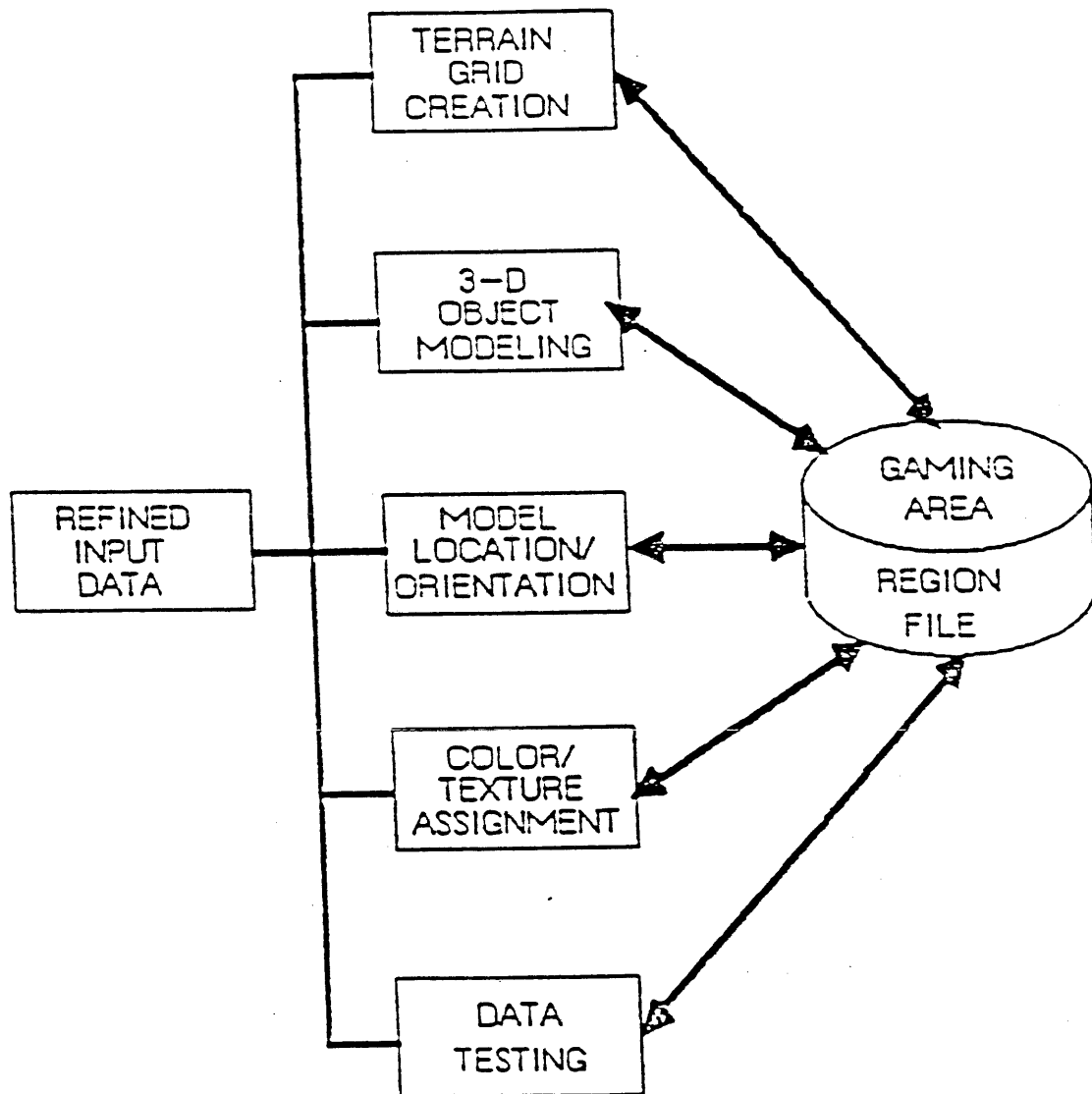
DATABASE CONSTRUCTION PHASE I



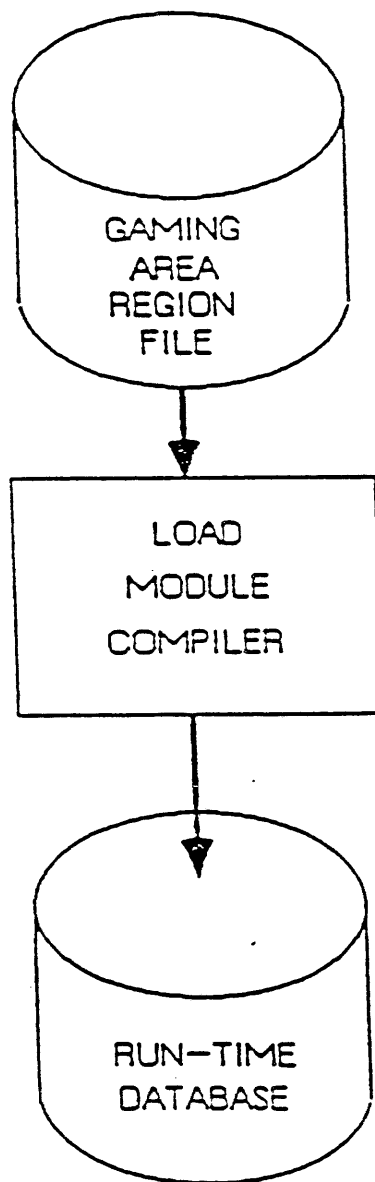
DATABASE CONSTRUCTION PHASE II

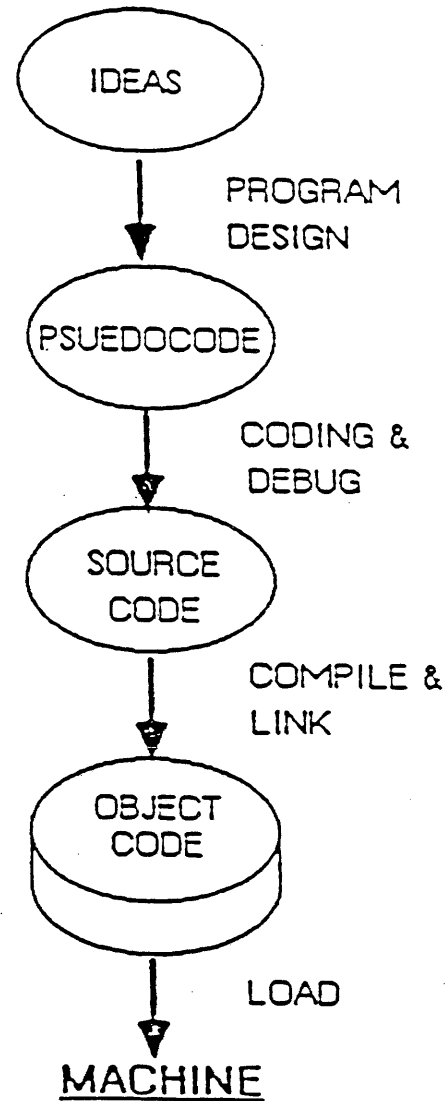
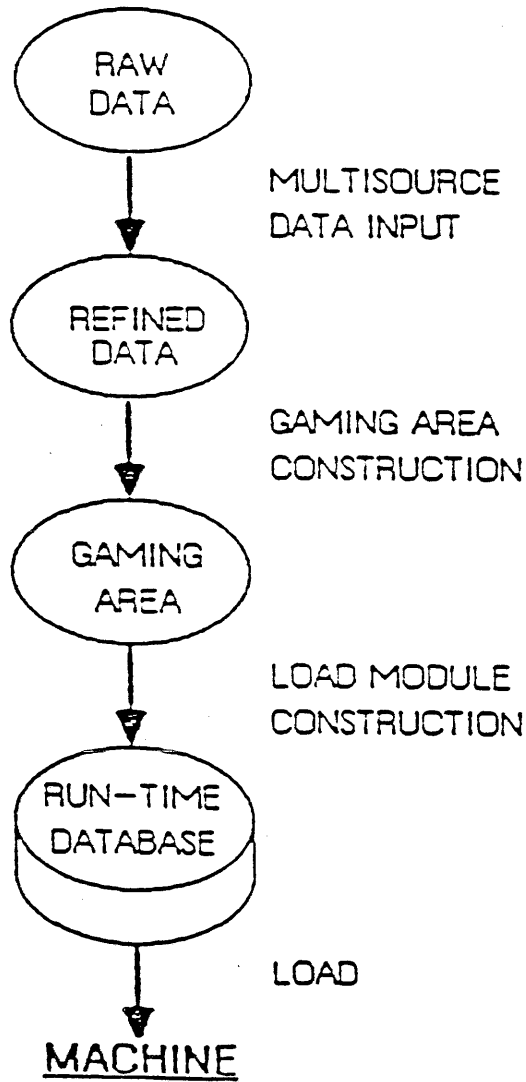
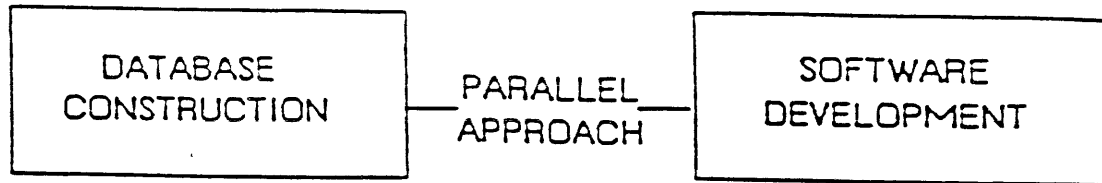


GAMING AREA CONSTRUCTION



LOAD MODULE CONSTRUCTION



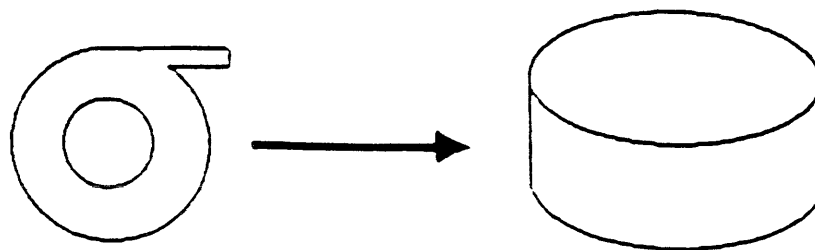


EXAMPLE

DATAPATH - TERRAIN



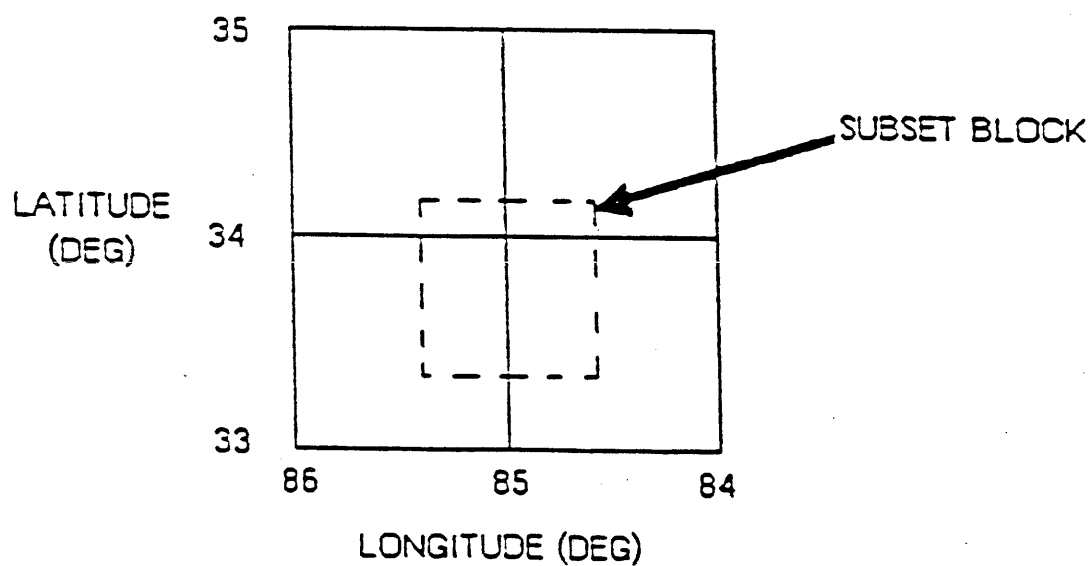
TERRAIN GRID CREATION



STEP 1

READ DMA LEVEL I ELEVATION DATA BLOCKS
FROM TAPE(S) TO DISK.

1° X 1° BLOCK (2.88 MByte)

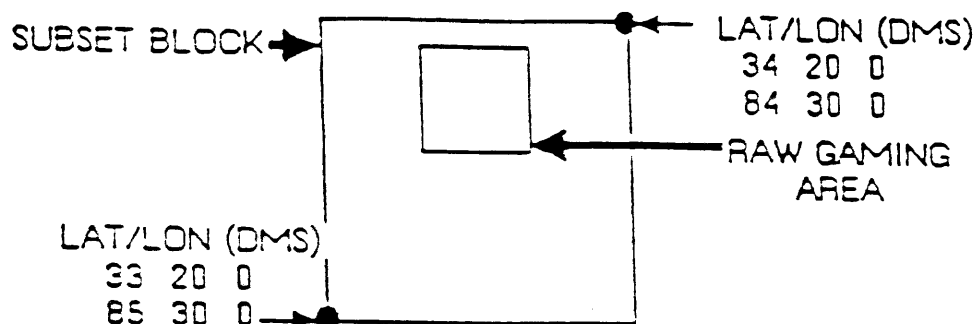


STEP 2

GROUP ADJACENT DMA BLOCKS, AND EXTRACT A
1° X 1° SUBJECT BLOCK SURROUNDING A POTENTIAL
GAMING AREA

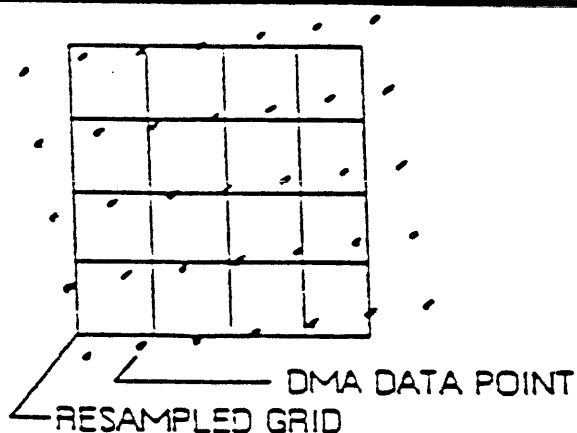


TERRAIN GRID CREATION



STEP 3

EXTRACT RAW GAMING AREA BLOCK OF ELEVATION VALUES, &
CONVERT DATA POINTS: (LATITUDE, LONGITUDE, ELEVATION)
TO
(NORTHING, EASTING, ELEVATION) IN UTM COORDINATES

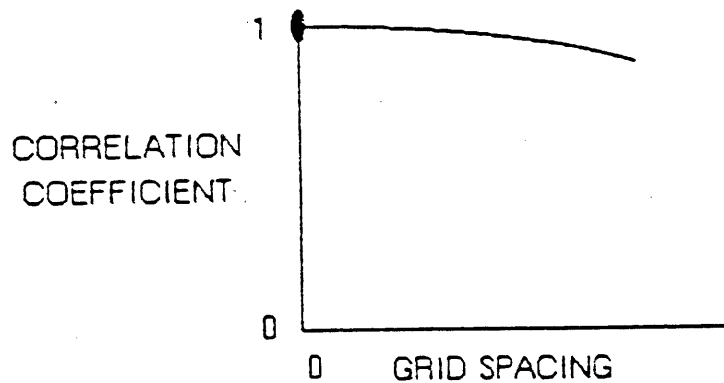


STEP 4

RESAMPLE CONVERTED DMA DATA TO FINAL GAMING AREA
SIZE AT SELECTED GRID SPACING.



TERRAIN GRID CREATION



STEP 5

DATA TESTING

DATA CORRELATION COEFFICIENT

— TO MATCH BASE TERRAIN DATA

SURFACE ROUGHNESS

— TO GAGE POLYGON RELAXATION POTENTIAL

BACKFACE PERCENTAGES

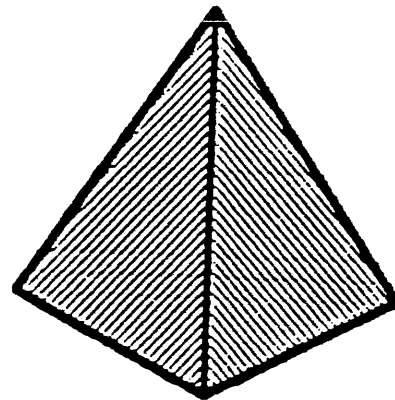
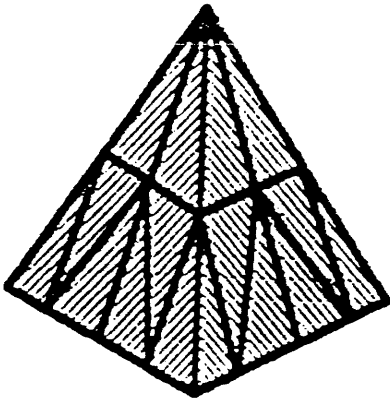
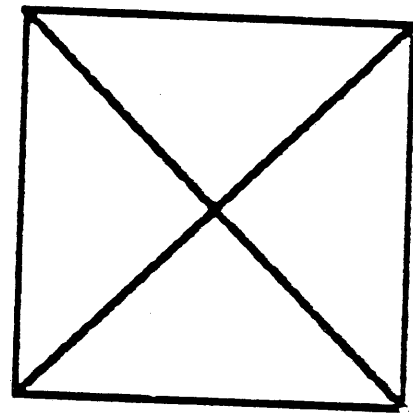
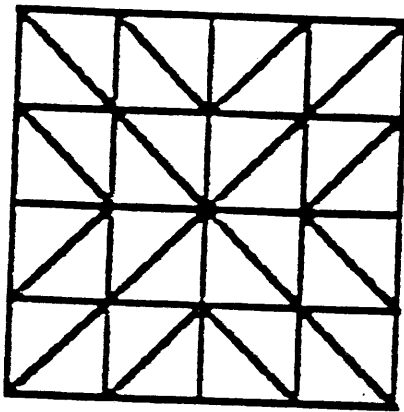
— TO ESTIMATE MODEL DATA DENSITIES



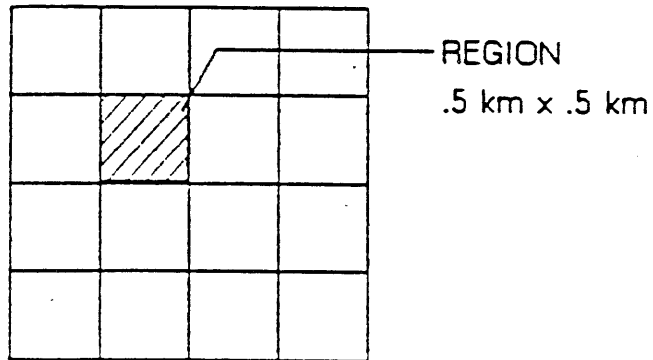
TERRAIN GRID CREATION

STEP 6

POLYGON RELAXATION



TERRAIN GRID CREATION



GAMING AREA (50 km x 50 km)

STEP 7

RESTRUCTURE GRID ARRAY INTO INDEPENDANT TERRAIN
REGIONS (10,000 REGIONS)



STEP 8

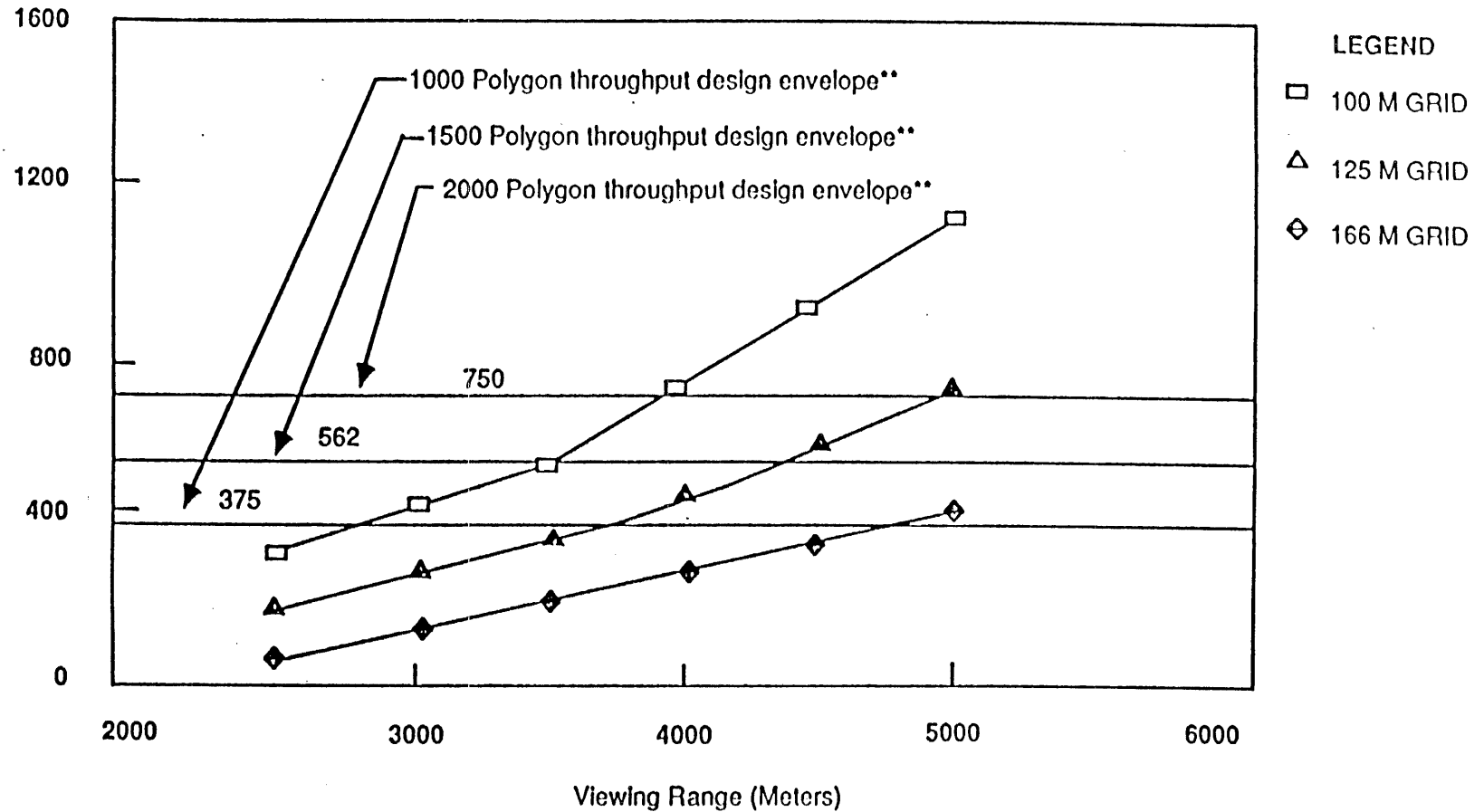
STORE TERRAIN REGIONS INTO GAMING AREA REGION FILE
(3.6 MBytes)



TERRAIN MODEL POLYGON COUNT VS VIEWING RANGE

30° FIELD OF VIEW ANGLE

POLYGON COUNT



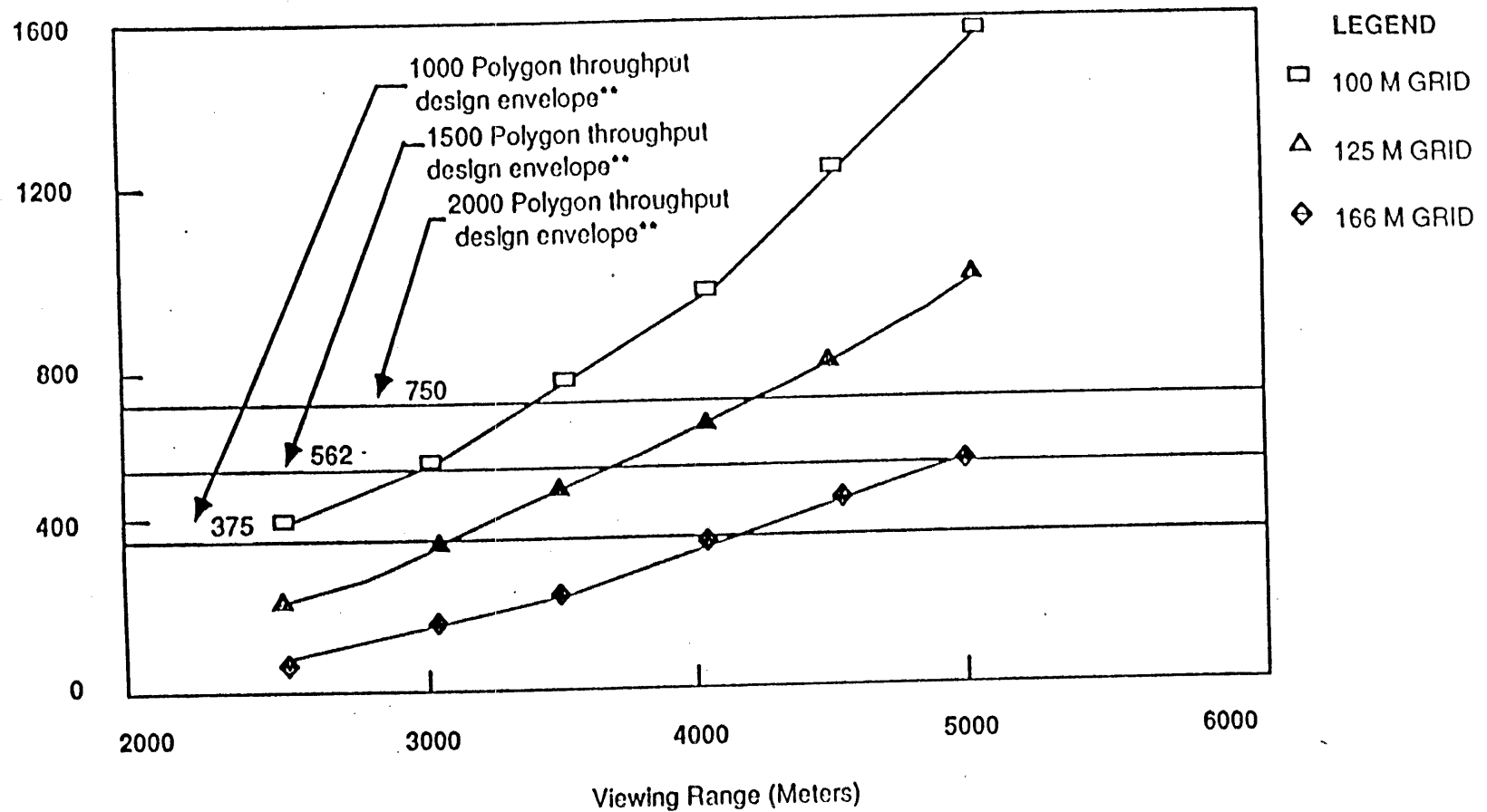
- 20% Polygon Relaxation
- ** 20% Backface Elimination



TERRAIN MODEL POLYGON COUNT VS VIEWING RANGE

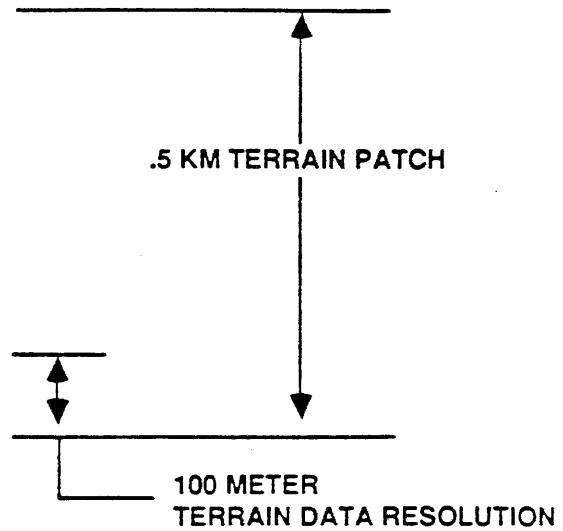
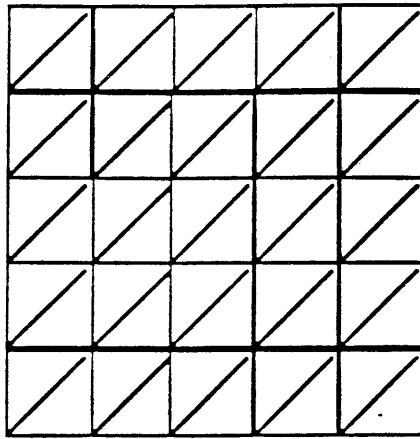
40° FIELD OF VIEW ANGLE

POLYGON COUNT

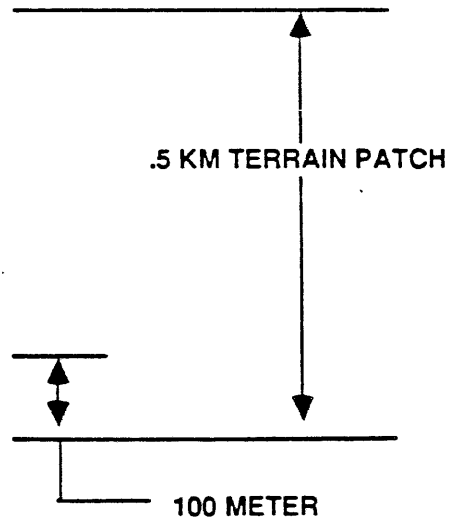
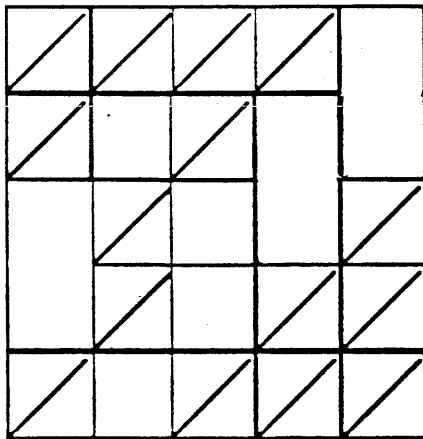


- * 20% Polygon Relaxation
- ** 20% Backface Elimination





TRIANGULATED TERRAIN GEOMETRY MODEL
(POLYGON COUNT = 50 POLYGONS)



RELAXED TERRAIN GEOMETRY MODEL
(POLYGON COUNT = 34)

NOTE: 32% GROSS POLYGON REDUCTION

