SIMNET
COMPUTER
IMAGE
GENERATION
SYSTEM

1987

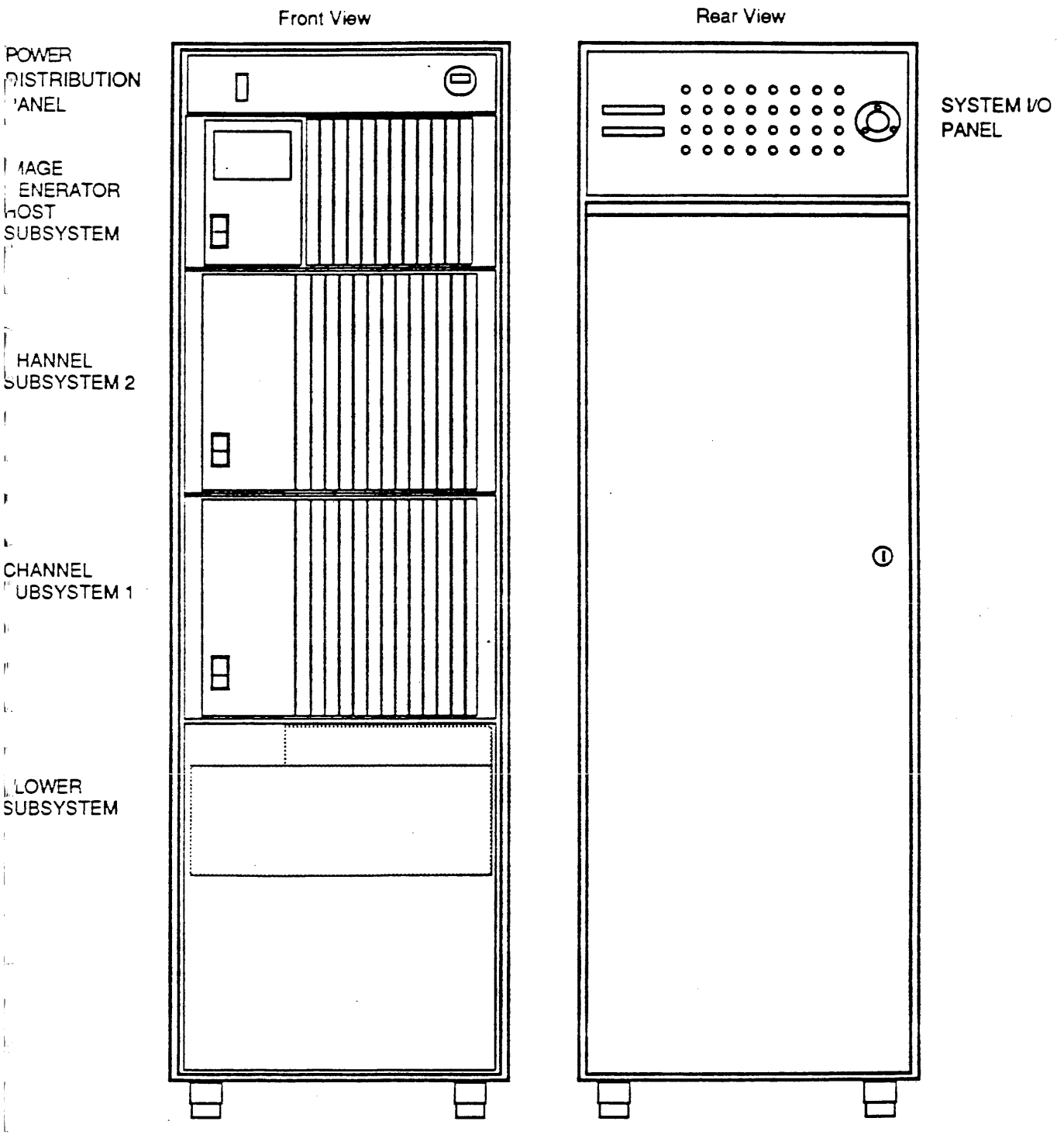
MICHAEL L. CYRUS

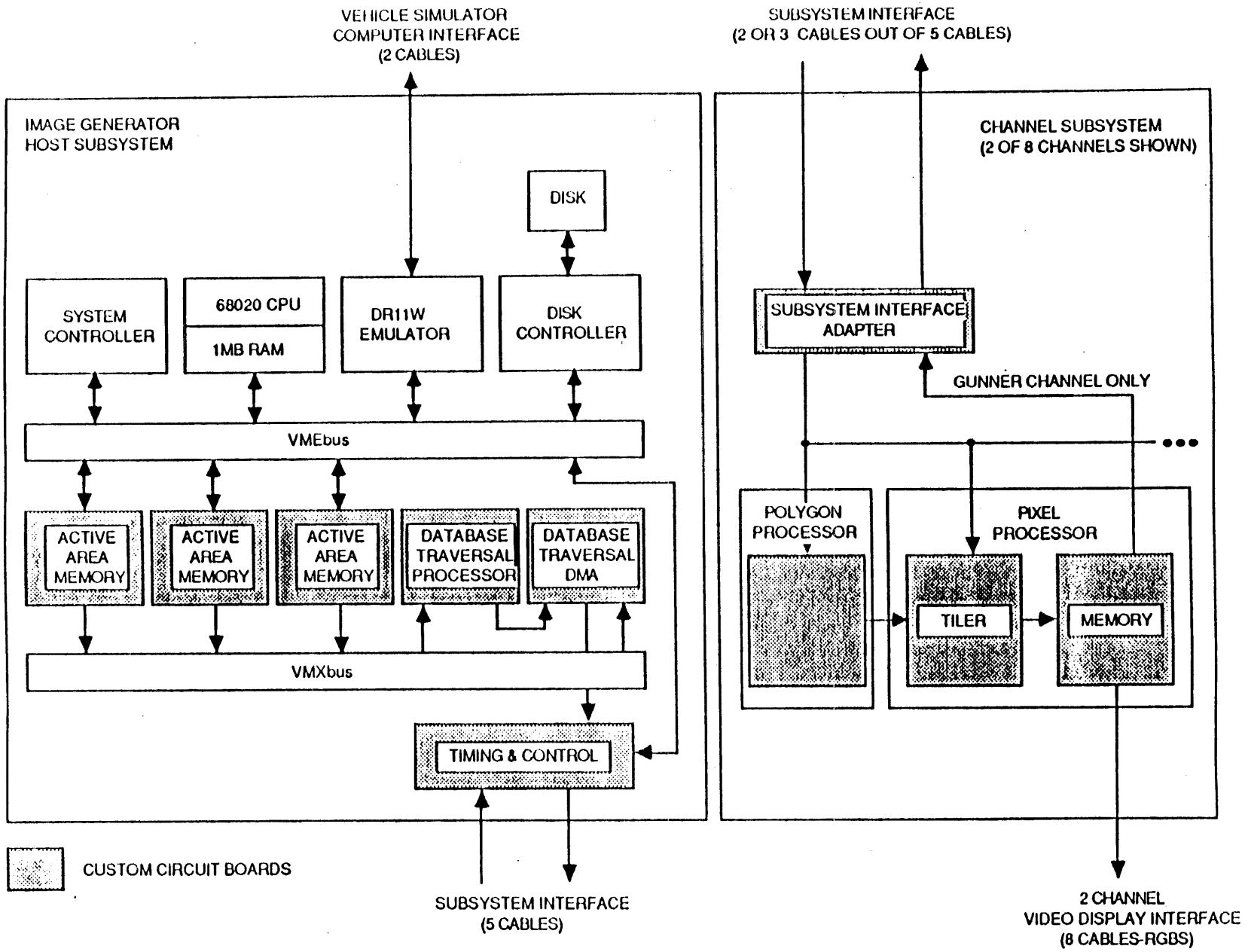
BBN Delta Graphics Inc.

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




VEHICLE SIMULATOR
COMPUTER INTERFACE
(2 CABLES)
SUBSYSTEM INTERFACE
(2 OR 3 CABLES OUT OF 5 CABLES)
IMAGE GENERATOR
HOST SUBSYSTEM
CHANNEL SUBSYSTEM
(2 OF 8 CHANNELS SHOWN)
DISK
SYSTEM
CONTROLLER
68020 CPU
1MB RAM
DR11W
EMULATOR
DISK
CONTROLLER
SUBSYSTEM INTERFACE
ADAPTER
GUNNER CHANNEL ONLY
VMEbus
ACTIVE
AREA
MEMORY
ACTIVE
AREA
MEMORY
ACTIVE
AREA
MEMORY
DATABASE
TRAVERSAL
PROCESSOR
DATABASE
TRAVERSAL
DMA
POLYGON
PROCESSOR
PIXEL
PROCESSOR
TILER
MEMORY
VMXbus
TIMING & CONTROL
CUSTOM CIRCUIT BOARDS
SUBSYSTEM INTERFACE
(5 CABLES)
2 CHANNEL
VIDEO DISPLAY INTERFACE
(8 CABLES-RGBS)

BBN Delta Graphics, Inc.

DELTA SimNet CIG System Performance Parameters

PARAMETER	CIG SYSTEM
Independent Viewing Channels	Up to 8
Occulting 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 Compatable.

ACTIVE AREA MEMORY

FUNCTIONS

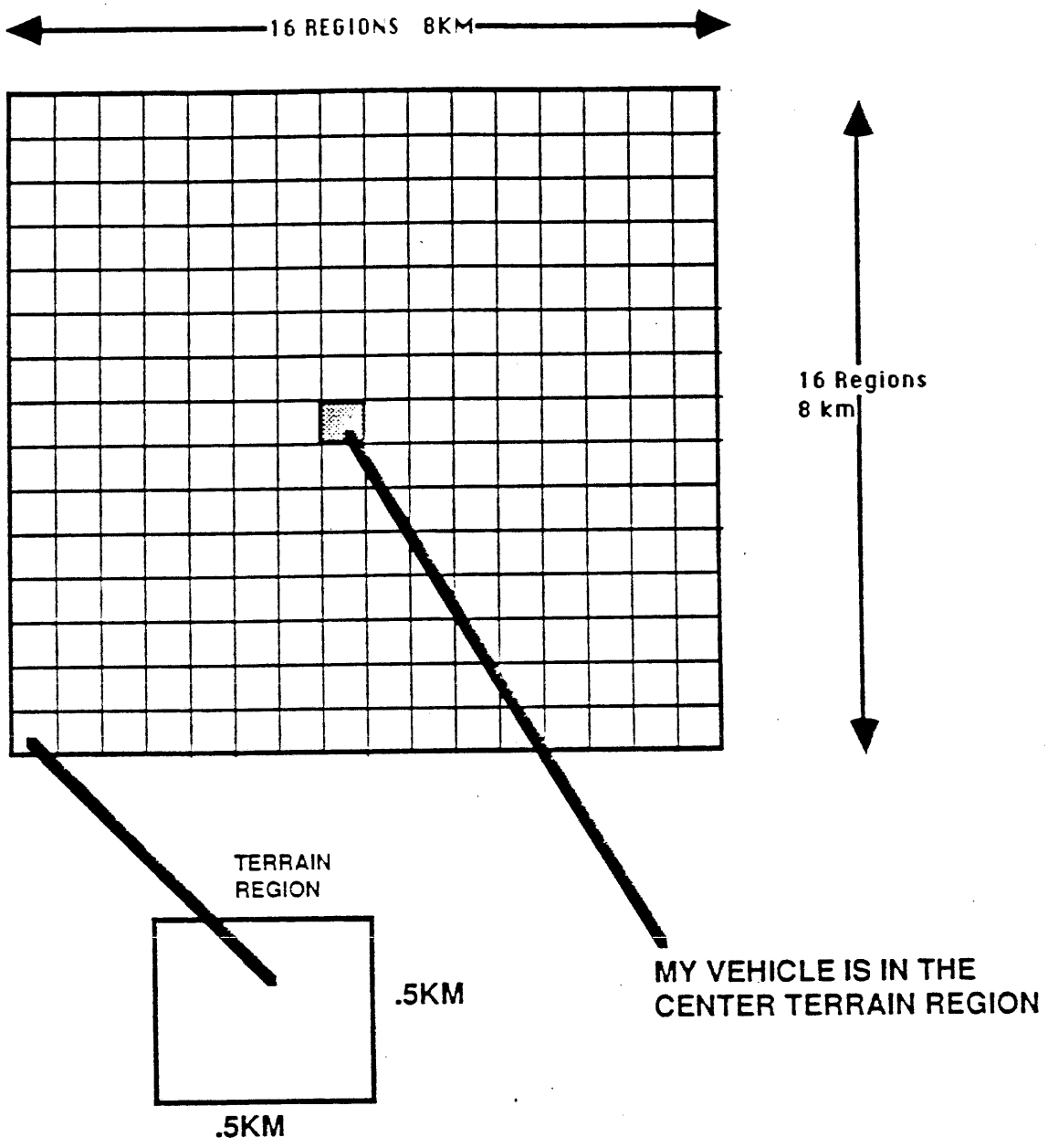
- 8 KILOMETER SQUARE OF ACTIVE AREA MEMORY
- VEHICLE POSITION INFORMATION IN DOUBLE BUFFERED MEMORY
- GENERIC OBJECT DATA STORAGE

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

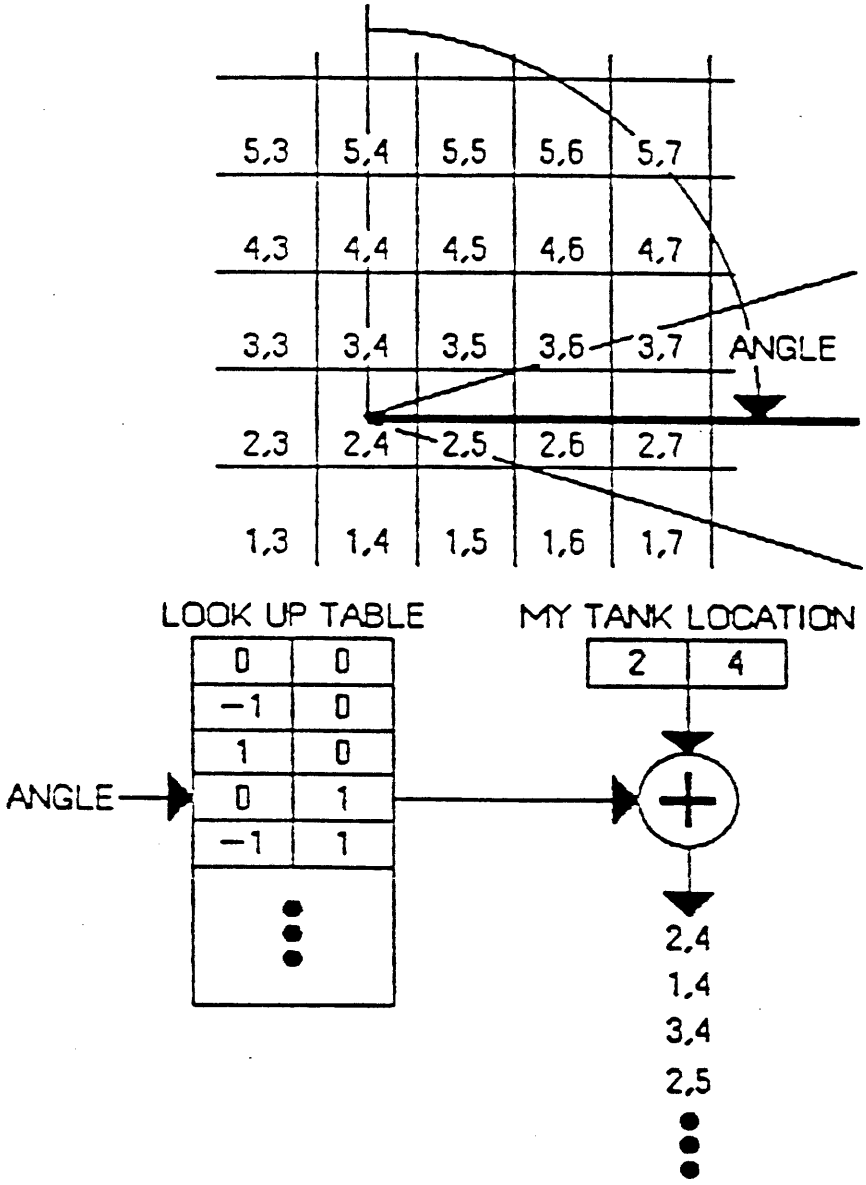
IMPLEMENTATION

- 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

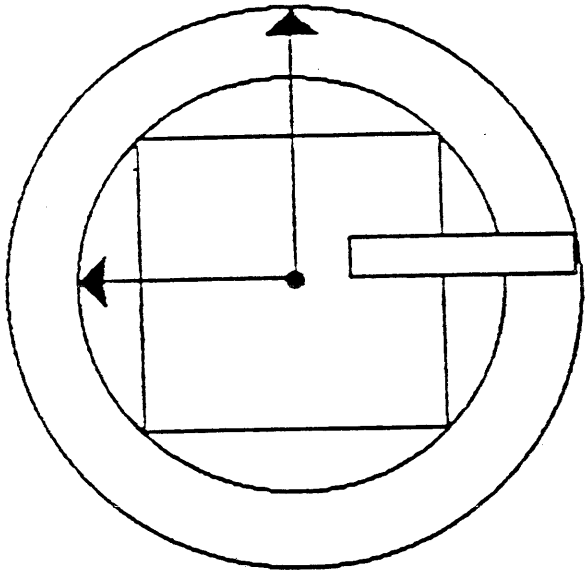
PRELIMINARY FIELD OF VIEW TEST



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

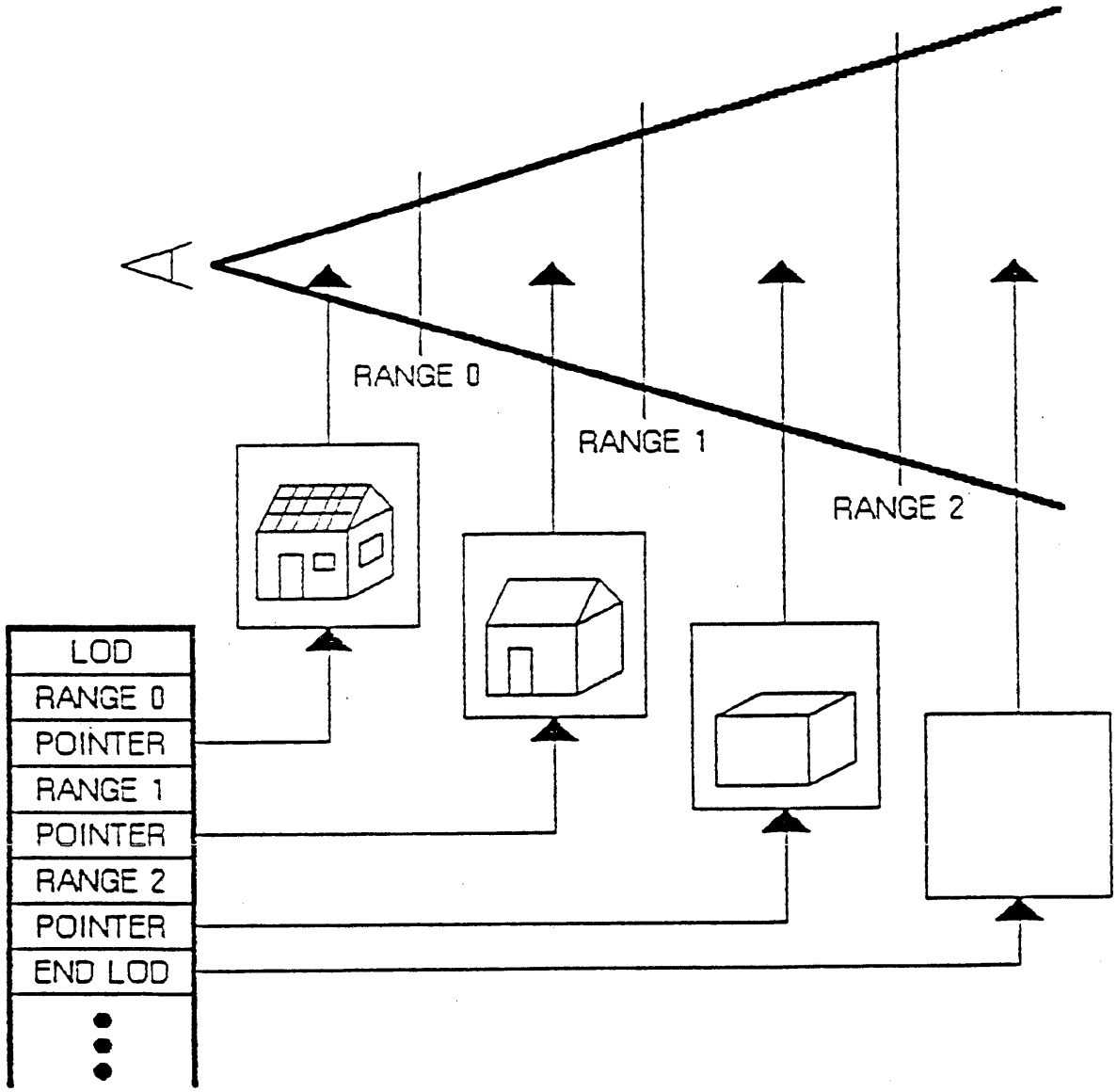
DETAILED
FIELD OF VIEW TEST

- 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

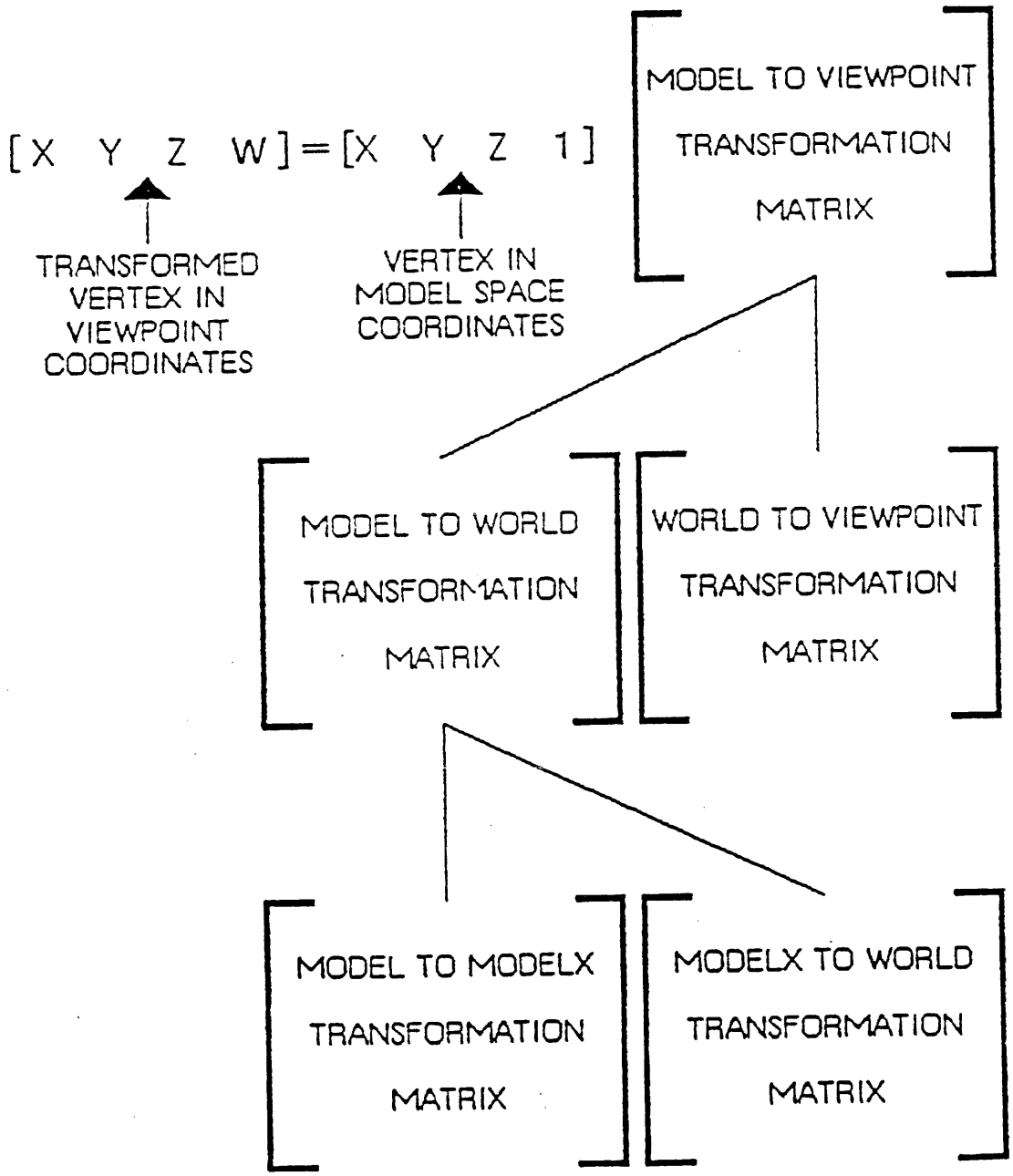
IMPLEMENTATION

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

SPECIFICATIONS

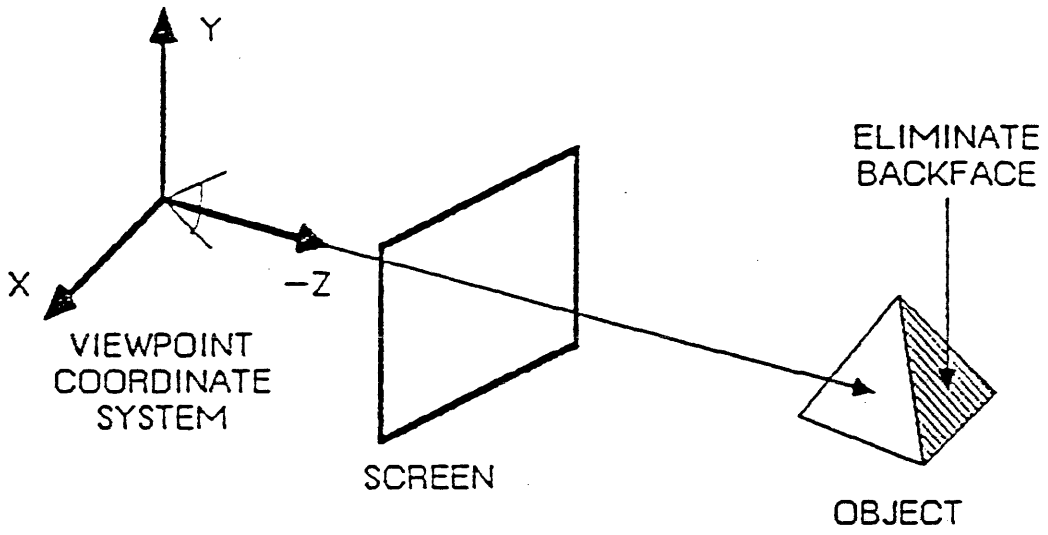
- 30,000 POTENTIALLY VISIBLE 4 SIDED TEXTURED POLYGONS PER SECOND
- 40 MFLOPS TOTAL PROCESSING POWER

VIEWPOINT TRANSFORMATION

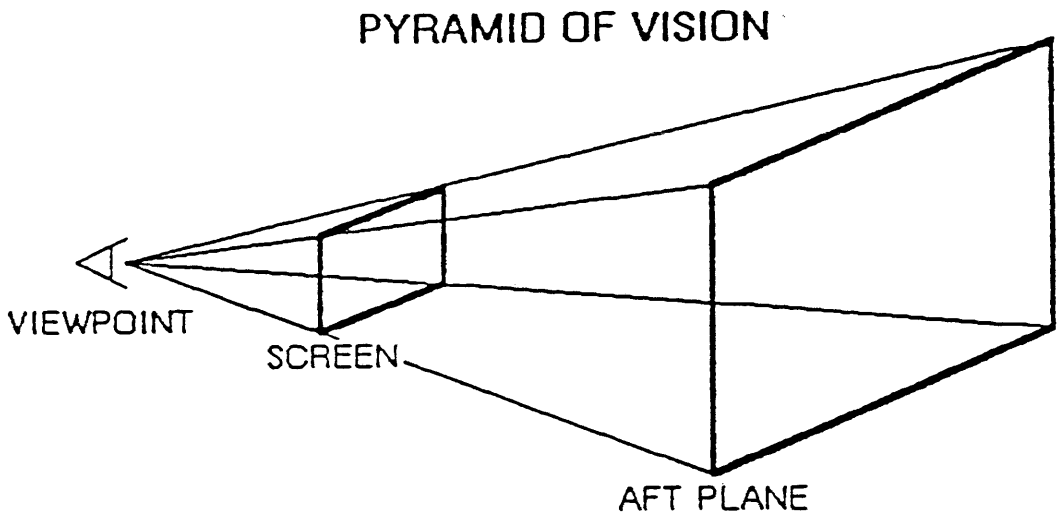


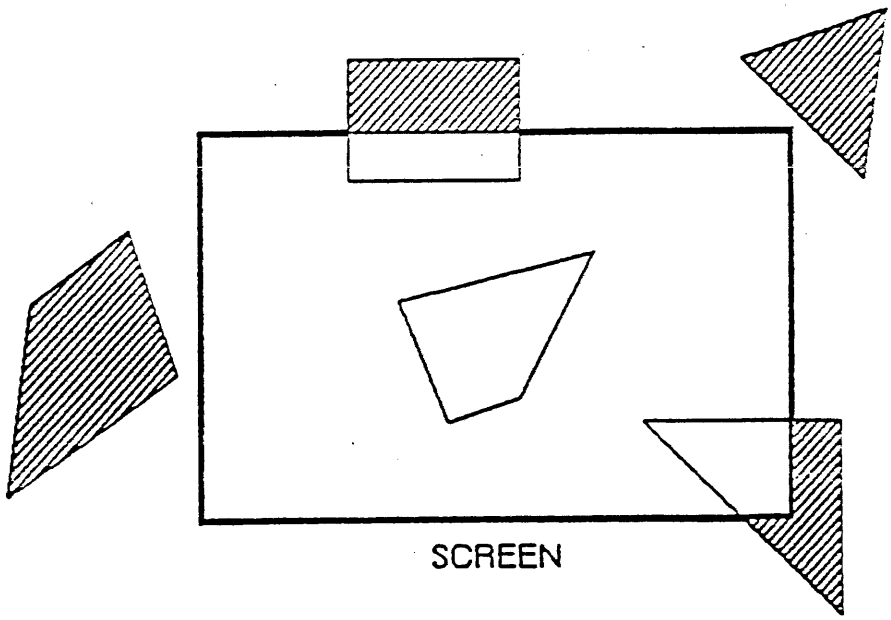
BACKFACE ELIMINATION &

VIEWPOINT TRANSFORMATION

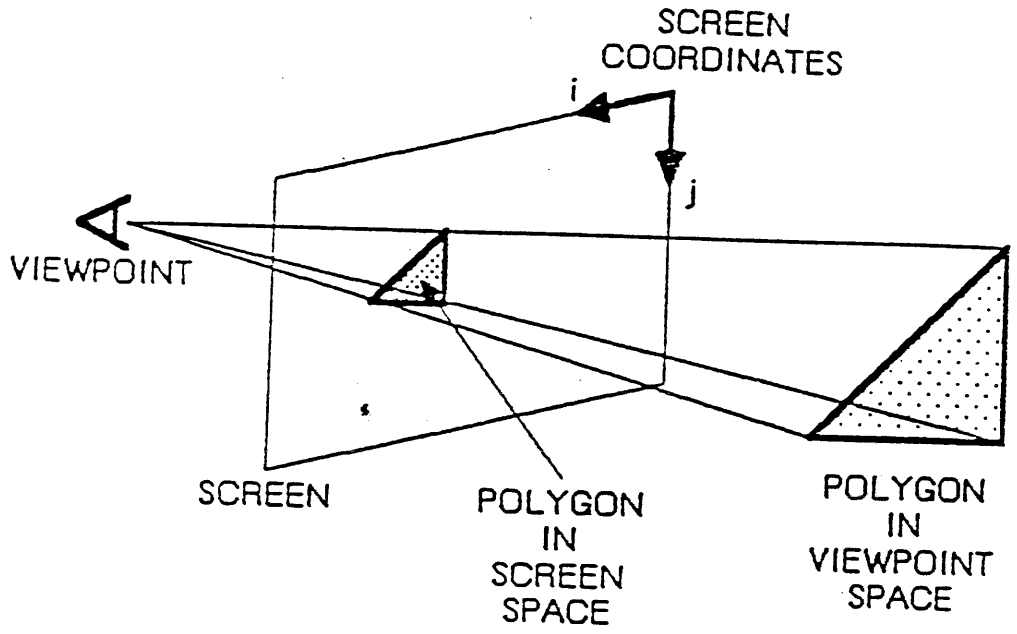


CLIPPING





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

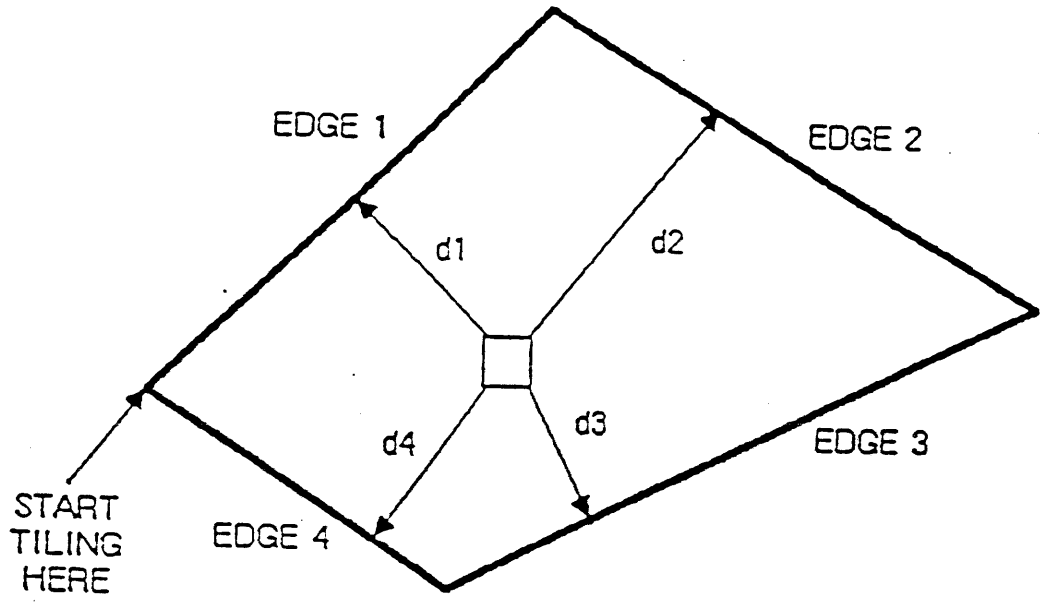
Implementation

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

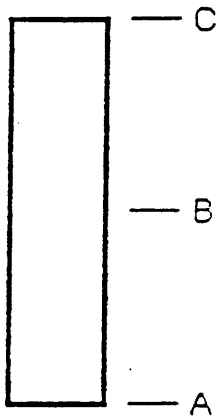
Specifications

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

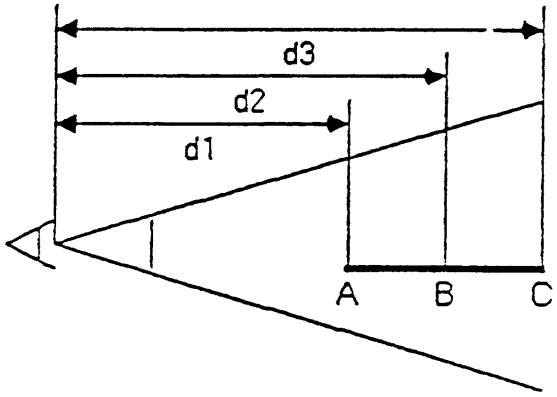
TILING



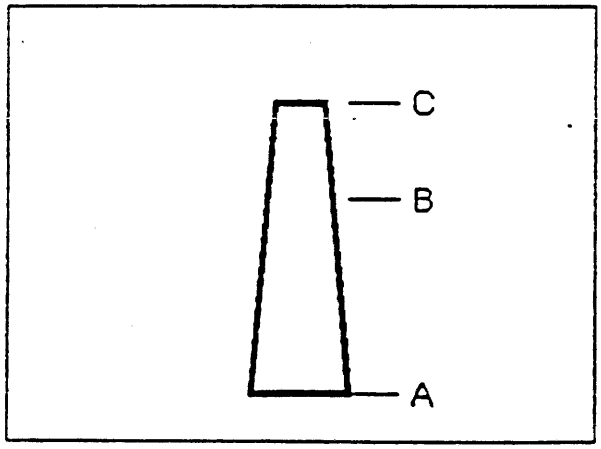
TILING & DEPTH LINEARITY



TOP VIEW OF OBJECT

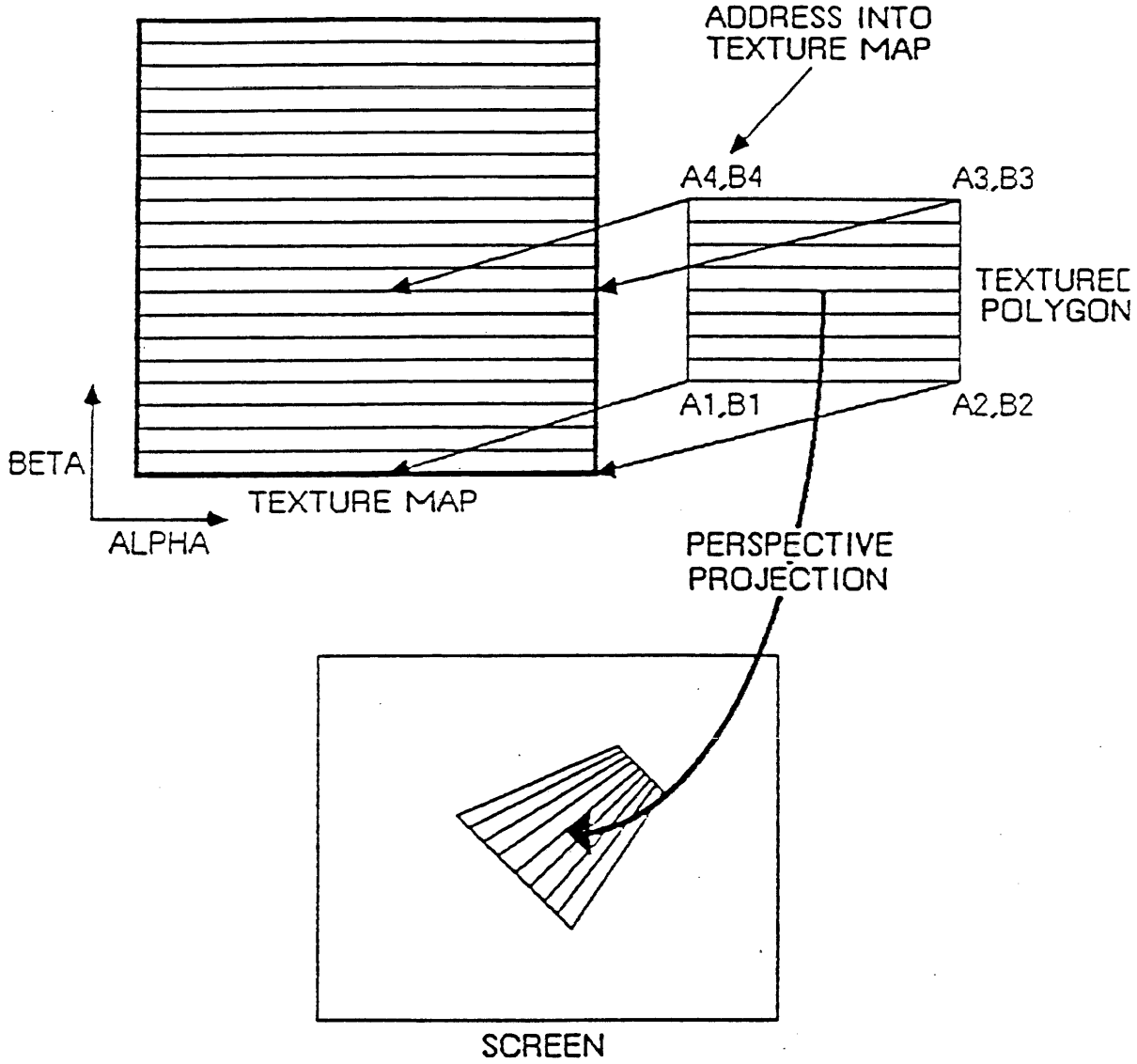


CROSS SECTION OF THE
OBJECT IN THE FIELD OF VIEW

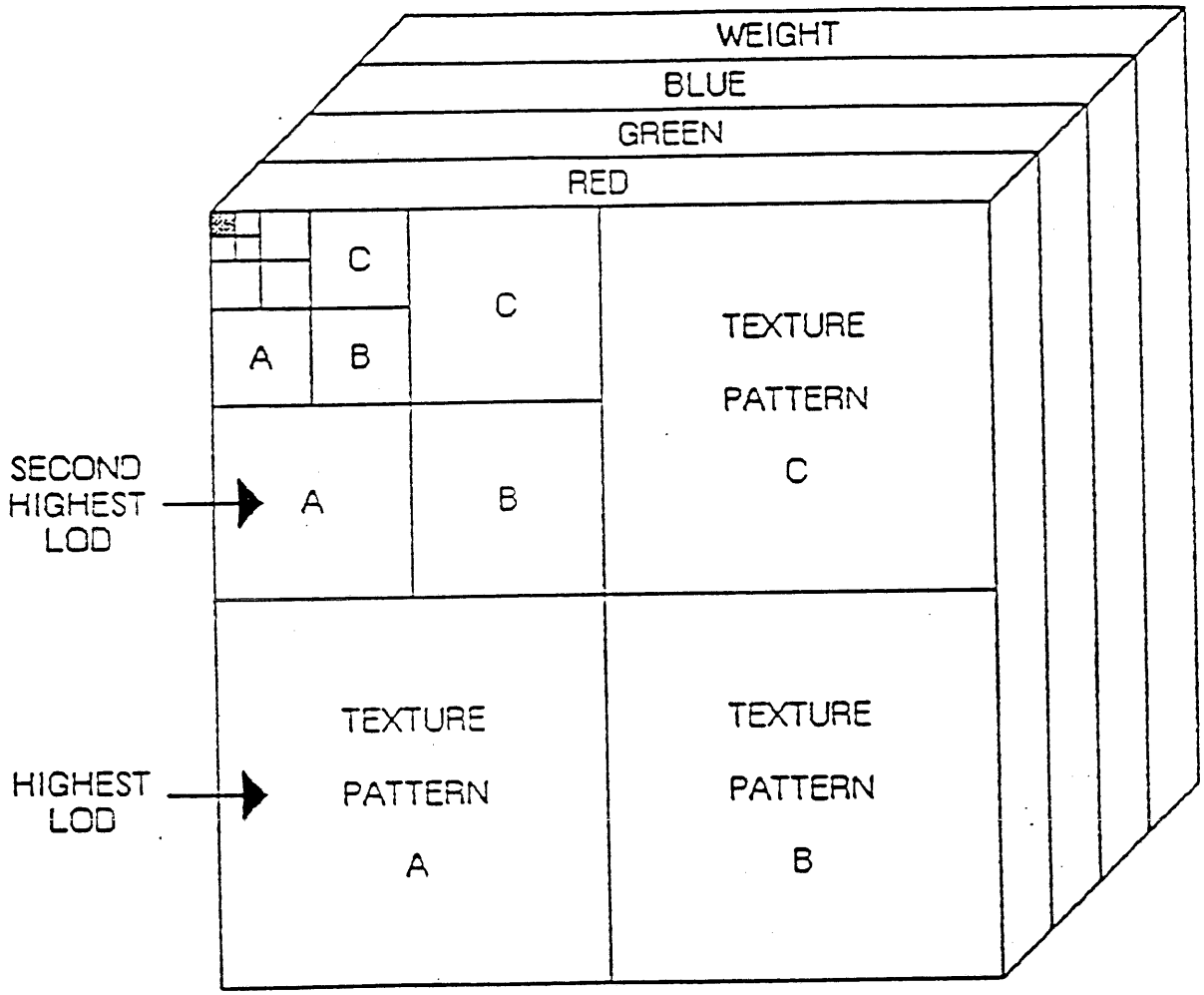


OBJECT IN SCREEN SPACE

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

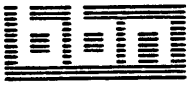
- Hidden surface elimination via hybrid depth buffer
- Color blending for Antialiasing and Transparency
- Sky coloring
- Video output control

Implementation

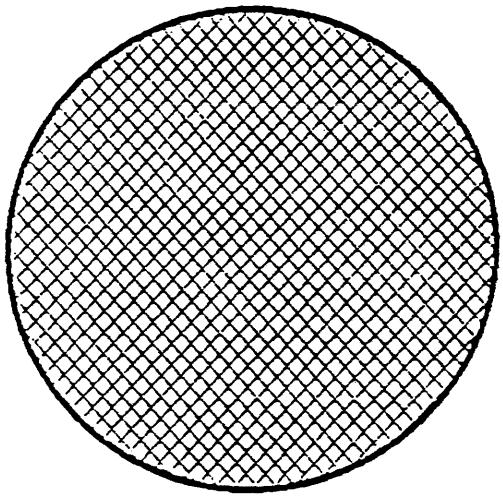
- Double Buffered Frame Stores
- 672 KBytes of Static RAM memory

Specifications

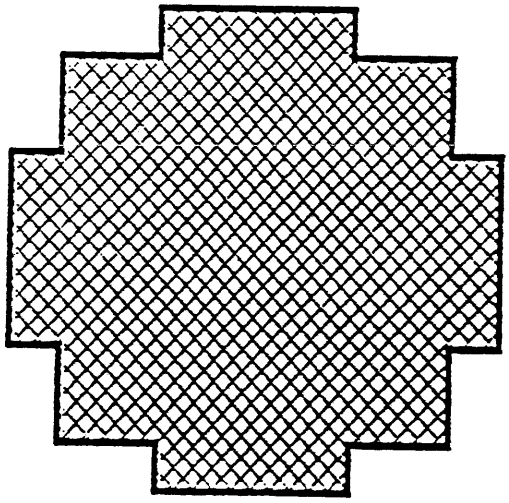
- RS 170 compatable



ALIASING EFFECTS
DISCRETE SAMPLING



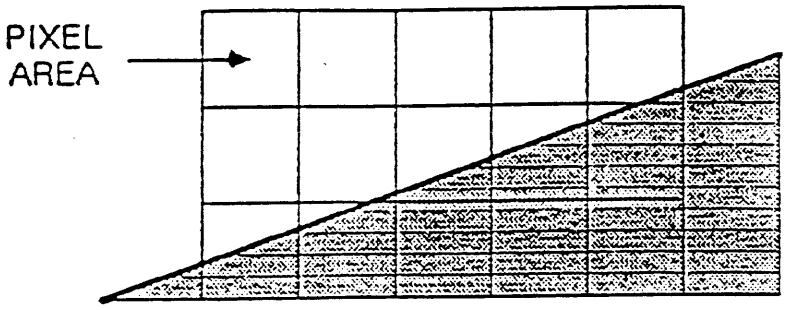
OBJECT WITHOUT ALIASING EFFECTS



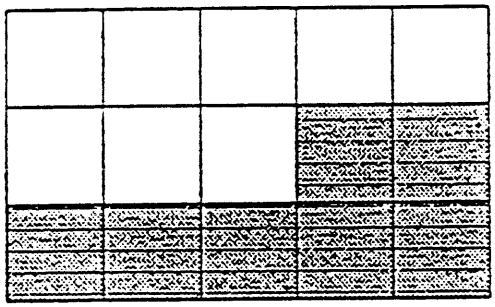
OBJECT SHOWING THE DISCRETE SAMPLING EFFECT

BBN Delta Graphics Inc.

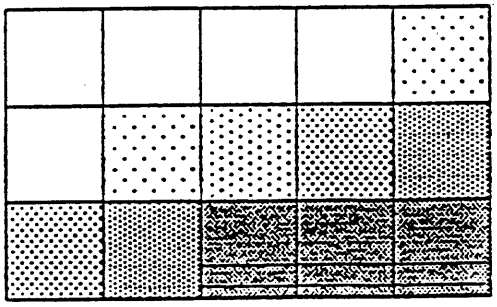
ANTIALIASING



ACTUAL EDGE CROSSING

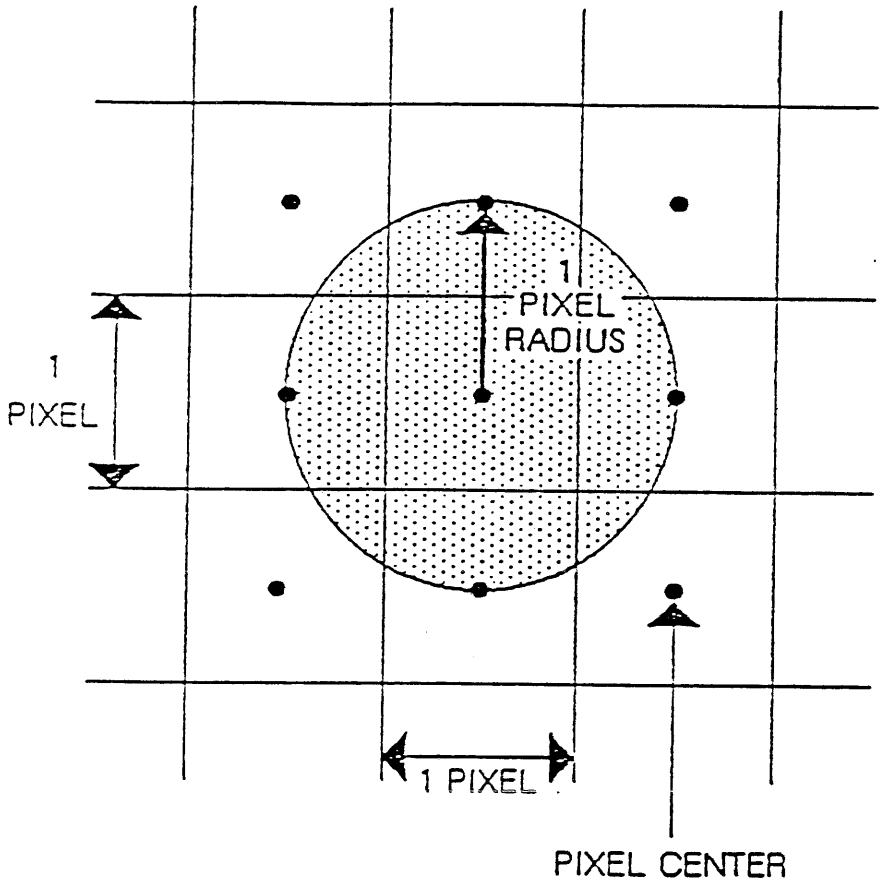


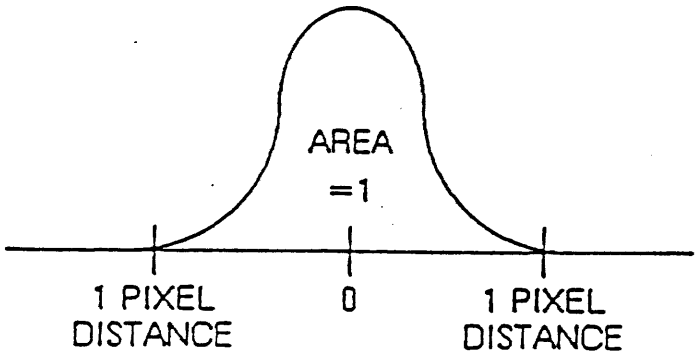
EDGE WITH NO ANTIALIASING



EDGE WITH ANTIALIASING

ANTIALIASING FILTER

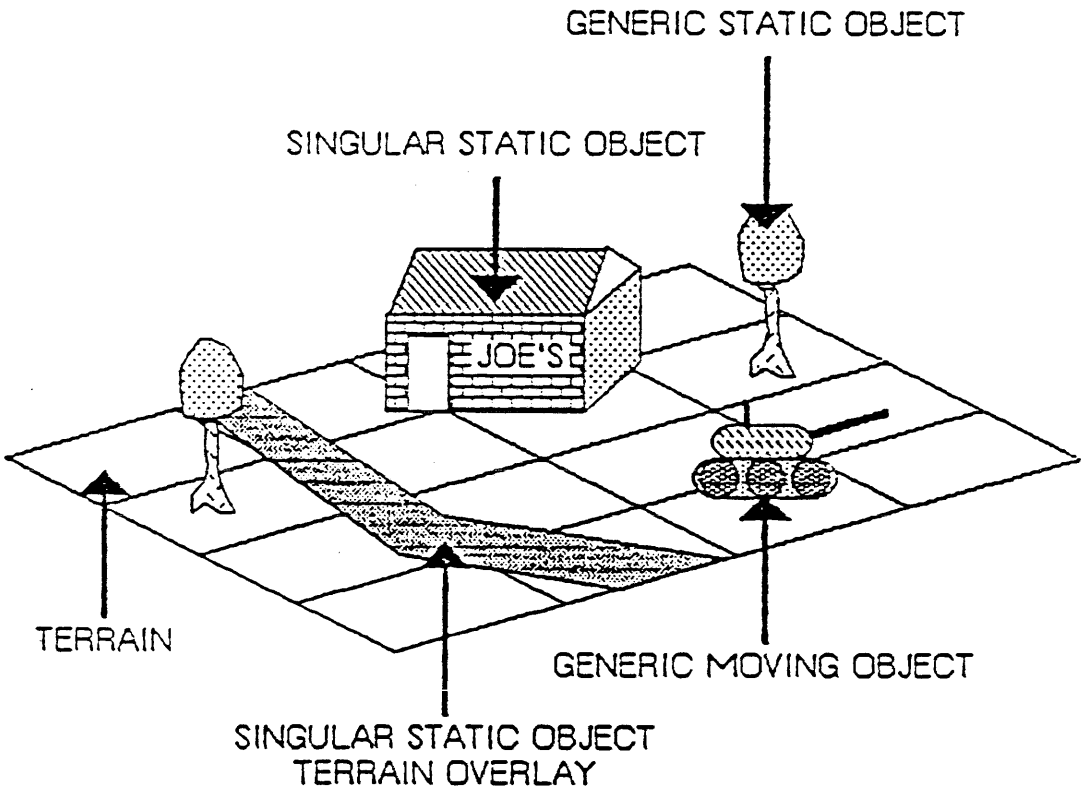




SIMNET OBJECT TYPES

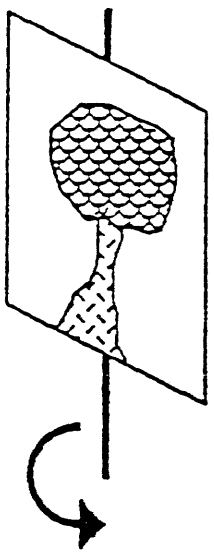
- REAL WORLD TERRAIN GRIDS.
- GENERIC STATIC OBJECTS.
- SINGULAR STATIC OBJECTS.
- TERRAIN OVERLAYS.
- MOVING OBJECTS.
- ROTATED STAMPS.

OBJECT DEFINITIONS



STAMPS

- A TEXTURED SURFACE THAT ROTATES TO FACE THE VIEWPOINT



AXIS OF ROTATION

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

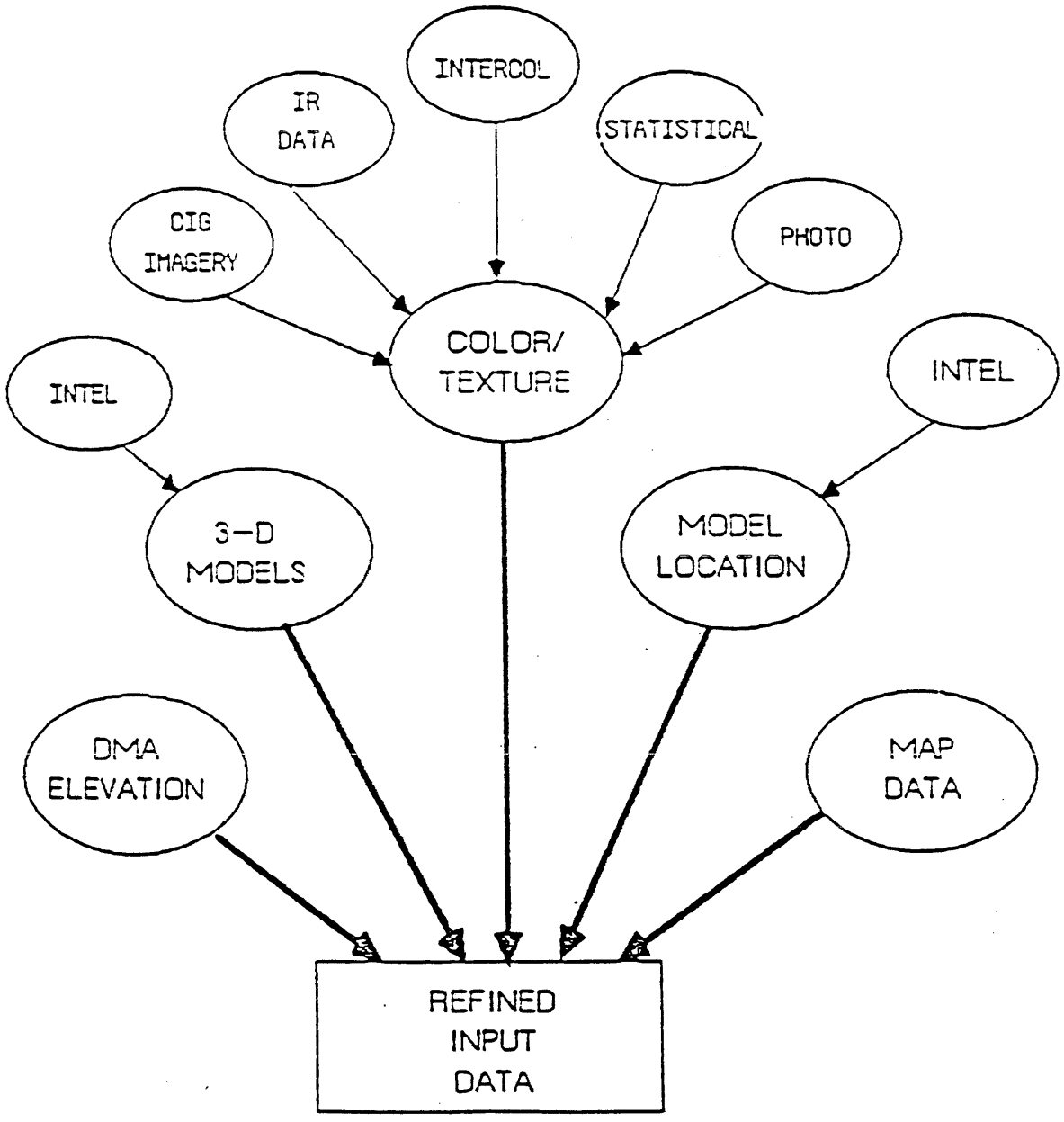
KEY TASKS

MULTISOURCE DATA INPUT

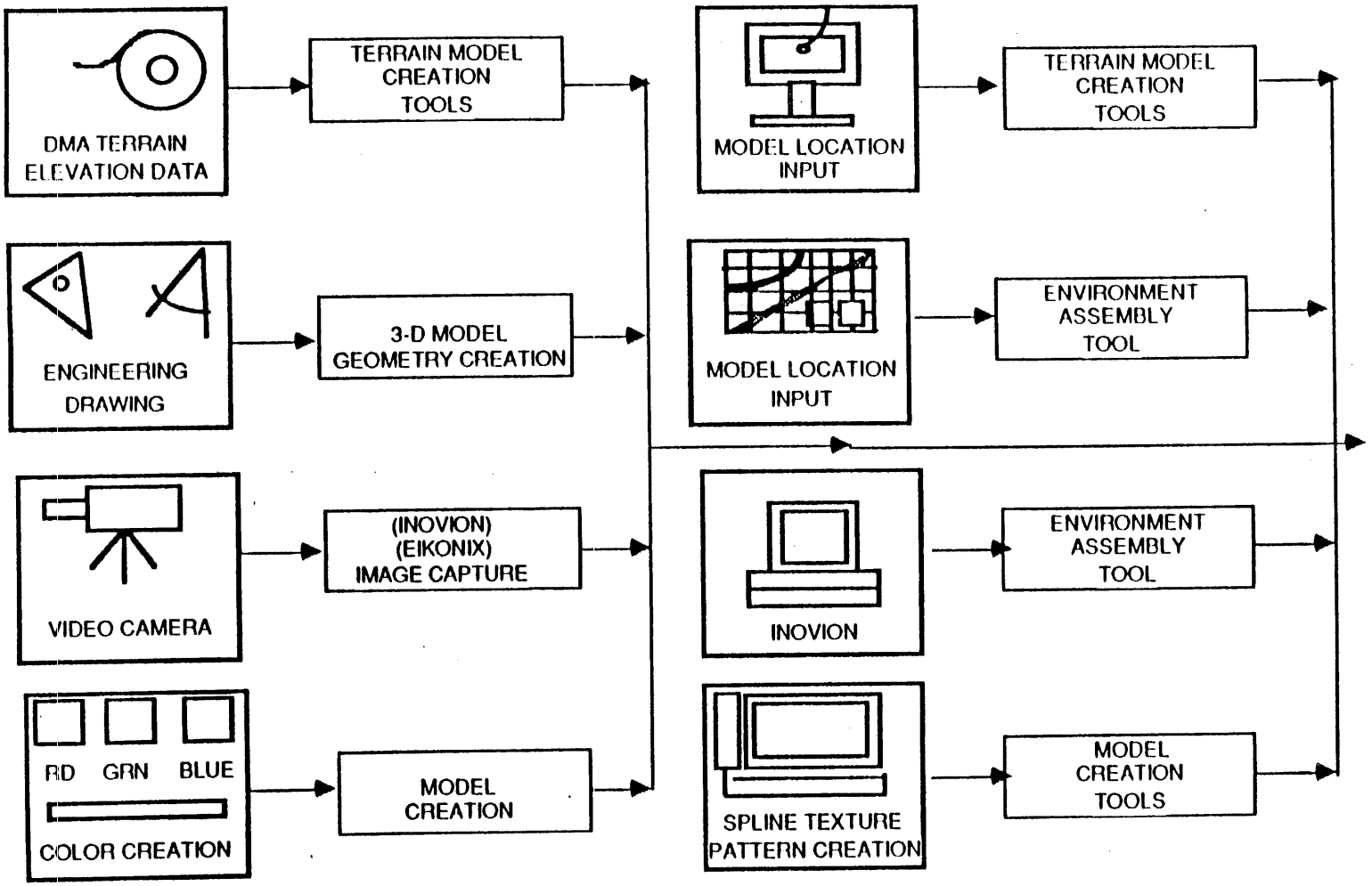
GAMING AREA CONSTRUCTION

LOAD MODULE CONSTRUCTION

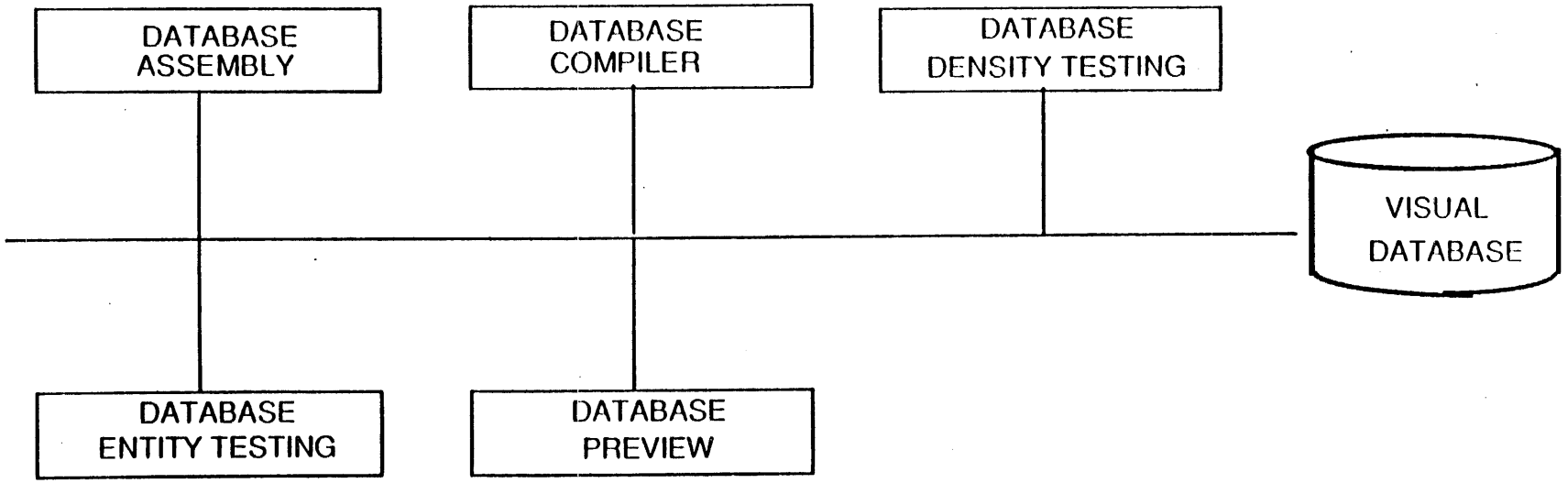
MULTISOURCE DATA INPUT



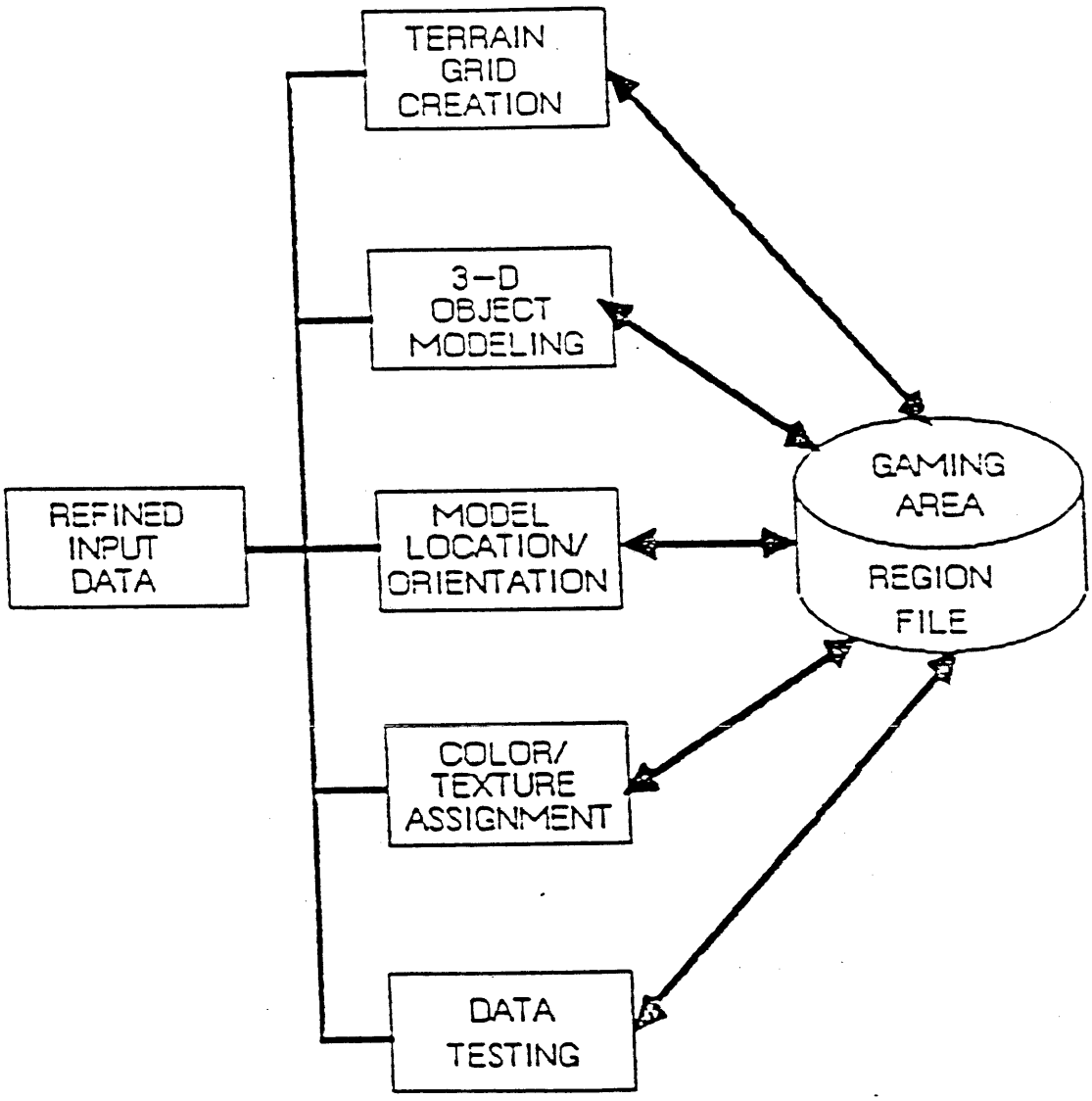
DATABASE CONSTRUCTION PHASE I



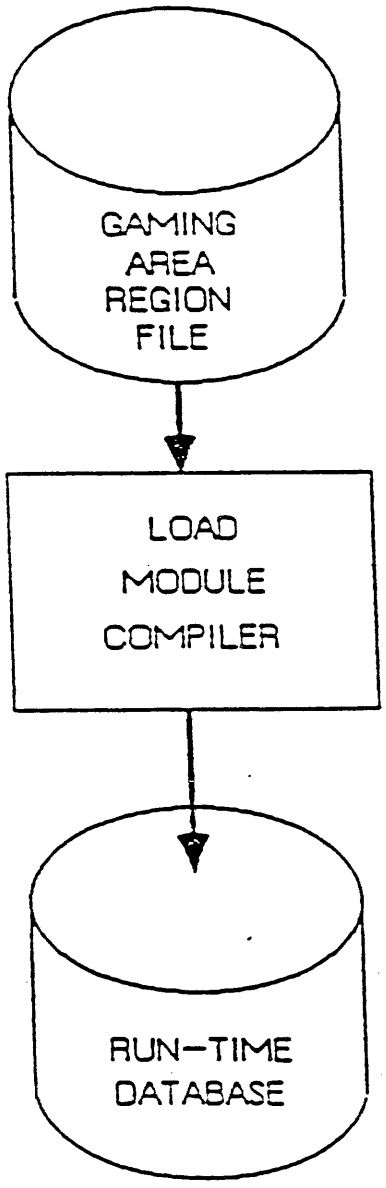
DATABASE CONSTRUCTION PHASE II

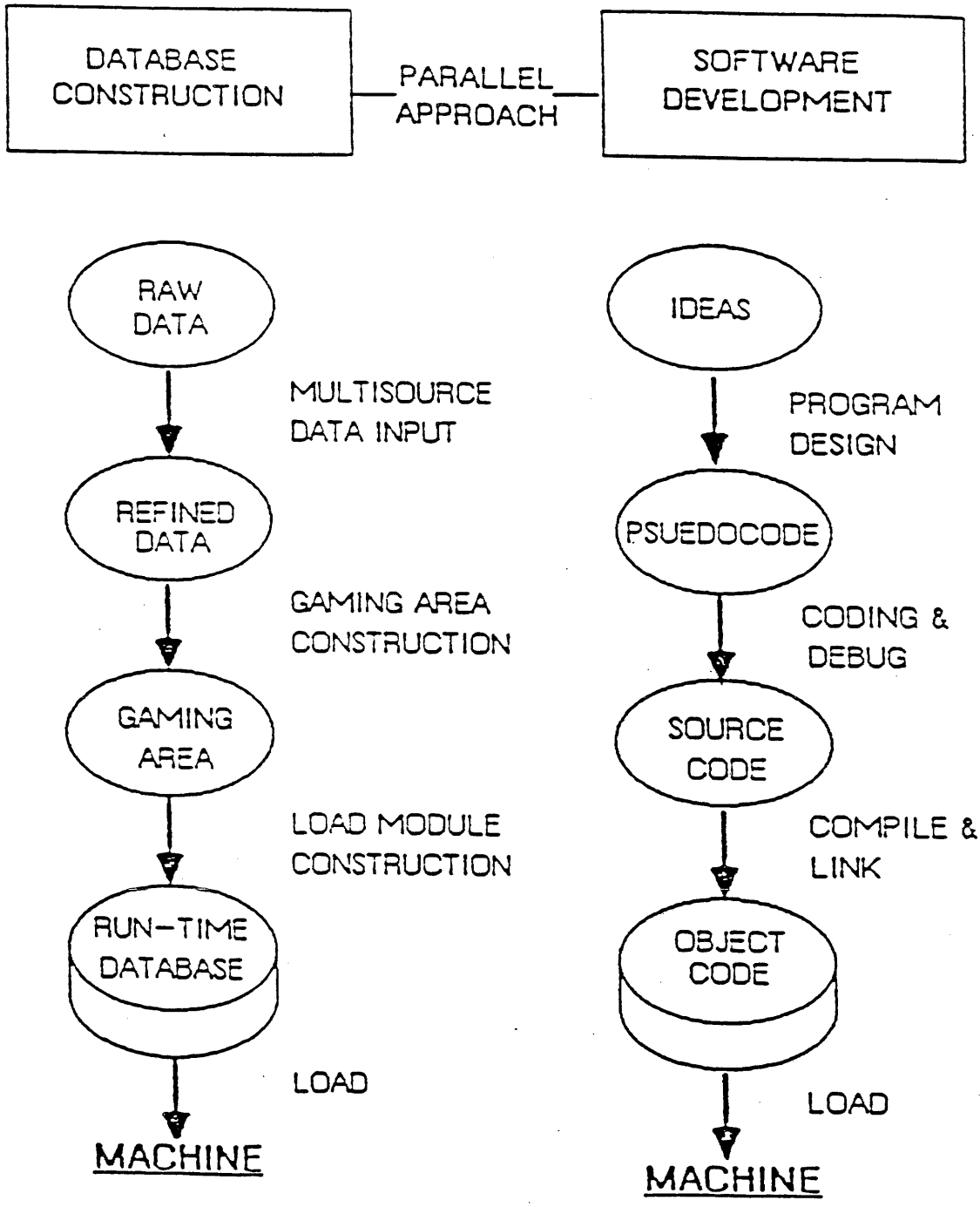


GAMING AREA CONSTRUCTION



LOAD MODULE CONSTRUCTION

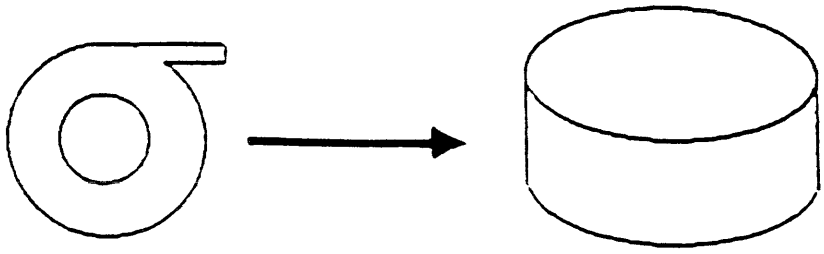



DATABASE CONSTRUCTION
PARALLEL APPROACH
SOFTWARE DEVELOPMENT
RAW DATA
MULTISOURCE DATA INPUT
REFINED DATA
GAMING AREA CONSTRUCTION
GAMING AREA
LOAD MODULE CONSTRUCTION
RUN-TIME DATABASE
LOAD
MACHINE
IDEAS
PROGRAM DESIGN
PSUEDOCODE
CODING & DEBUG
SOURCE CODE
COMPILE & LINK
OBJECT CODE
LOAD
MACHINE

EXAMPLE

DATAPATH - TERRAIN

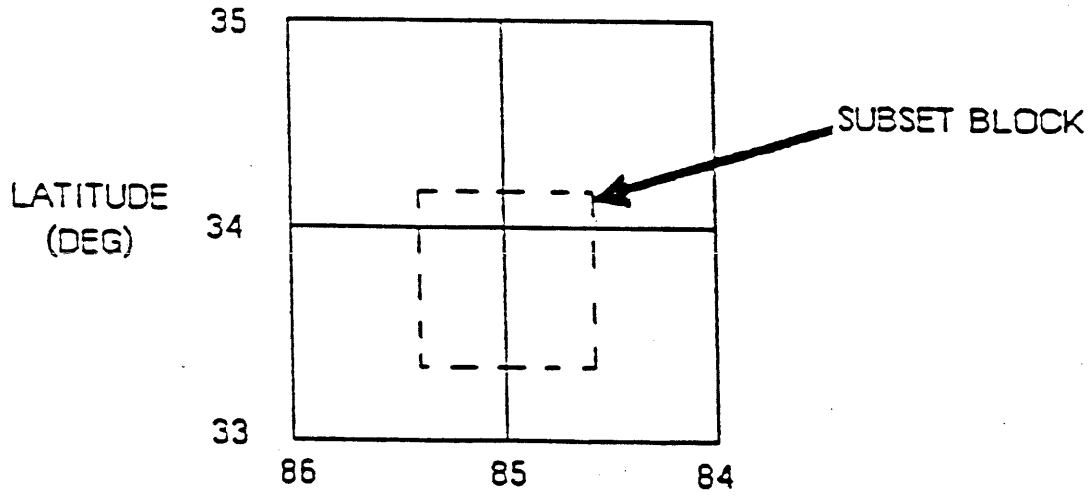
TERRAIN GRID CREATION



STEP 1

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

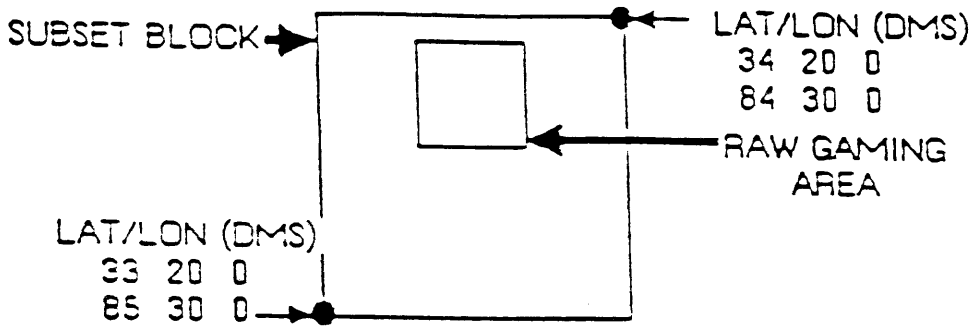
1° X 1° BLOCK (2.88 MByte)



STEP 2

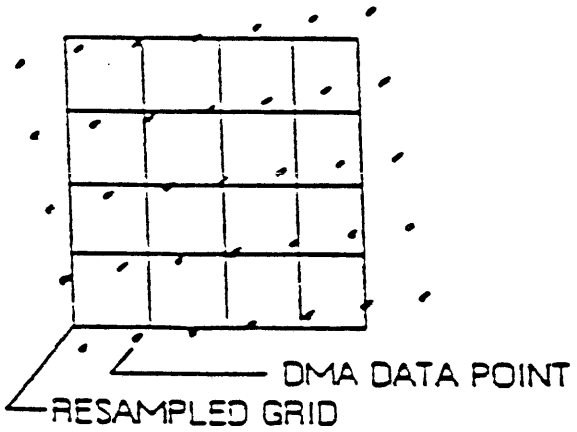
GROUP ADJACENT DMA BLOCKS, AND EXTRACT A 1° X 1° SUBJECT BLOCK SURROUNDING A POTENTIAL GAMING AREA

TERRAIN GRID CREATION



STEP 3

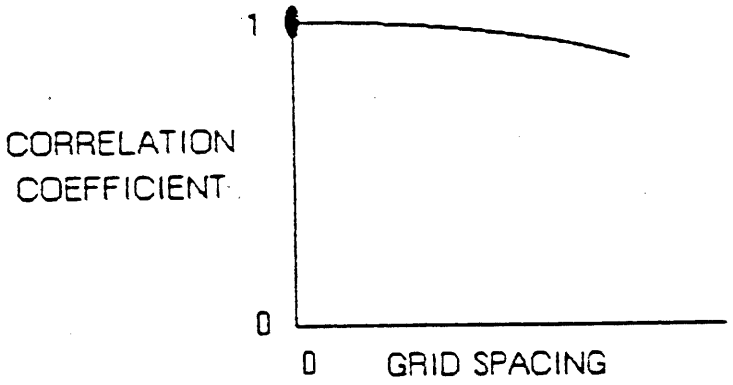
EXTRACT RAW GAMING AREA BLOCK OF ELEVATION VALUES, & CONVERT DATA POINTS: (LATITUDE, LONGITUDE, ELEVATION) TO
(NORTHING, EASTING, ELEVATION) IN UTM COORDINATES



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

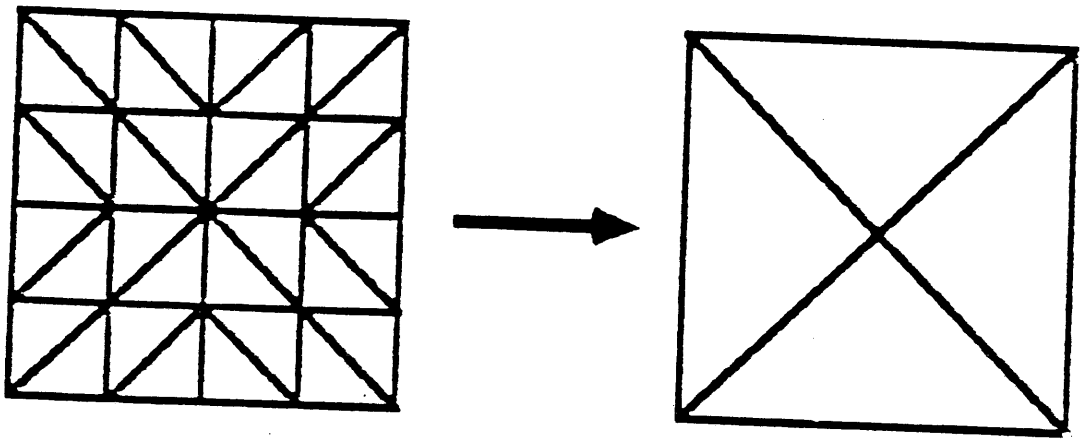
BACKFACE PERCENTAGES

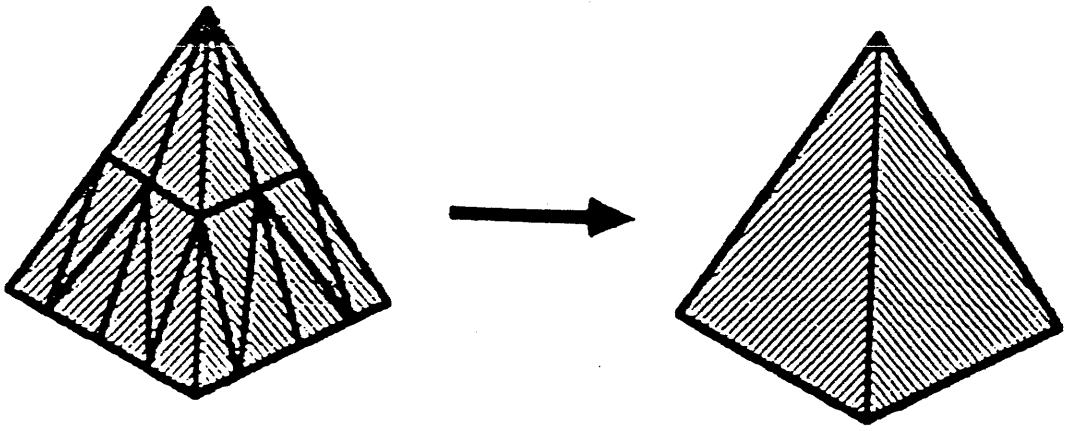
– TO ESTIMATE MODEL DATA DENSITIES

TERRAIN GRID CREATION

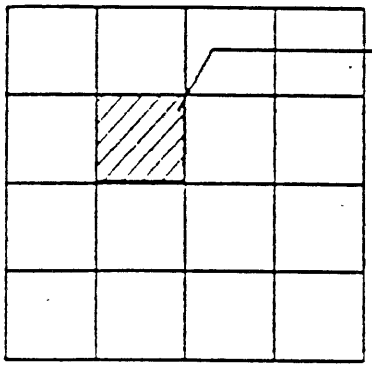
STEP 6

POLYGON RELAXATION





TERRAIN GRID CREATION



GAMING AREA (50 km x 50 km)

STEP 7

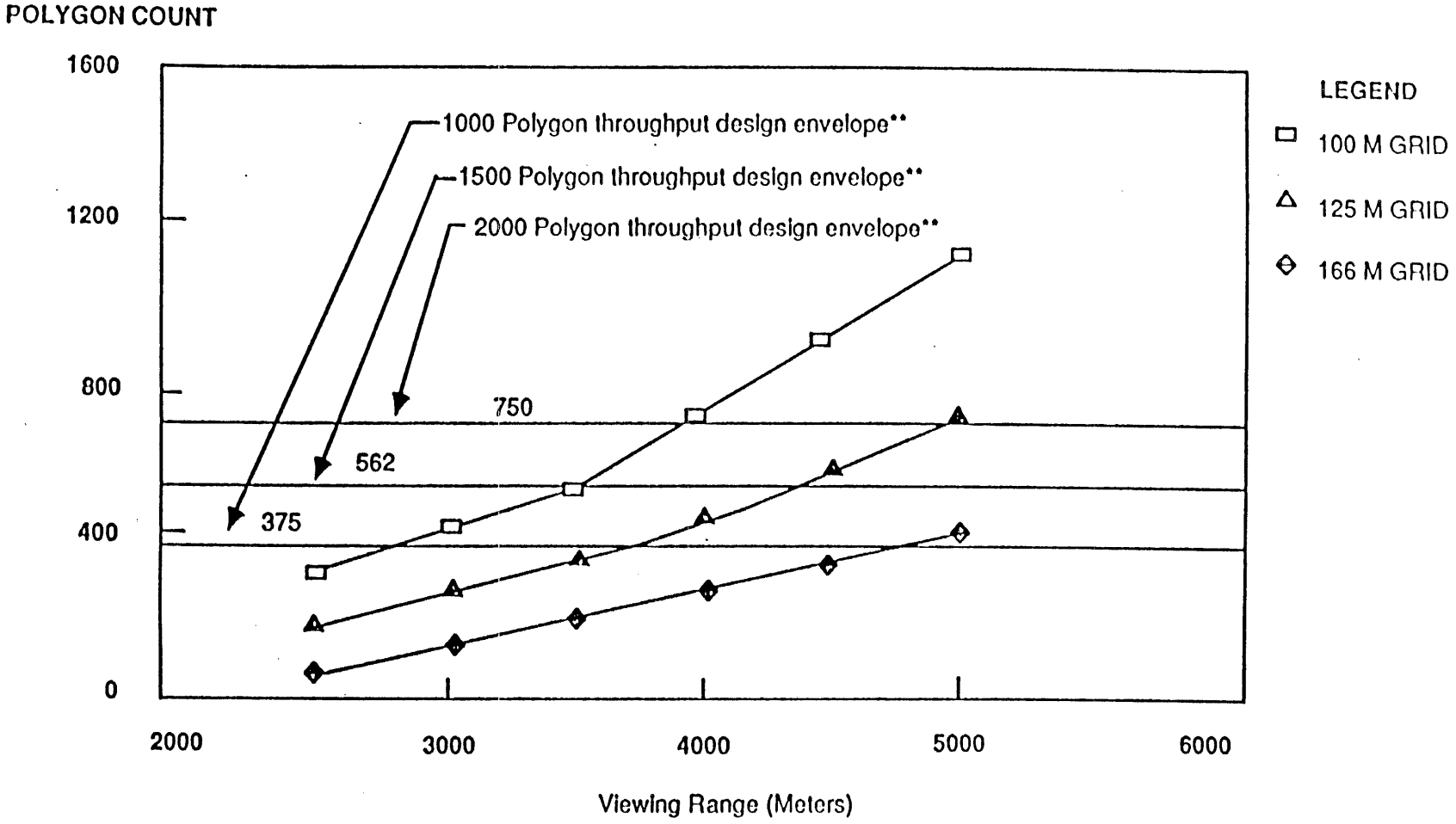
RESTRUCTURE GRID ARRAY INTO INDEPENDANT TERRAIN REGIONS (10,000 REGIONS)

STEP 8

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

TERRAIN MODEL POLYGON COUNT VS VIEWING RANGE

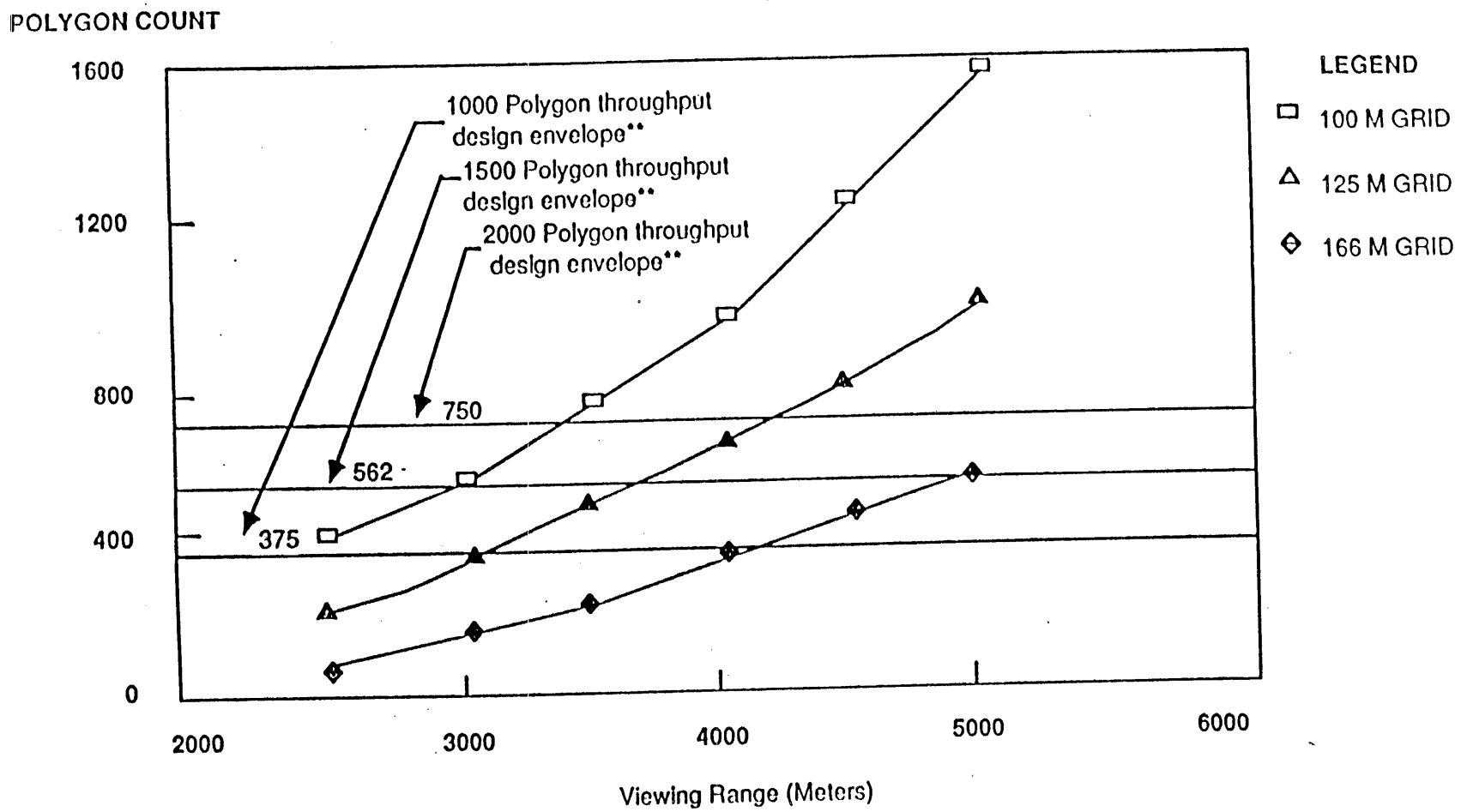
30° FIELD OF VIEW ANGLE



* 20% Polygon Relaxation
** 20% Backface Elimination

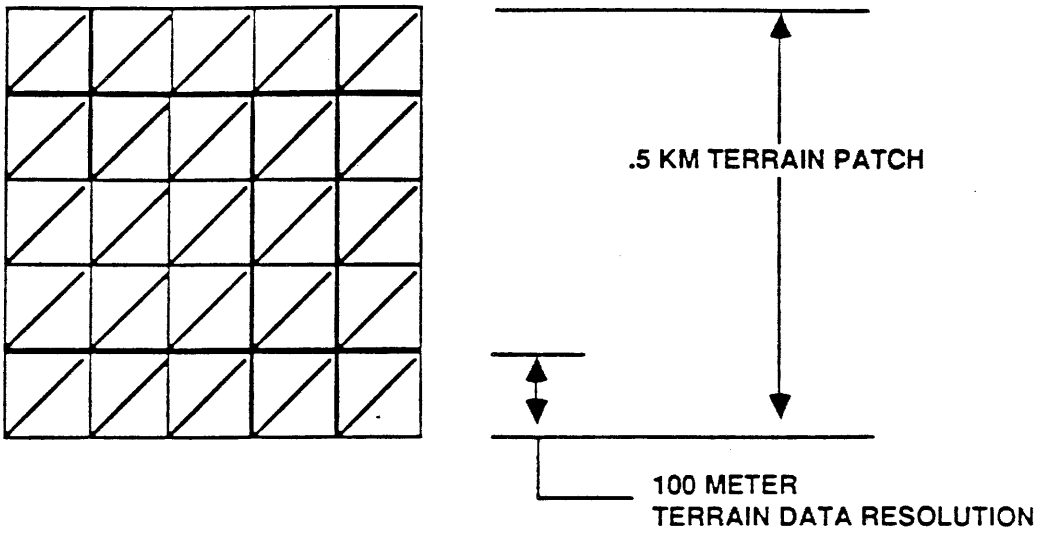
TERRAIN MODEL POLYGON COUNT VS VIEWING RANGE

40° FIELD OF VIEW ANGLE

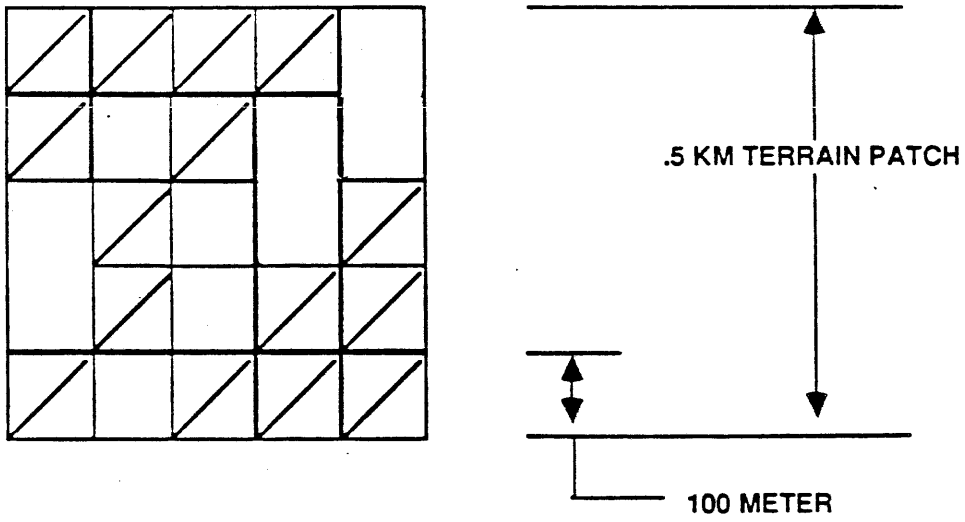


* 20% Polygon Relaxation
** 20% Backface Eliminlation

BBN Delta Graphics Inc.



TRAINGULATED TERRAIN GEOMETRY MODEL
(POLYGON COUNT = 50 POLYGONS)



RELAXED TERRAIN GEOMETRY MODEL
(POLYGON COUNT = 34)

NOTE: 32% GROSS POLYGON REDUCTION