GPS Data Logger

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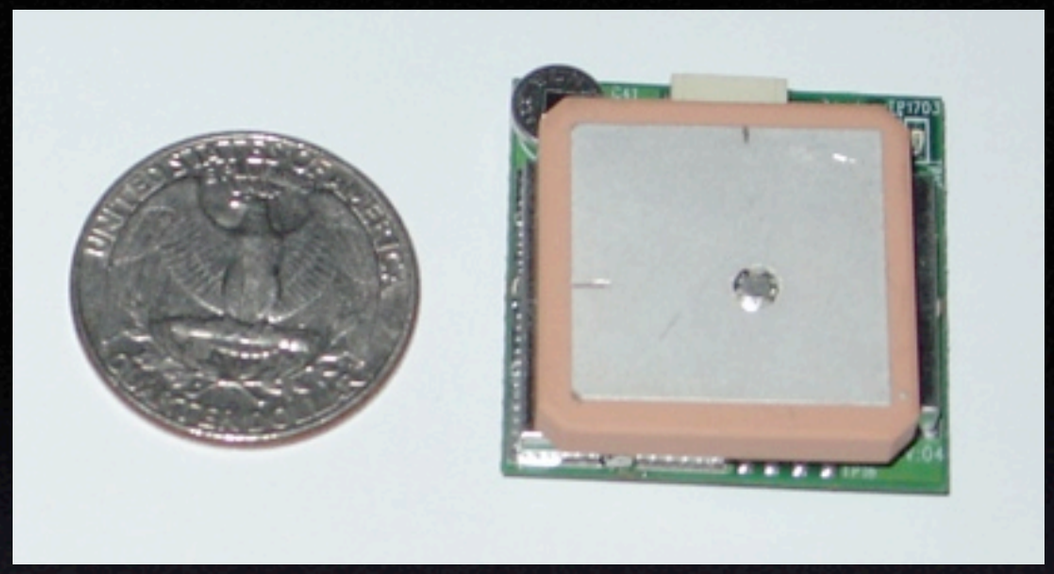
Design Objectives

- Build a system that logs its position over time using GPS, displays position history
- Data logging component should be portable, optimized for use in automobiles (fast movements, low precision)
- Visualization component can be separate, output different renderings of the data on a VGA display

Data Logger

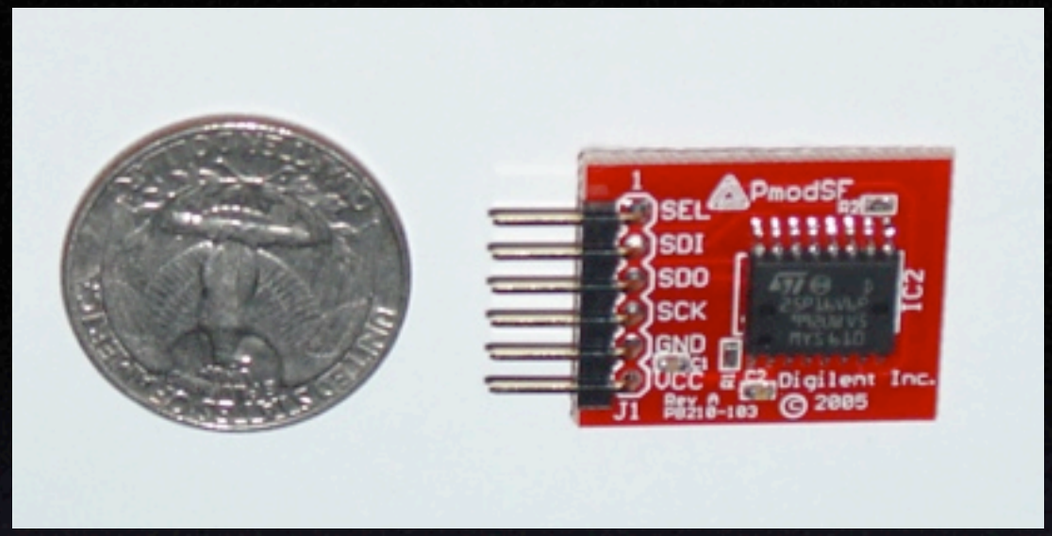
- Implementation will be on Digilent Nexys board
  - Small, portable, low power consumption - can be driven from batteries
- Use SiRF StarIII GPS Receiver to obtain data
- Use Micron P25M16 Serial Flash module to store data, transfer to visualization

SiRF StarIII



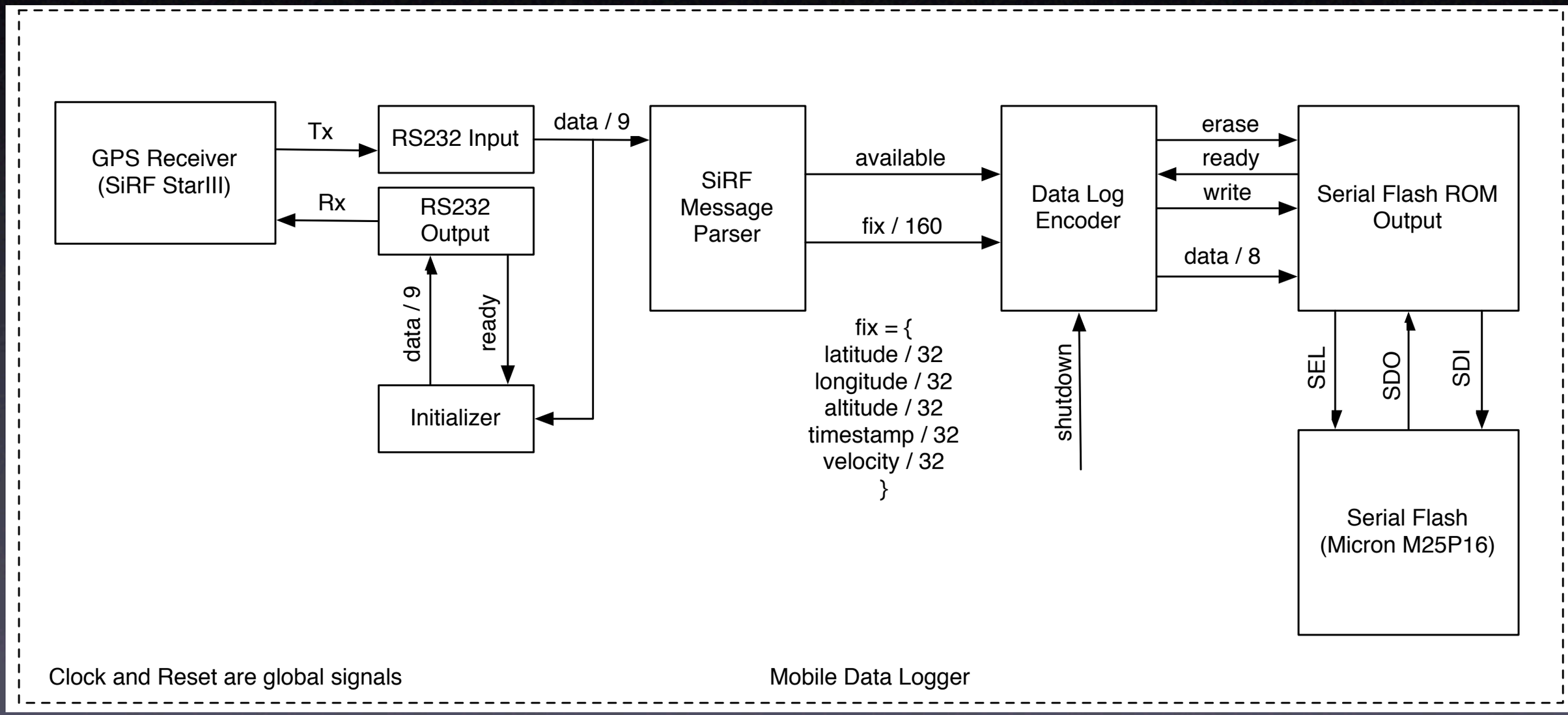
- Self-contained GPS module (on right)
- Communication through an RS232 interface (TTL-level)
- Once locked, provides 3-axis position, 3-axis velocity, heading, etc. at 1Hz
- Proprietary binary protocol vs. NMEA (ASCII)

Micron M25P16



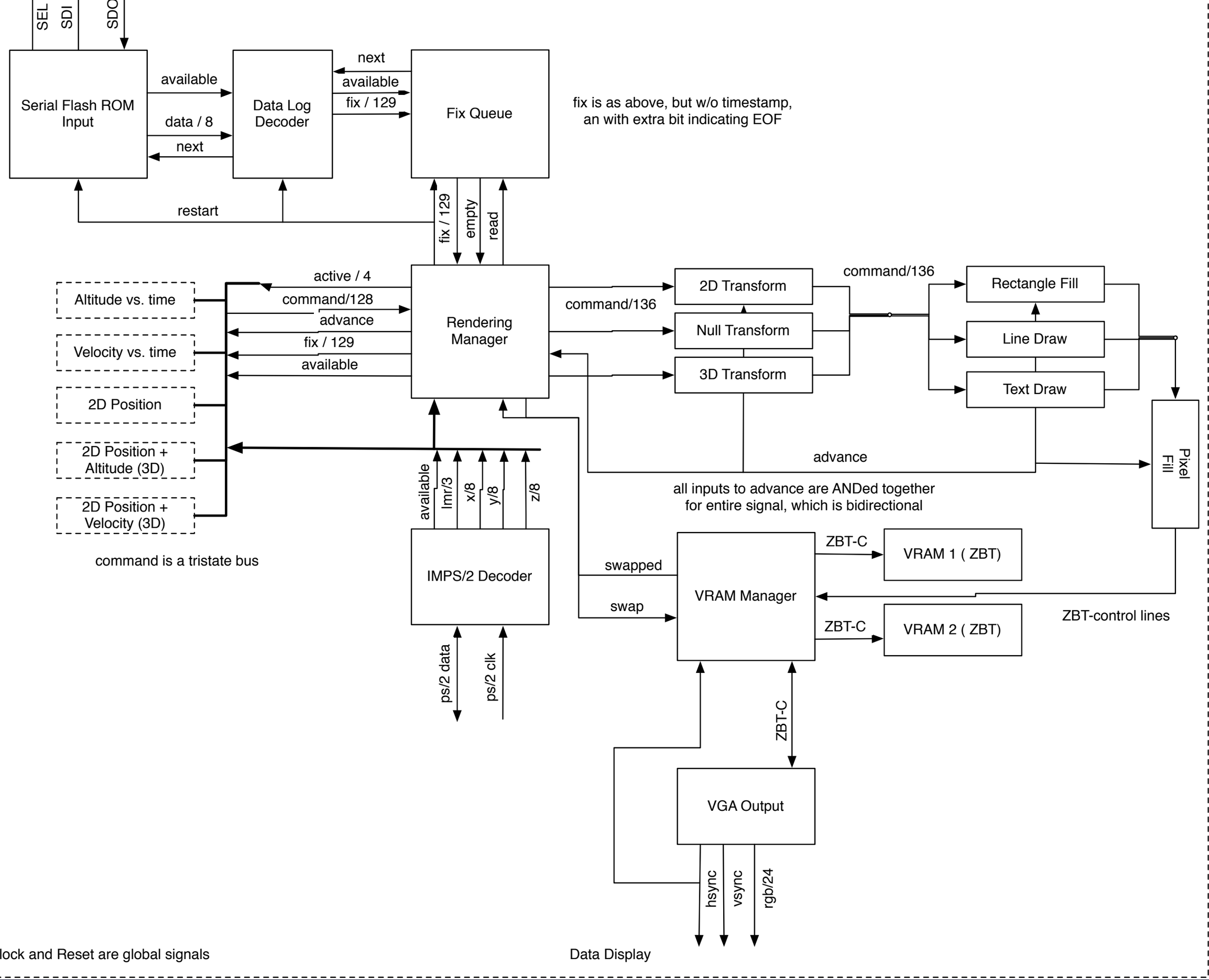
- 16 megabit Flash module - SPI interface
- Each position fix is 128 bits long - latitude, longitude, velocity (x,y), altitude
- Recording every fix received yields 35 hours of recording time

Data Logger Implementation



Visualization Component

- Will be implemented on 6.111 labkit - Nexys board too limited
- Read data from flash ROM
- Visualizations: various combinations of position/altitude/velocity vs. time - 2D and 3D
- All will support panning / zooming / rotation through a PS/2 mouse


SEL
SDI
SDO
Serial Flash ROM Input
available
data / 8
next
Data Log Decoder
next
available
fix / 129
Fix Queue
fix is as above, but w/o timestamp, an with extra bit indicating EOF
restart
fix / 129
empty
read
active / 4
command/128
advance
fix / 129
available
Rendering Manager
Altitude vs. time
Velocity vs. time
2D Position
2D Position + Altitude (3D)
2D Position + Velocity (3D)
command is a tristate bus
command/136
2D Transform
Null Transform
3D Transform
command/136
Rectangle Fill
Line Draw
Text Draw
Pixel Fill
advance
all inputs to advance are ANDed together for entire signal, which is bidirectional
available
lmr/3
x/8
y/8
z/8
IMPS/2 Decoder
ps/2 data
ps/2 clk
swapped
swap
VRAM Manager
ZBT-C
VRAM 1 (ZBT)
ZBT-C
VRAM 2 (ZBT)
ZBT-control lines
ZBT-C
VGA Output
hsync
vsync
rgb/24
Clock and Reset are global signals
Data Display

Commands

Command Format

TRANS / 4	DRAW / 4	FILL / 10	Data / 256

Transform Commands:

NOOP
Set 2D Camera Limits
Set 3D Camera Limits
Transform 2Dx1
Transform 2Dx2
Transform 3Dx1
Transform 3Dx2

Draw Commands:

NOOP
Draw Line
Fill Rectangle
Draw Text
Draw Text Continue
Draw Polygon

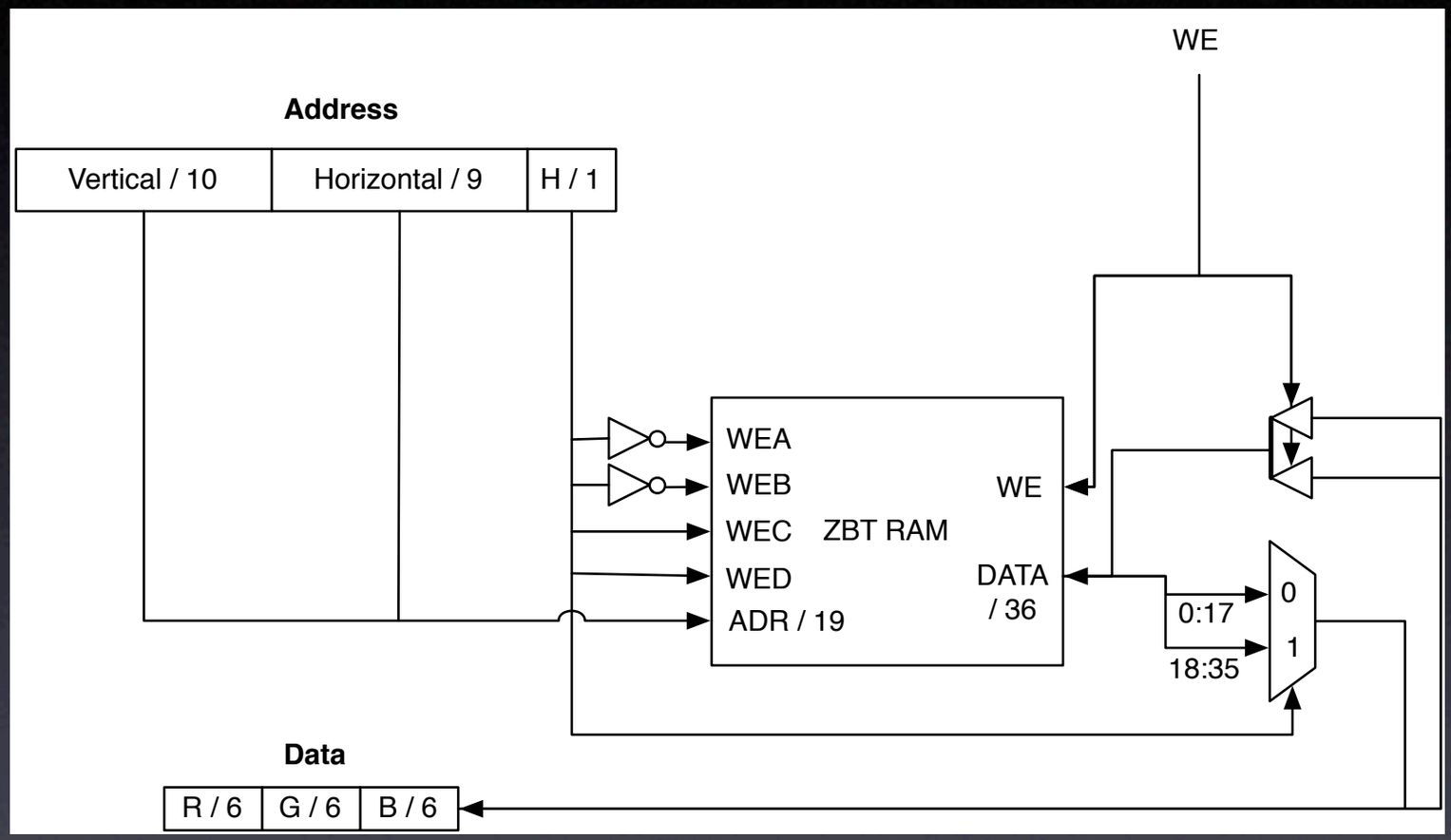
Fill Commands:

NOOP
Standard Fill
Alpha Fill

- Command format consists of three control fields, plus data
- Each control field controls a specific stage in transform
- Commands may be broken into multiple subcommands

VRAM Addressing

- 512k x 36 ZBT RAM
- Storing 1024x768 pixels - 768k locations
- Use 18-bit pixels (6 bpc), store two pixels in each location
- Aided by ZBT partial-write



3D Transform Math

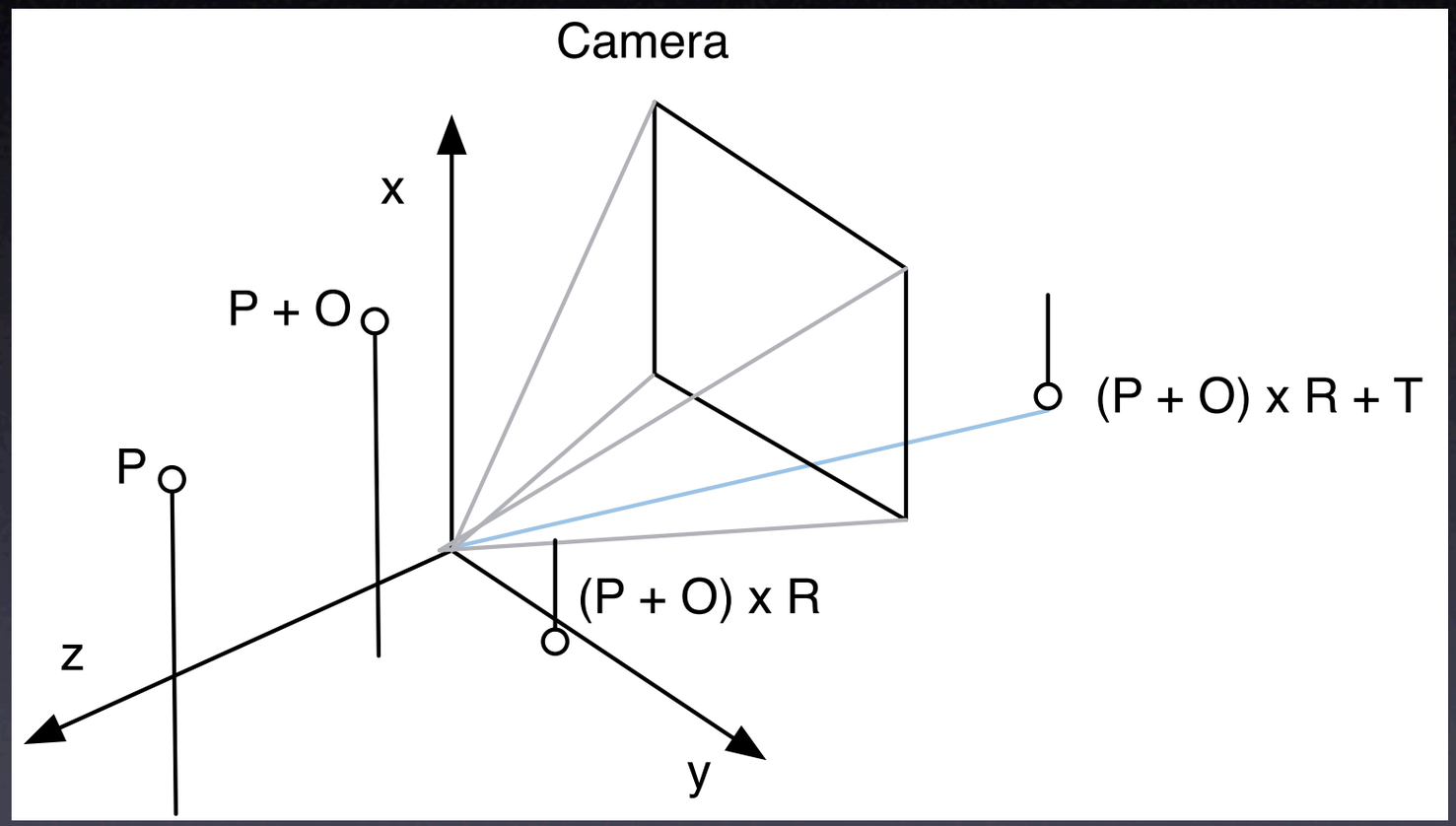
$$R = \begin{bmatrix} cos(\theta_z) & -sin(\theta_z) & 0 \\ sin(\theta_z) & cos(\theta_z) & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & cos(\theta_x) & -sin(\theta_x) \\ 0 & sin(\theta_x) & cos(\theta_x) \end{bmatrix} \times \begin{bmatrix} cos(\theta_y) & 0 & sin(\theta_y) \\ 0 & 1 & 0 \\ -sin(\theta_y) & 0 & cos(\theta_y) \end{bmatrix}$$

$$M = \begin{bmatrix} R_{11} & R_{12} & R_{13} & T_x \\ R_{21} & R_{22} & R_{23} & T_y \\ R_{31} & R_{32} & R_{33} & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$O = \begin{bmatrix} O_x \\ O_y \\ O_z \end{bmatrix}$$

$$P_T = (P + O)$$

$$F = \begin{bmatrix} P_{T_x} \\ P_{T_y} \\ P_{T_z} \\ 1 \end{bmatrix} \times M$$



$$y = -\frac{e}{F_z} F_y$$

$$x = -\frac{e}{F_z} F_x$$

Timeline

- November 17 - data logger and data retrieval finished
- November 24 - Video RAM, pixel fill, line drawing, rectangle fill
- December 1 - IMPS/2 Interface, rendering manager, text drawing, 2D and 3D transforms
- December 8 - remaining visualization modules completed

Additional Functionality

- Awareness of Earth's curvature
- Anti-aliased line drawing
- Polygon drawing