SCALING GREAT VR

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Scaling Great VR

Roadmap

What Is Scaling

What’s Different About VR Scaling

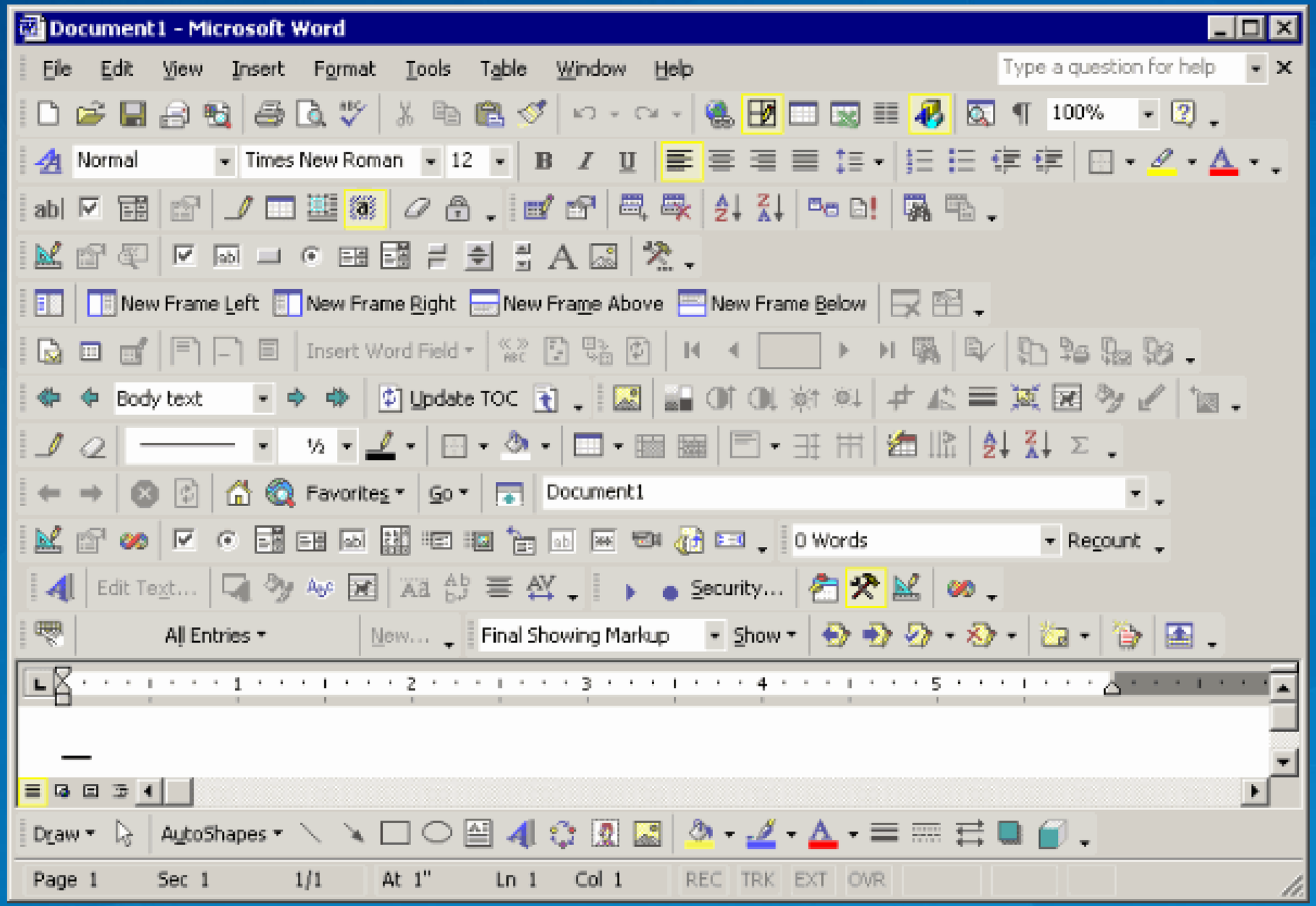
Scaling Tools & Resources

Why Bother Scaling

“Great” VR Content

Conclusions / Q&A

WHAT IS SCALING?


Document1 - Microsoft Word
File Edit View Insert Format Tools Table Window Help
Type a question for help
100%
Normal
Times New Roman
12
New Frame Left
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Document1
0 Words
Recount
Edit Text...
Security...
All Entries
New...
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Draw
AutoShapes
Page 1
Sec 1
1/1
At 1"
Ln 1
Col 1
REC
TRK
EXT
OVR

Scaling Great VR

Types of Scaling

1. Manual User Tuning

Scaling Great VR

Types of Scaling

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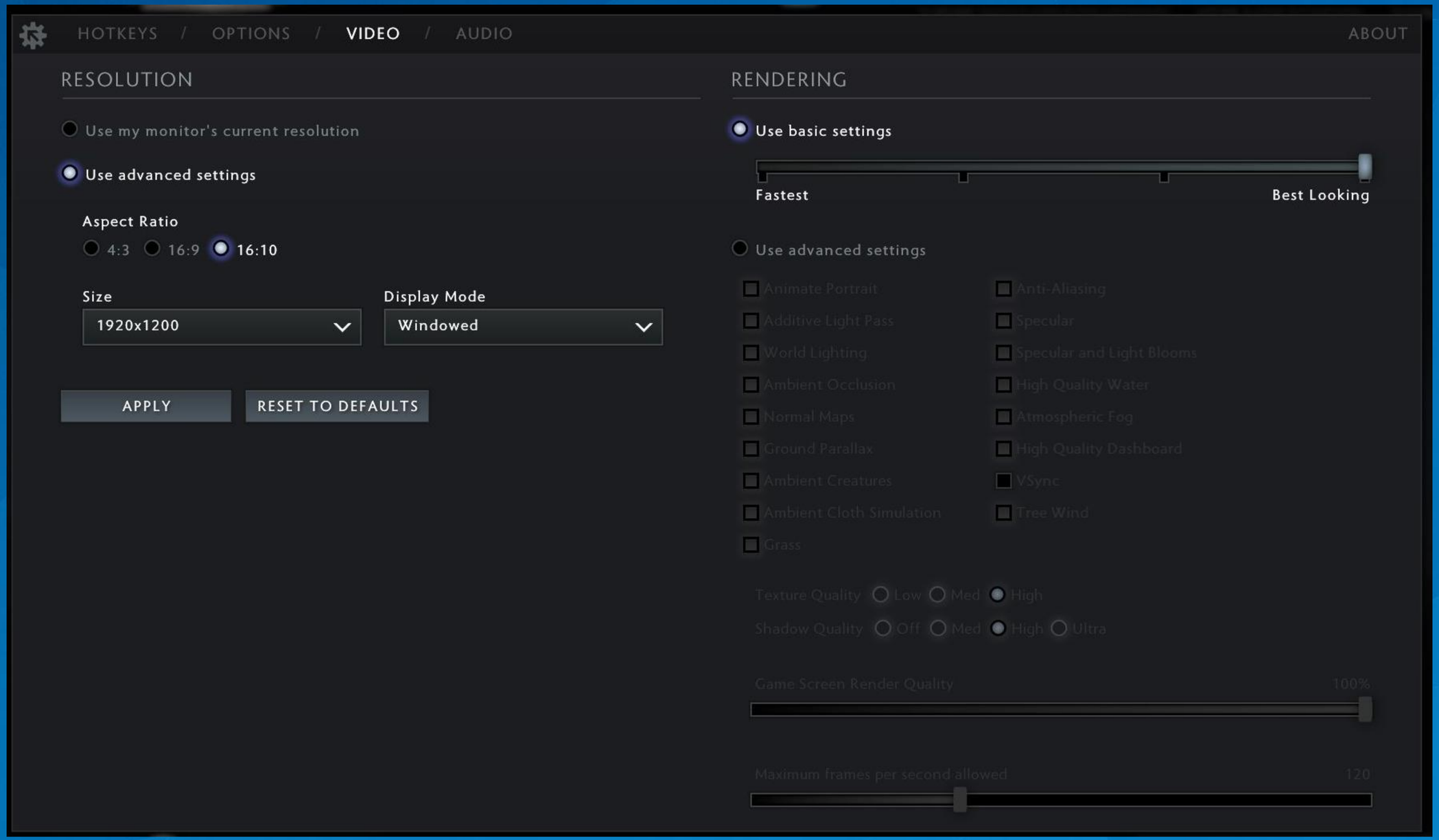
2. **One-Time Auto-Tuning**

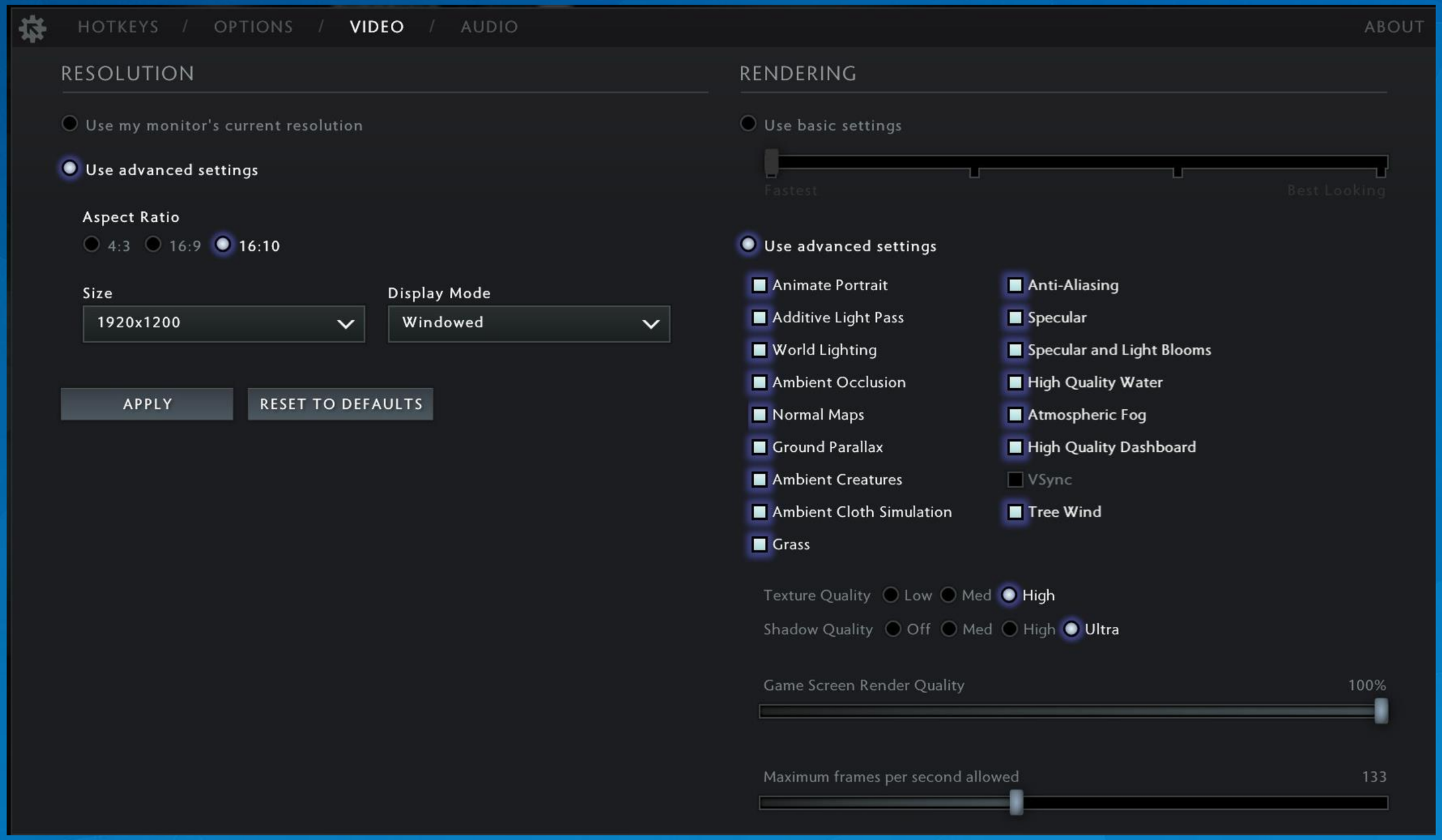
Types of Scaling

1. Manual User Tuning
2. One-Time Auto-Tuning
3. **Adaptive Scaling**

Graphics Scaling



Graphics Scaling




0
0:55
0
Move to your Ancient
Right-click to move your hero.
540
LUNA
1
0/200
540 / 540
266 / 266
49
3
335
15+2
18+2
16+2
625
SHOP
K/D/A 0/0/0
LH/D 0/0


0
0:54
0
Move to your Ancient
Right-click to move your hero.
540
LUNA
1
0/200
540 / 540
266 / 266
49
3
335
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18+2
16+2
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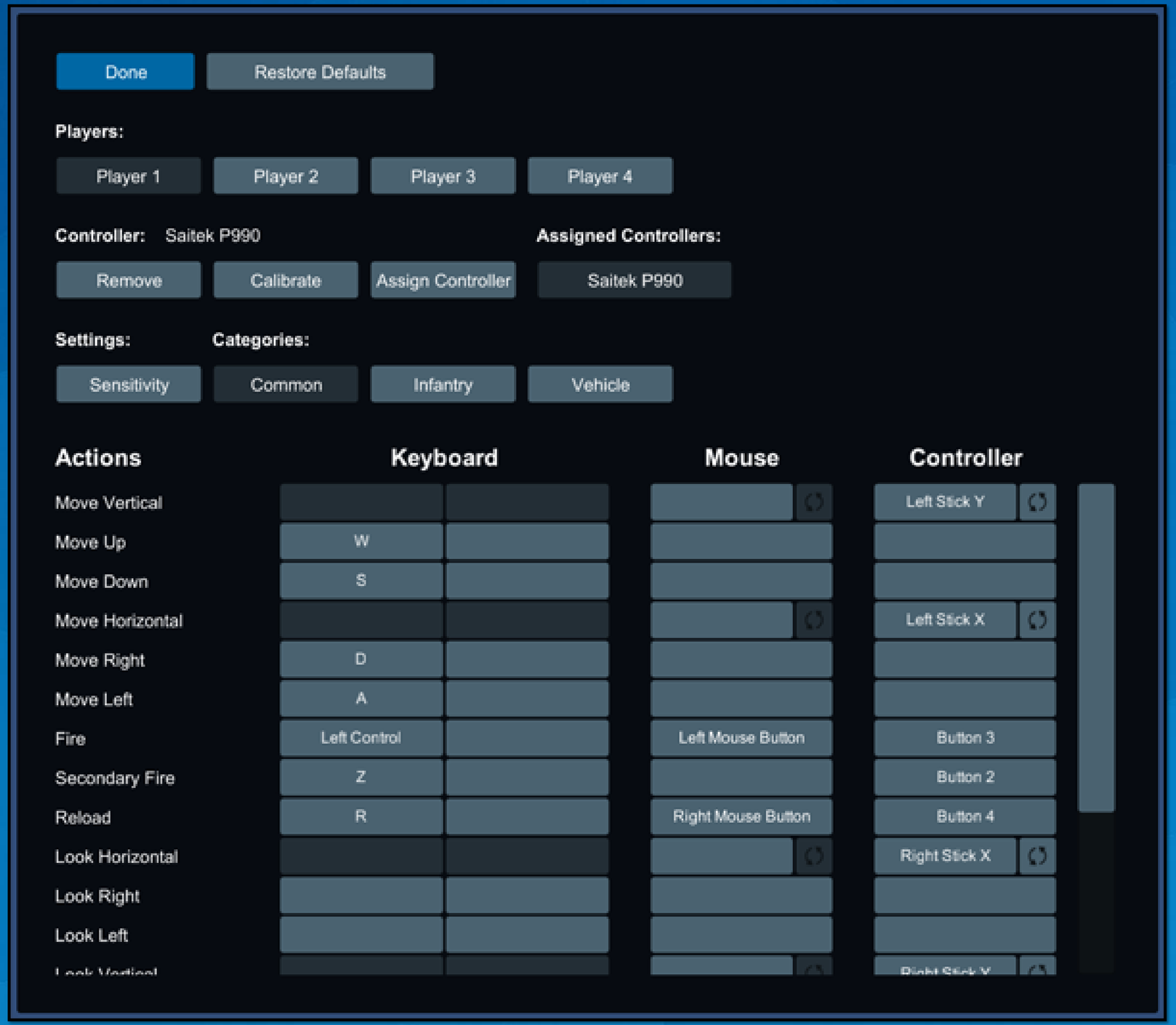
K/D/A 0/0/0
LH/D 0/0

540


540

Input Scaling



Desktop configuration

ADD ACTION SET

RIGHT MOUSE

LEFT CONTROL

MOUSE BACK

TAB

LEFT MOUSE

LEFT ALT

MOUSE FORWARD

ESCAPE

SCROLLWHEEL
- SCROLL DOWN
- SCROLL UP
- MIDDLE MOUSE

- UP ARROW
- LEFT ARROW
- RIGHT ARROW
- DOWN ARROW
- SHOW KEYBOARD

- Y PAGE DOWN
- X PAGE UP
- B SPACE
- A RETURN

MOUSE
- LEFT SHIFT

BROWSE CONFIGS | EXPORT CONFIG | DONE

Doom

By ScottD

ADD ACTION SET

Swap To Unified Pad

LEFT TRIGGER

LEFT BUMPER

SELECT

MOUSE

MOUSE

LEFT MOUSE

RIGHT TRIGGER

RIGHT BUMPER, R Pad -> Joystick Move

START

DPAD UP
DPAD LEFT
DPAD RIGHT
DPAD DOWN

JOYSTICK MOVE
LS CLICK

JOYSTICK MOVE
RS CLICK

Y BUTTON
X BUTTON
B BUTTON
A BUTTON

SELECT BROWSE CONFIGS EXPORT CONFIG DONE

WHAT'S DIFFERENT ABOUT VR SCALING?

VR Scaling

VR Adds Tough Constraints

- You must maintain 90Hz
- Reprojection techniques are a safety net for occaisional misses, not a crutch

VR Scaling

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- **Players have extreme camera control**

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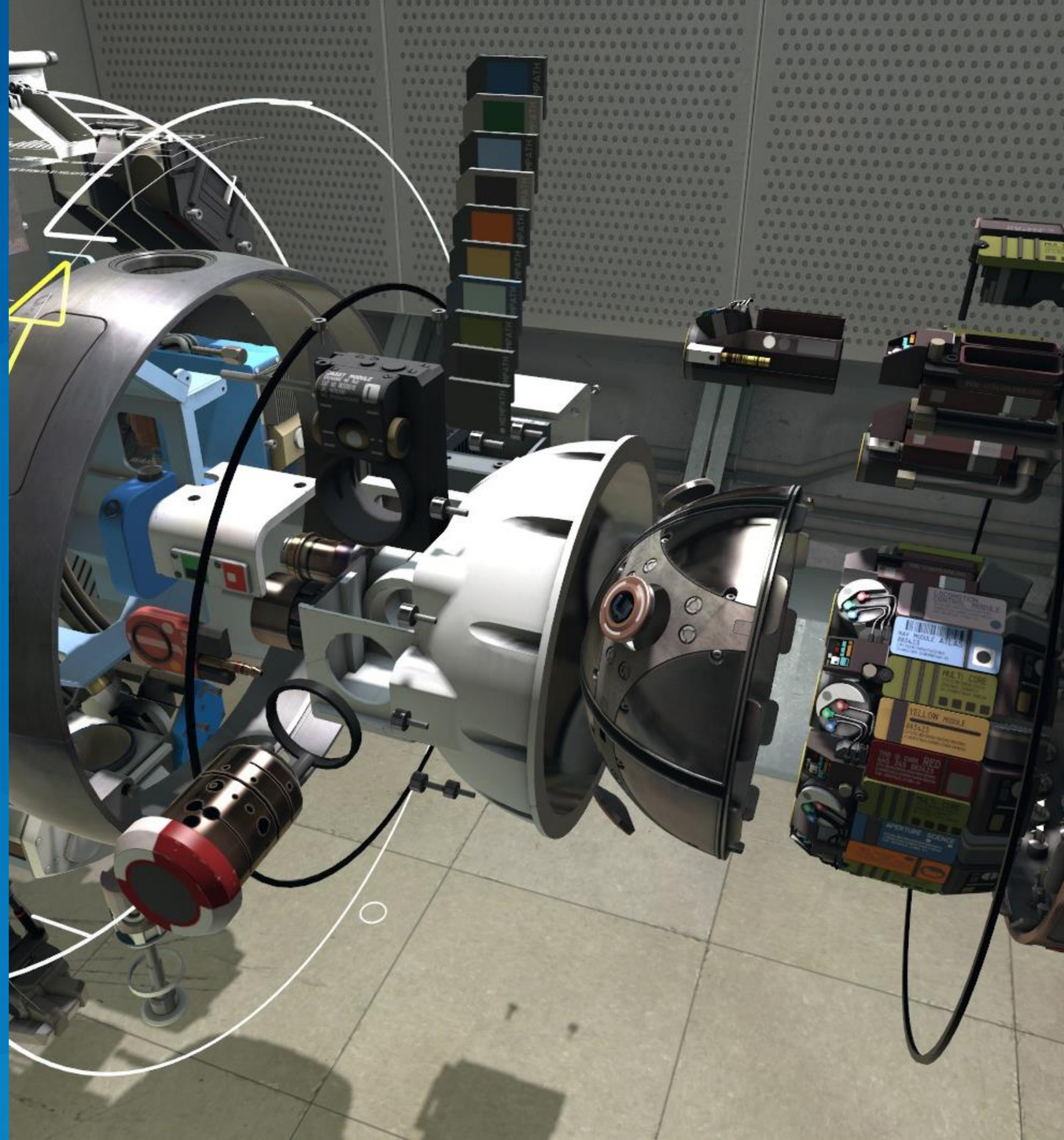

VR Scaling

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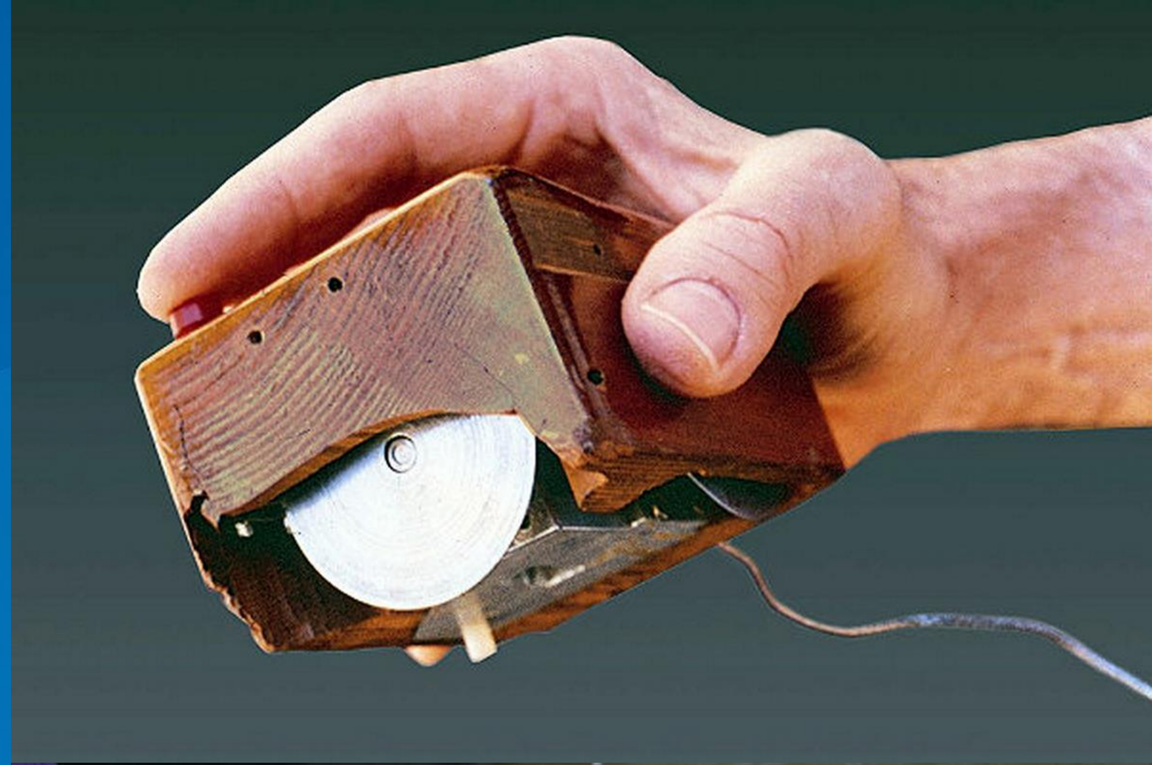
- **Reconfigurable worlds turn performance tuning on its head**

VR Scaling

VR Adds Tough Constraints

- You must maintain 90Hz
- Players have extreme camera control
- Reconfigurable worlds make turn performance tuning on its head
- **It’s early days in VR**



SCALING TOOLS & RESOURCES

Input Tools & Resources

Abstracting Input Through OpenVR

- Mapping Input Events
- Identifying Input Surfaces/Sources
- Great example from driver perspective:

  https://github.com/ValveSoftware/driver_hydra
- Example from application perspective:

  SteamVR_RenderModel.cs in the Unity plugin

IVRSystem

::GetControllerState

::GetControllerStateWithPose

```
/** VR controller button and axis IDs */
enum EVRButtonId
{
    k_EButton_System             = 0,
    k_EButton_ApplicationMenu    = 1,
    k_EButton_Grip               = 2,
    k_EButton_DPad_Left          = 3,
    k_EButton_DPad_Up            = 4,
    k_EButton_DPad_Right         = 5,
    k_EButton_DPad_Down          = 6,
    k_EButton_A                  = 7,

    k_EButton_ProximitySensor    = 31,

    k_EButton_Axis0              = 32,
    k_EButton_Axis1              = 33,
    k_EButton_Axis2              = 34,
    k_EButton_Axis3              = 35,
    k_EButton_Axis4              = 36,

    // aliases for well known controllers
    k_EButton_SteamVR_Touchpad   = k_EButton_Axis0,
    k_EButton_SteamVR_Trigger    = k_EButton_Axis1,

    k_EButton_Dashboard_Back     = k_EButton_Grip,

    k_EButton_Max                = 64
};
```

```
/** Identifies what kind of axis is on the controller at index n. Read this type
* with pVRSystem->Get( nControllerDeviceIndex, Prop_Axis0Type_Int32 + n );
*/
enum EVRControllerAxisType
{
    k_eControllerAxis_None = 0,
    k_eControllerAxis_TrackPad = 1,
    k_eControllerAxis_Joystick = 2,
    k_eControllerAxis_Trigger = 3, // Analog trigger data is in the X axis
};


/** contains information about one axis on the controller */
struct VRControllerAxis_t
{
    float x; // Ranges from -1.0 to 1.0 for joysticks and track pads. Ranges from 0.0 to 1.0 for triggers were 0 is fully released.
    float y; // Ranges from -1.0 to 1.0 for joysticks and track pads. Is always 0.0 for triggers.
};


/** the number of axes in the controller state */
static const uint32_t k_unControllerStateAxisCount = 5;


/** Holds all the state of a controller at one moment in time. */
struct VRControllerState001_t
{
    // If packet num matches that on your prior call, then the controller state hasn't been changed since
    // your last call and there is no need to process it
    uint32_t unPacketNum;

    // bit flags for each of the buttons. Use ButtonMaskFromId to turn an ID into a mask
    uint64_t ulButtonPressed;
    uint64_t ulButtonTouched;

    // Axis data for the controller's analog inputs
    VRControllerAxis_t rAxis[ k_unControllerStateAxisCount ];
};
```

IVRRenderModel

::GetComponentCount

::GetComponentName

::GetComponentButtonMask

::GetComponentState


```
struct RenderModel_ComponentState_t
{
    HmdMatrix34_t mTrackingToComponentRenderModel;
    HmdMatrix34_t mTrackingToComponentLocal;
    VRComponentProperties uProperties;
};
```

Graphics Tools & Resources

Low-Level Background:

- http://www.gdcvault.com/play/1021771/Advanced-VR-2015
- http://www.gdcvault.com/play/1023522/Advanced-VR-2016

- Dynamic Resolution and dynamic MSAA

Adaptive Quality

Stated simply: “Adaptive Quality dynamically changes rendering settings to maintain framerate while maximizing GPU utilization”

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- Goal #1: Reduce the chances of dropping frames and reprojecting
- Goal #2: Increase quality when there are idle GPU cycles

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- Goal #1: Reduce the chances of dropping frames and reprojecting
- Goal #2: Increase quality when there are idle GPU cycles

Example is the Aperture Robot Repair VR demo running at target framerate on an NVIDIA 680 using two different methods

Adaptive Quality Benefits

- Lower GPU min spec for your application
- Increased art asset limits – Artists can now make the tradeoff between slightly lower fidelity rendering for higher poly assets or more complex materials
- Don’t need to rely on reprojection to maintain framerate
- Happy Fallout: Our apps look better on all hardware

What Settings Are Changed?

What you can’t adjust:

- Can’t toggle visual features like specular
- Can’t toggle shadows

What you can adjust:

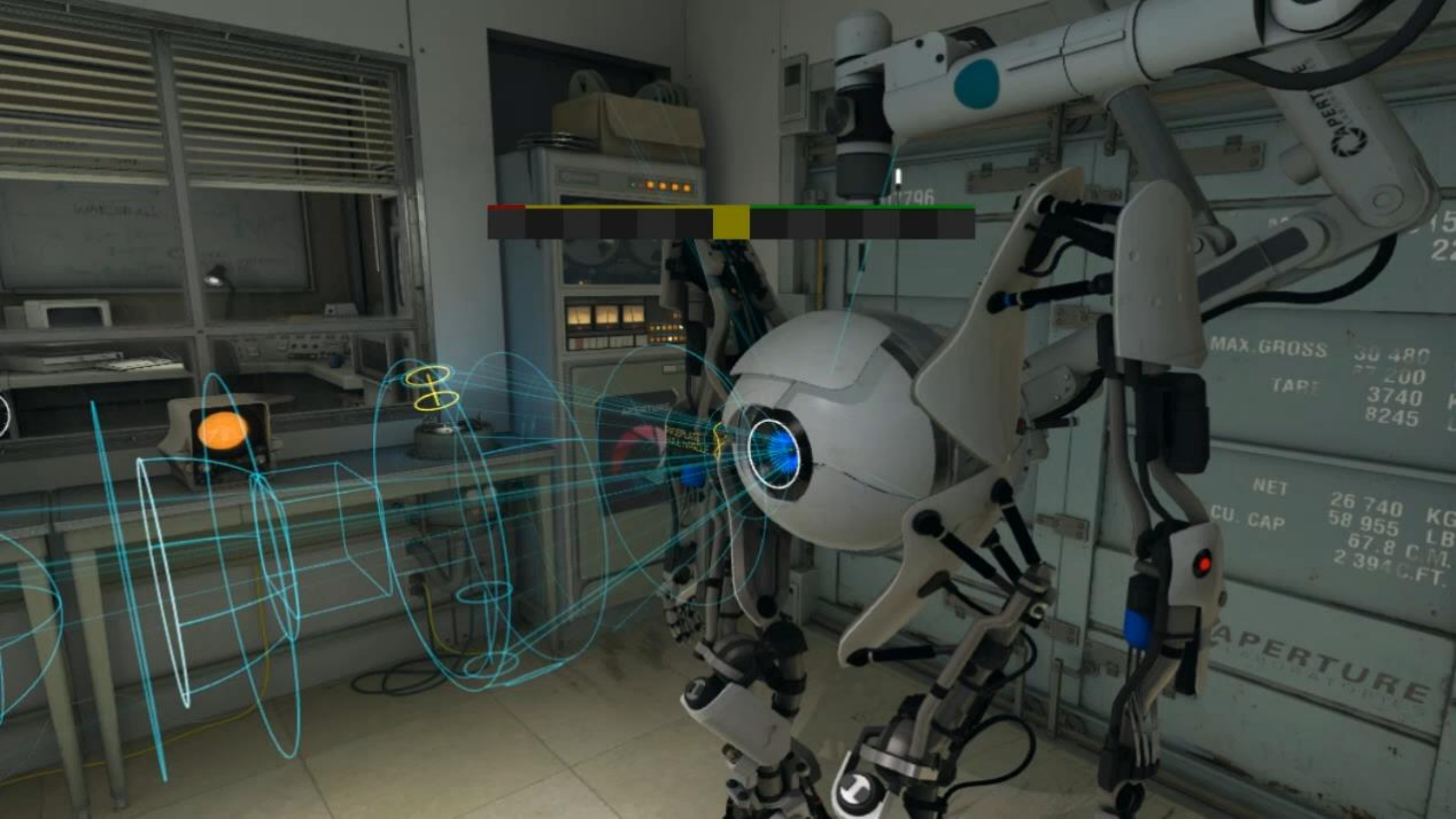
- Rendering resolution/viewport (aka Dynamic Resolution)
- MSAA level or anti-aliasing algorithm
- Fixed Foveated Rendering
- Radial Density Masking
- etc.

Quality Level	MSAA	Resolution Scale	Radial Density Masking	Reprojection Hint	Render Resolution
+6	8x	1.4	-	-	2116x2352
+5	8x	1.3	-	-	1965x2184
+4	8x	1.2	-	-	1814x2016
+3	8x	1.1	-	-	1663x1848
+2	8x	1.0	-	-	1512x1680
+1	4x	1.1	-	-	1663x1848
0	**4x**	**1.0**	**-**	**-**	**1512x1680**
-1	4x	0.9	-	-	1360x1512
-2	4x	0.81	-	-	1224x1360
-3	4x	0.81	-	Yes	1224x1360
-3	4x	0.73	-	-	1102x1224
-4	4x	0.65	On	-	992x1102

Default

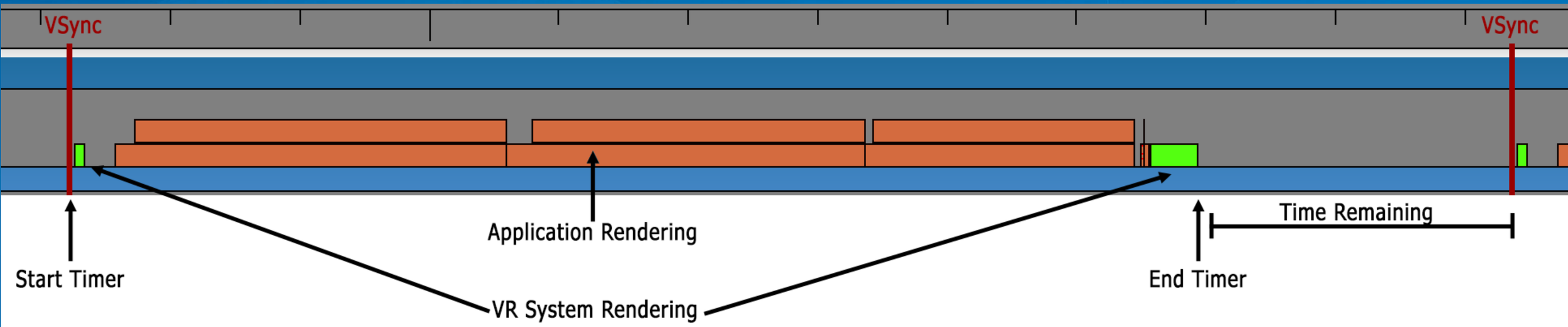
Text

No Text


MAX.GROSS
TARE
3740
8245
NET
26 740 KG
CU. CAP
58 955 LB
APERTURE

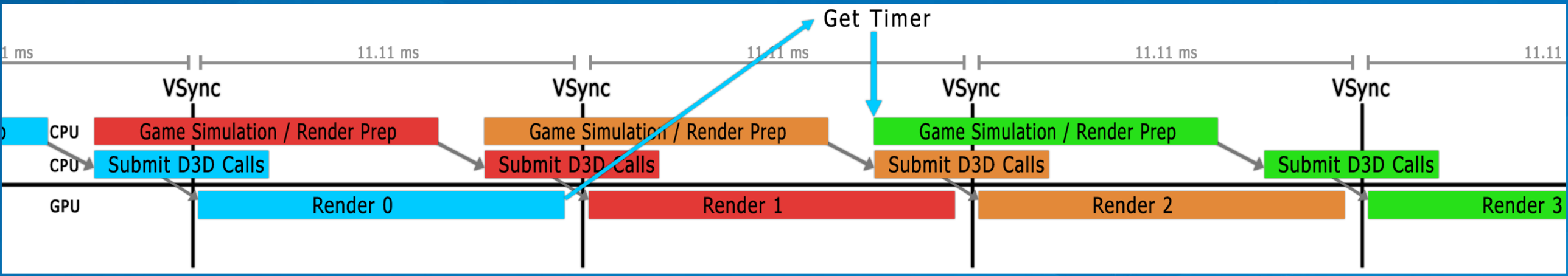
Measuring GPU Workload

- You GPU workload isn’t always solid, might have bubbles
- VR system GPU workload is variable: lens distortion, chromatic aberration, chaperone bounds, overlays, etc.
- Get timings from the VR system, not your application. OpenVR provides a total GPU timer that accounts for all GPU work



GPU Timers - Latency

- Your GPU queries are always going to be 1 frame old
- In Source2 we also have 1 or 2 frames in the queue that can't be modified – you probably will, too



Implementation Details – 3 Rules

Goal: Maintain 70%-90% GPU utilization

High = 90% of frame (10.0ms)

- Decrease aggressively: If the last frame finished rendering after the 90% threshold of the GPU frame, drop 2 levels, wait 2 frames

Implementation Details – 3 Rules

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- Increase conservatively: If the last 3 frames finished below the 70% threshold of the GPU frame, increase 1 level, wait 2 frames

Prediction = 85% of frame (9.4ms)

- Use linear extrapolation from last two frames to predict rapid increases
- If last frame is above the 85% threshold and the linearly extrapolated next frame is above the high threshold (90%), drop 2 levels, wait 2

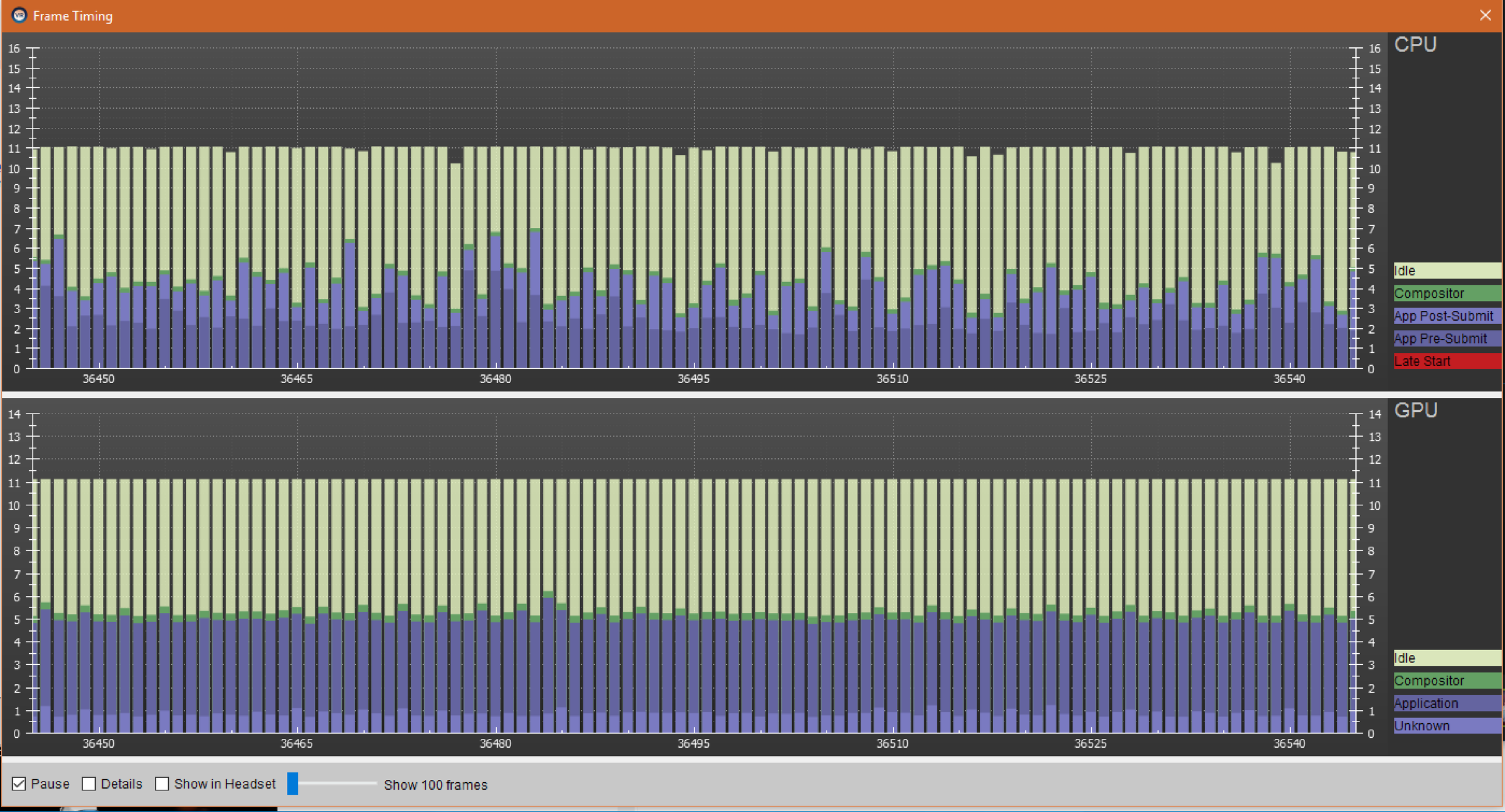
10% Idle Rule

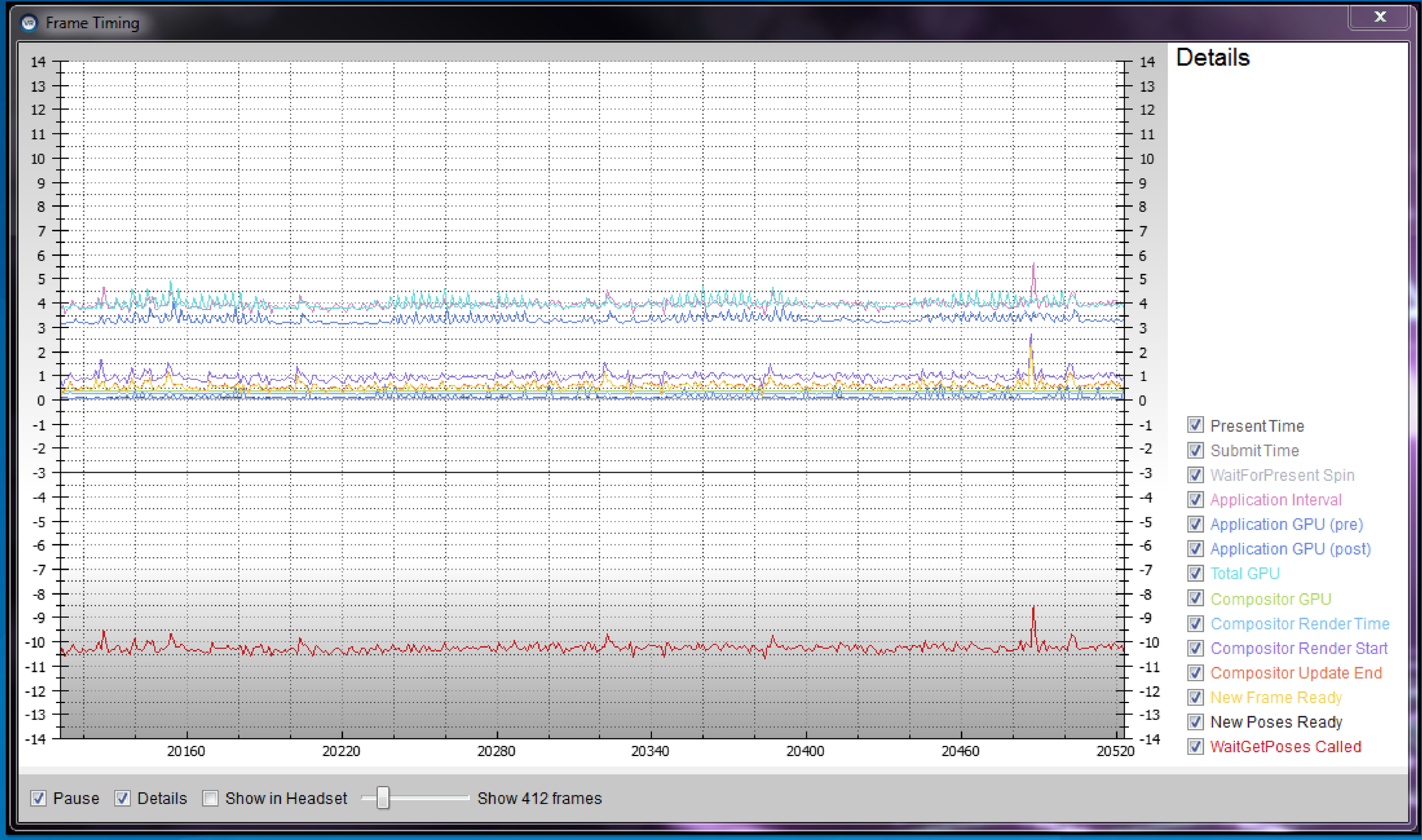
- The high threshold of 90% leaves 10% of the GPU idle for other processes almost every frame. This is a good thing.
- You need to share the GPU with other processes, even Windows desktop needs a slice of the GPU every few VR frames.
- Last year we recommended a GPU budget of 11.11ms but now we recommend less - 10.0ms per frame, so you almost never starve other processes of GPU cycles.

Graphics Tools & Resources

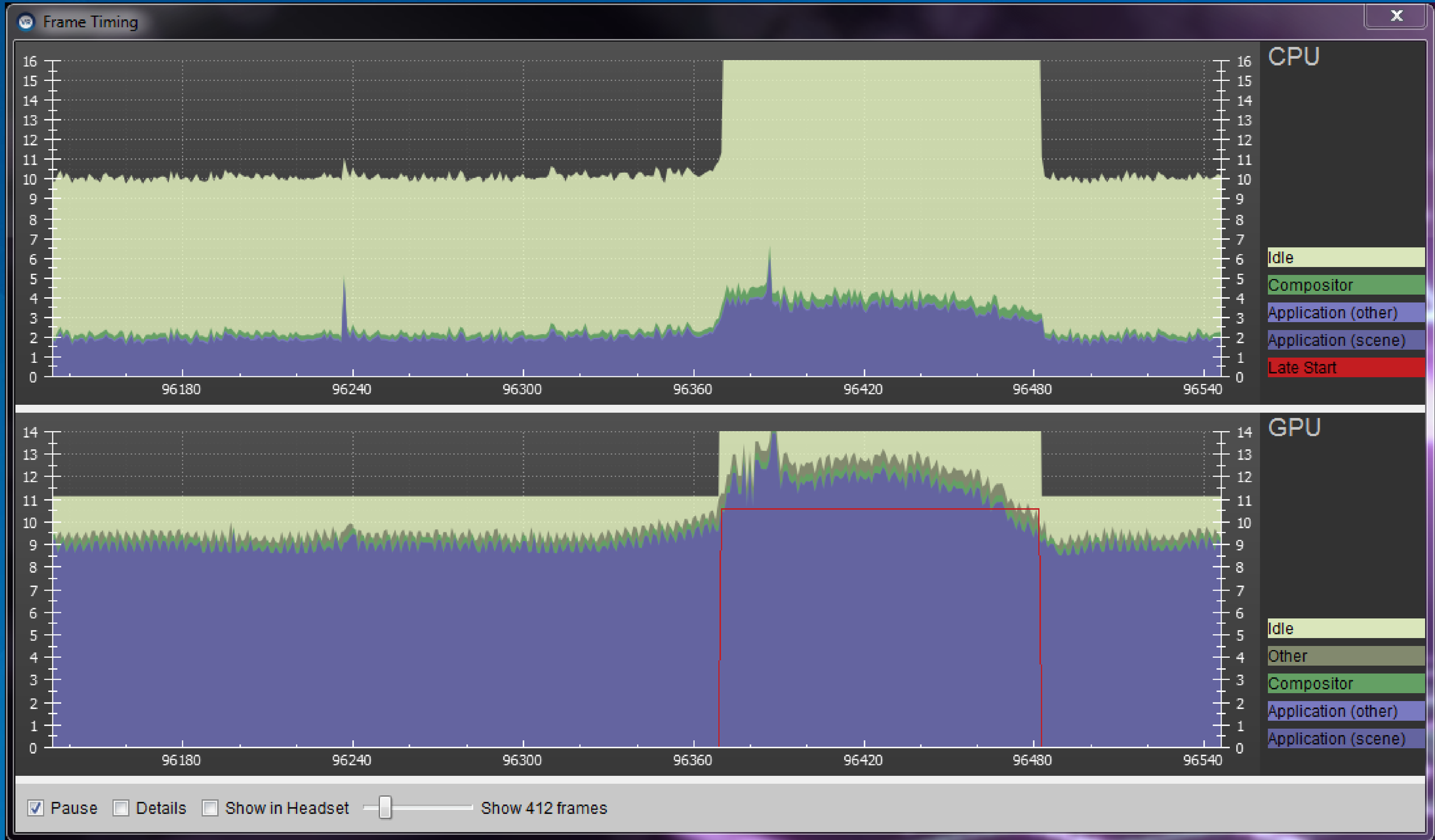
Medium-Level Background:

- https://developer.valvesoftware.com/wiki/SteamVR/Frame_Timing
- https://developer.valvesoftware.com/wiki/SteamVR/Installing_GPU View
- IVRCompositor::GetFrameTiming && ::GetFrameTimeRemaining


Frame Timing
CPU
Idle
Compositor
App Post-Submit
App Pre-Submit
Late Start
GPU
Idle
Compositor
Application
Unknown
36450
36465
36480
36495
36510
36525
36540
Pause
Details
Show in Headset
Show 100 frames


Frame Timing
Details
Present Time
Submit Time
WaitForPresent Spin
Application Interval
Application GPU (pre)
Application GPU (post)
Total GPU
Compositor GPU
Compositor Render Time
Compositor Render Start
Compositor Update End
New Frame Ready
New Poses Ready
WaitGetPoses Called
20160
20220
20280
20340
20400
20460
20520
Pause
Details
Show in Headset
Show 412 frames


Frame Timing
Details
Present Time
Submit Time
WaitForPresent Spin
Application Interval
Application GPU (pre)
Application GPU (post)
Total GPU
Compositor GPU
Compositor Render Time
Compositor Render Start
Compositor Update End
New Frame Ready
New Poses Ready
WaitGetPoses Called
Pause
Details
Show in Headset
Show 126 frames


Frame Timing
CPU
Idle
Compositor
Application (other)
Application (scene)
Late Start
GPU
Idle
Other
Compositor
Application (other)
Application (scene)
96180
96240
96300
96360
96420
96480
96540
Pause
Details
Show in Headset
Show 412 frames

Scaling Tools & Resources

Graphics

- **Unity - The Lab Renderer**

  https://www.assetstore.unity3d.com/en/#!/content/63141

- Implements a single-pass forward renderer with MSAA, dynamic resolution, custom shaders / materials for shadows, GPU flushing
- We've fixed a few bugs since it initially launched, please reach out if you hit problems

WHY BOTHER SCALING

Why Bother Scaling

- Broaden Your Reach At Launch – You Choose Your Minimum Spec

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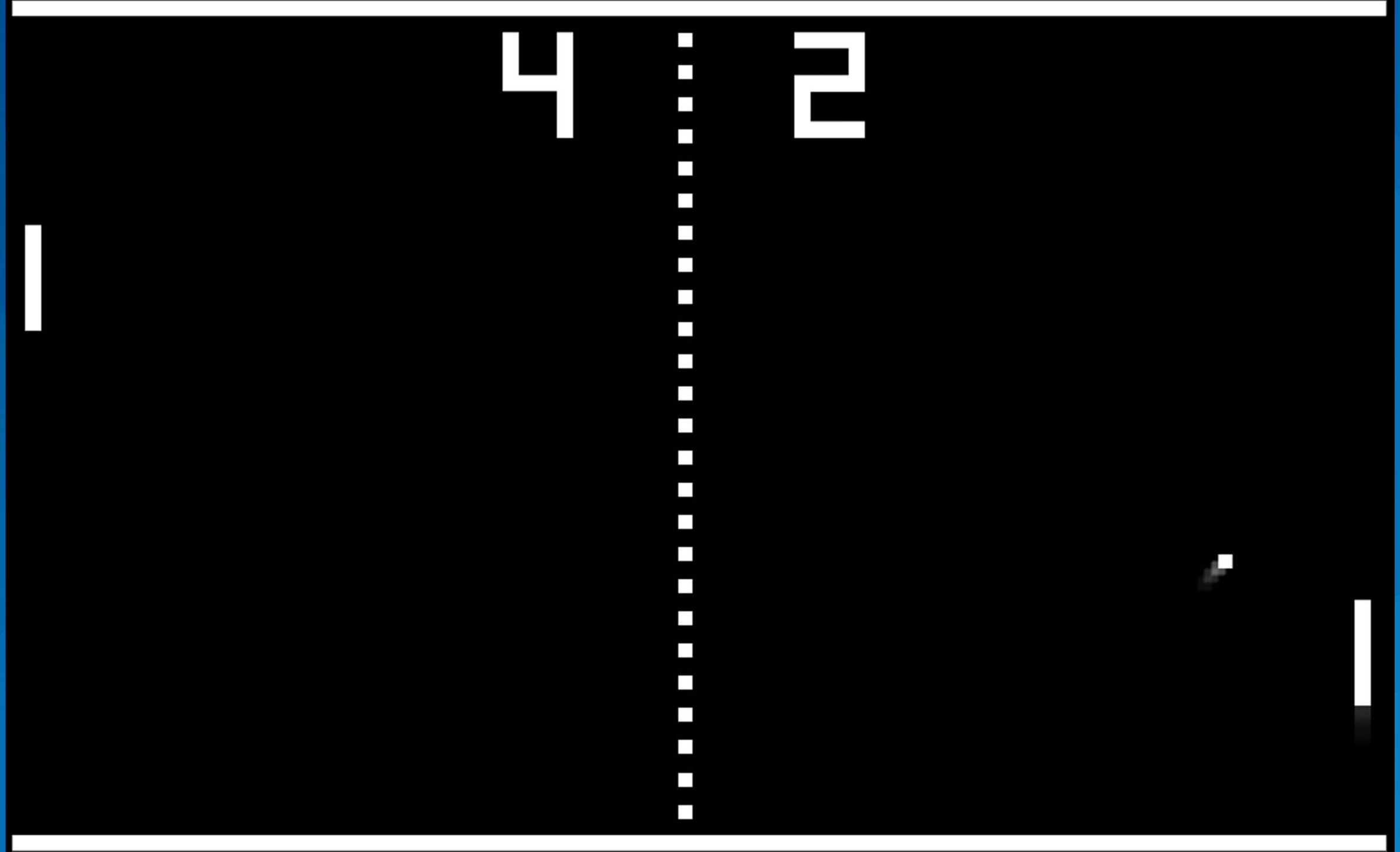
- **Longer Reach & Appeal Over Time**

Why Bother Scaling

- Broaden Your Reach At Launch – You Choose Your Minimum Spec
- Longer Reach & Appeal Over Time
- **OpenVR – Good For The Whole VR Ecosystem**

What Makes Great VR?


4
2

Vanishing Realms is an immersive RPG designed exclusively for Virtual Reality. Grab your sword and fight life-sized monsters in epic face-to-face melee combat. Explore mystic domains, outwit magical wards, seek lost artifacts, wield sorcery and steel to take on denizens of the Undead Realm.

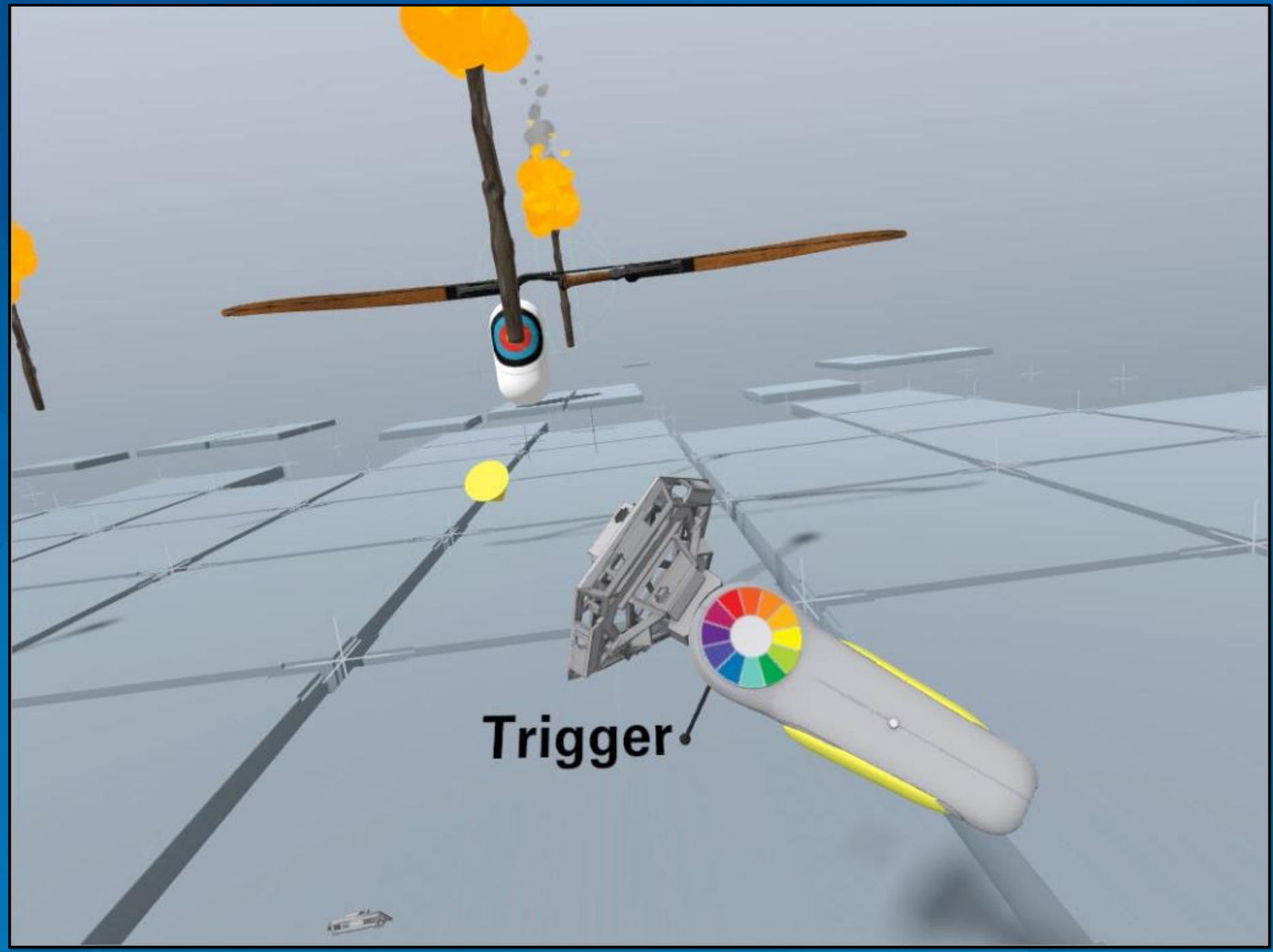
User reviews:
RECENT: Very Positive (98 reviews)
OVERALL: Overwhelmingly Positive (1,063 reviews)

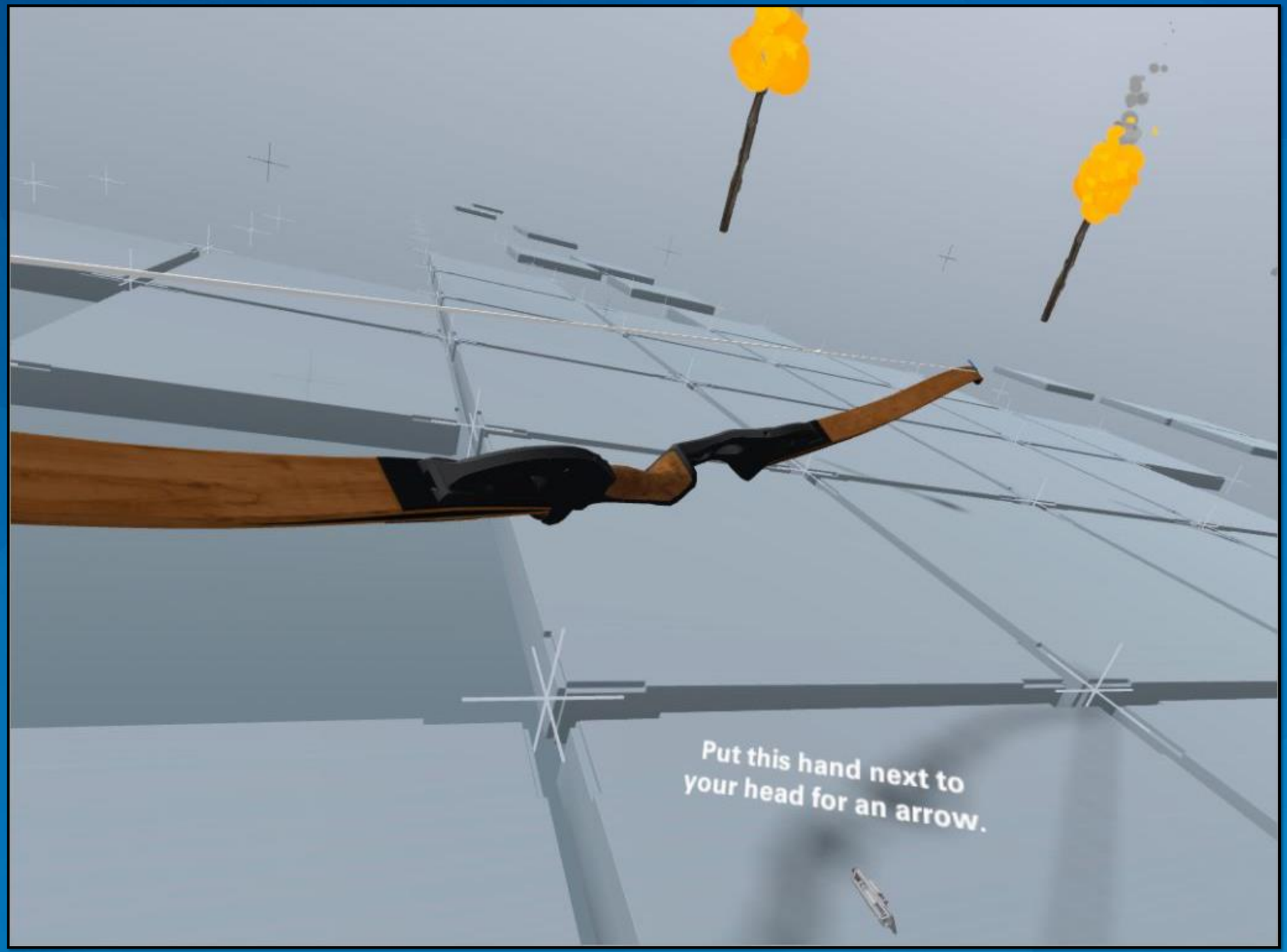
Release Date: Apr 5, 2016

Popular user-defined tags for this product:

Early Access | RPG | Adventure | VR


Gate Health


Trigger


Put this hand next to
your head for an arrow.


EMPLOYEE OF THE MONTH
JOBBOT
HUMAN
FRESH N' TASTY
100% MEAT
HOT DOGS
ONLY $2.99
MANAGER
BIG ROM
FIREWIRE
BLAZING FAST GUM
Dapple Sprackles
Triangles
Ranch Flavored
Triangle Corn Chip Snack
MOUNTAIN SCREAM!
LEMON LIME CREAM SODA
Job Simulation
BUNS!
LOTTERY TICKETS

Types of Scaling

1. Manual (User) Tuning
2. Automatic One-Time Tuning
3. Adaptive Scaling
4. Experience Scaling?

Conclusions

Diverse hardware is good

Embrace the medium – room-scale, tracked controllers

Consistency of interaction trumps perfect graphics

Use early-access to refine and polish

Ask yourself: Is there polish I could automatically or adaptively scale?

Q & A