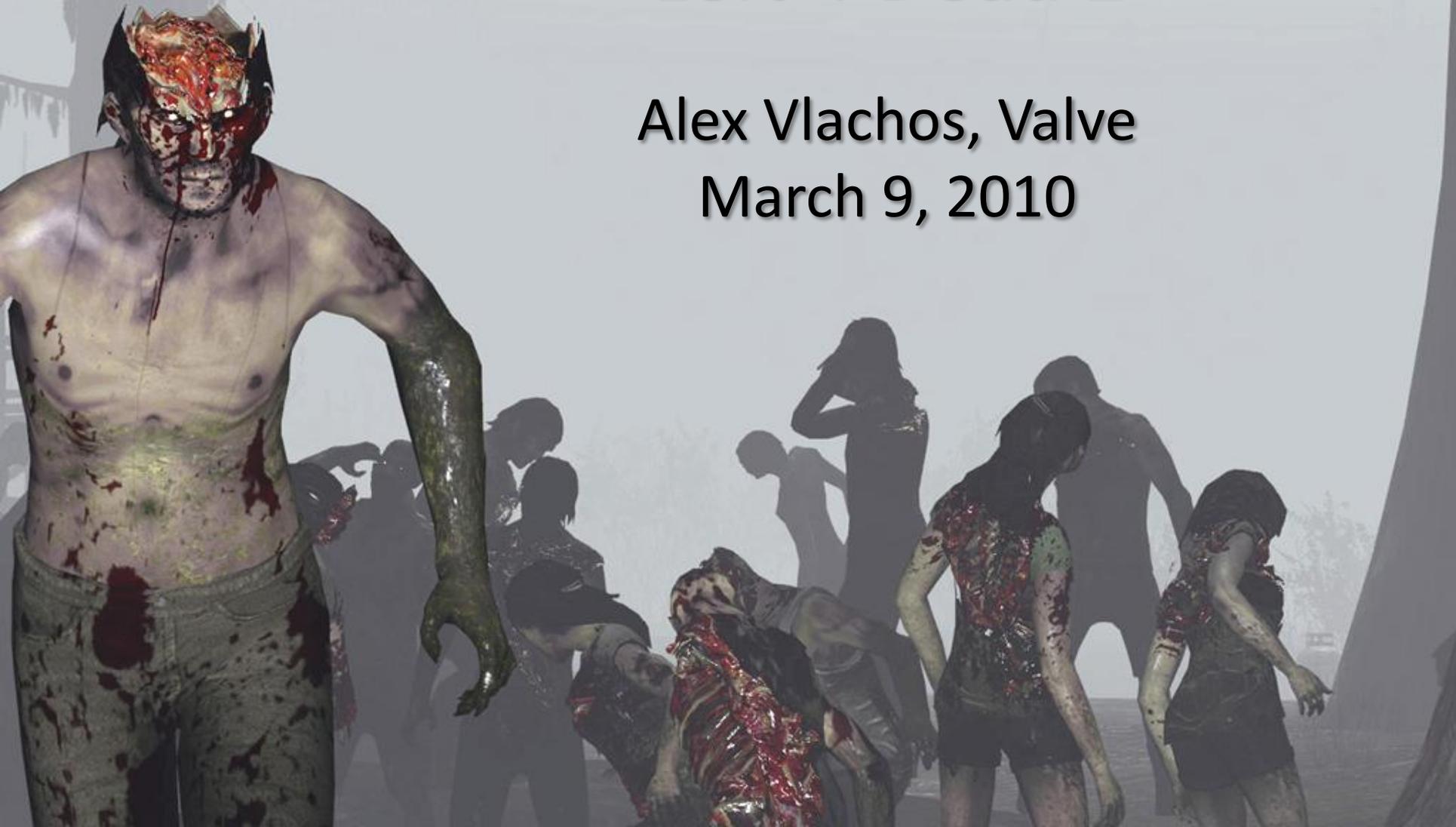


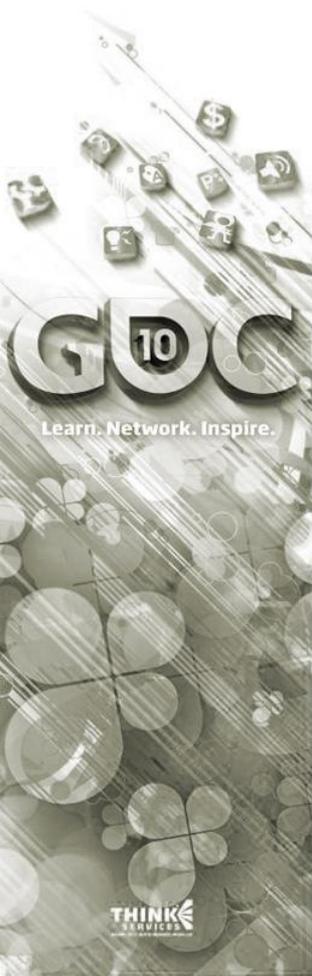
Rendering Wounds in Left 4 Dead 2

Alex Vlachos, Valve
March 9, 2010



Outline

- Goals
- Technical Constraints
- Initial Prototype
- Final Solution



Left 4 Dead 1 Wounds

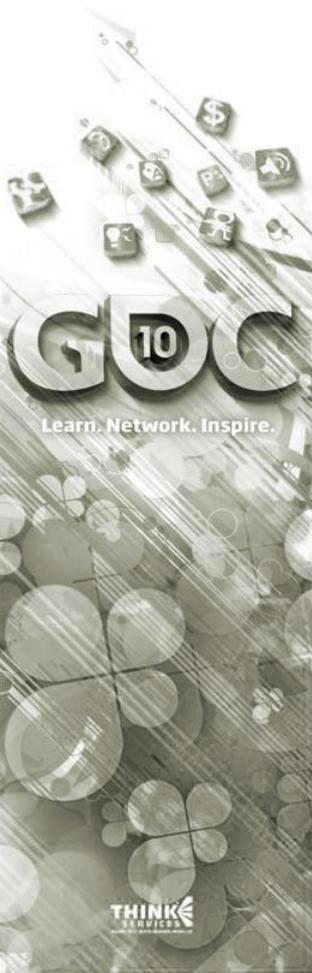
- Built-in
- 5 variations only
- Requires texture support
- Always Fatal



The Pitch

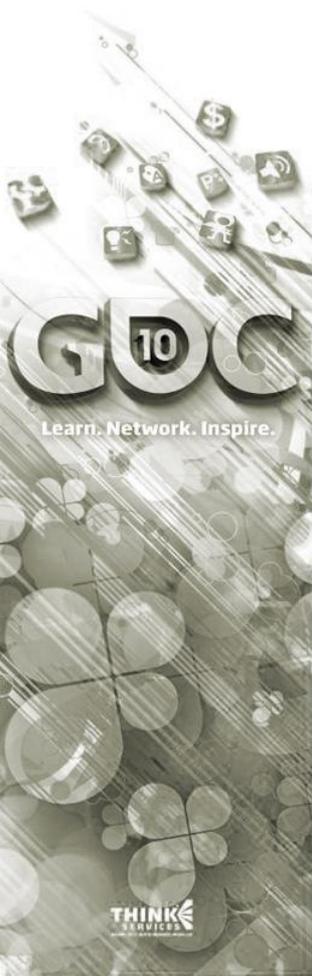
Gray Horsfield lives for destruction

(Gray is a Visual Effects Artist at Valve, previously at Weta)



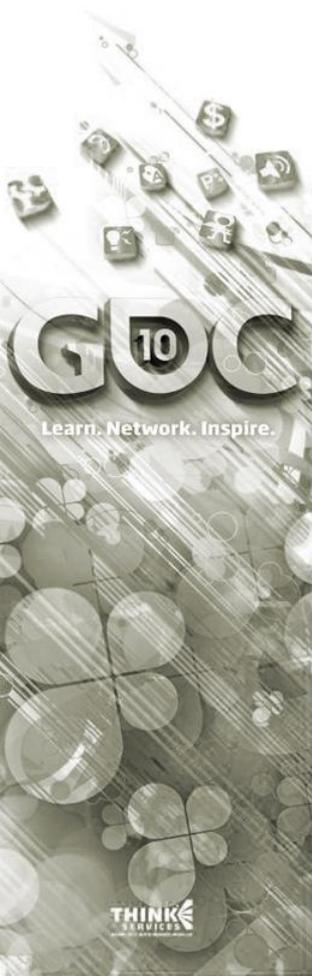
Goals

- Accurate location of wounds
- Wounds match weapon strength
 - Remove limbs, torso, head, half of body
- Separate wound geometry & textures
- Several active/visible wounds per model
 - Shipped up to 2 active wounds



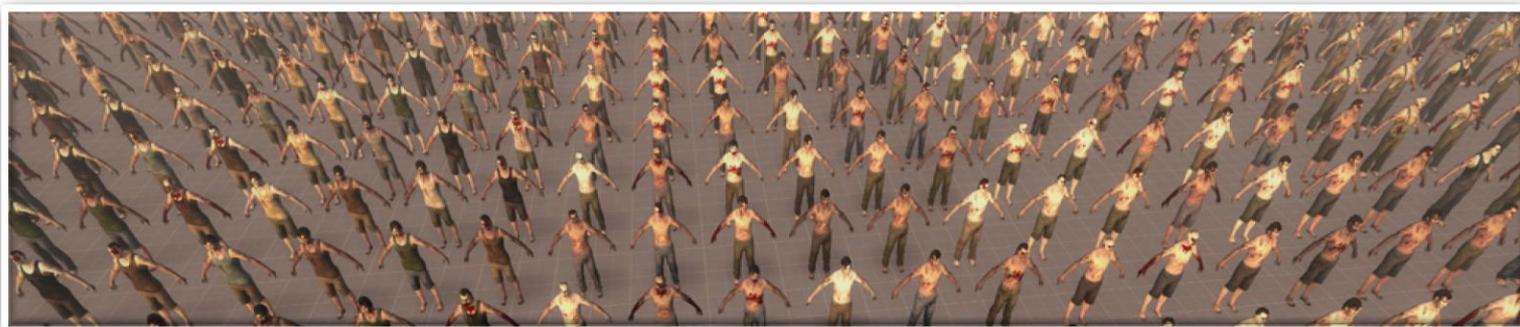
Technical Constraints

- Already at memory limits on the Xbox 360
- Didn't want heavy CPU setup
- Ideally wanted a GPU solution
- No additional base meshes except for wound geometry
 - Better for artists to author
 - Share wound models among many infected

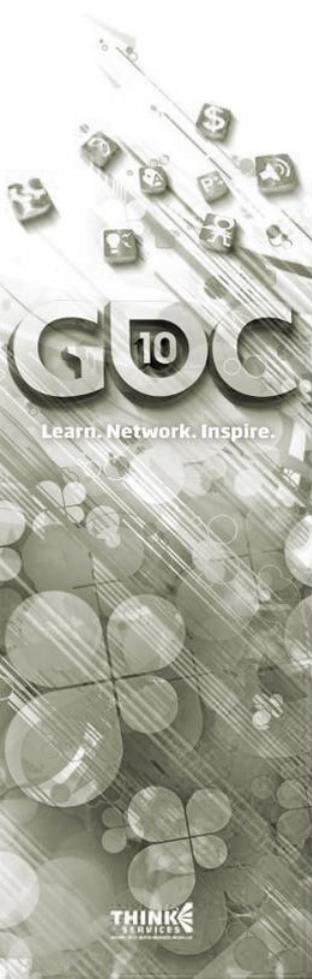


Common Infected Variation

- Simplest infected has over 24,000 variations

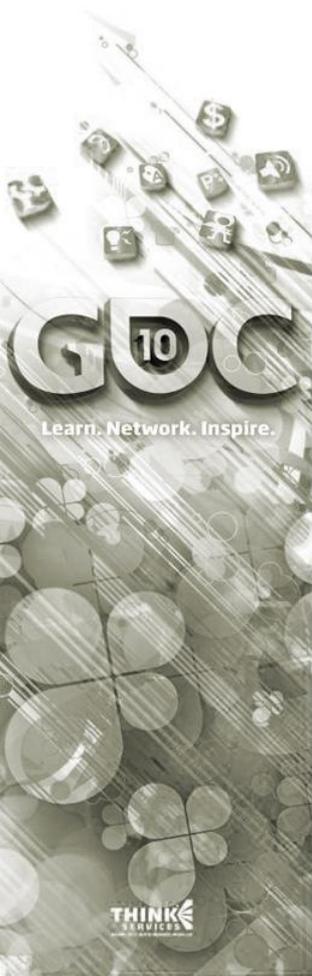


- We didn't want to add another variable to this



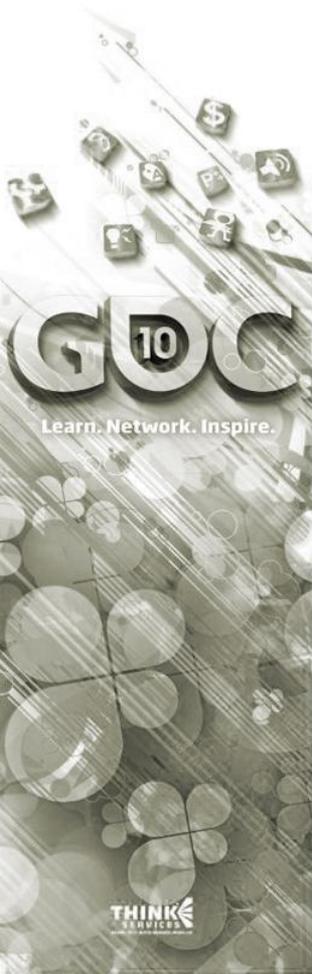
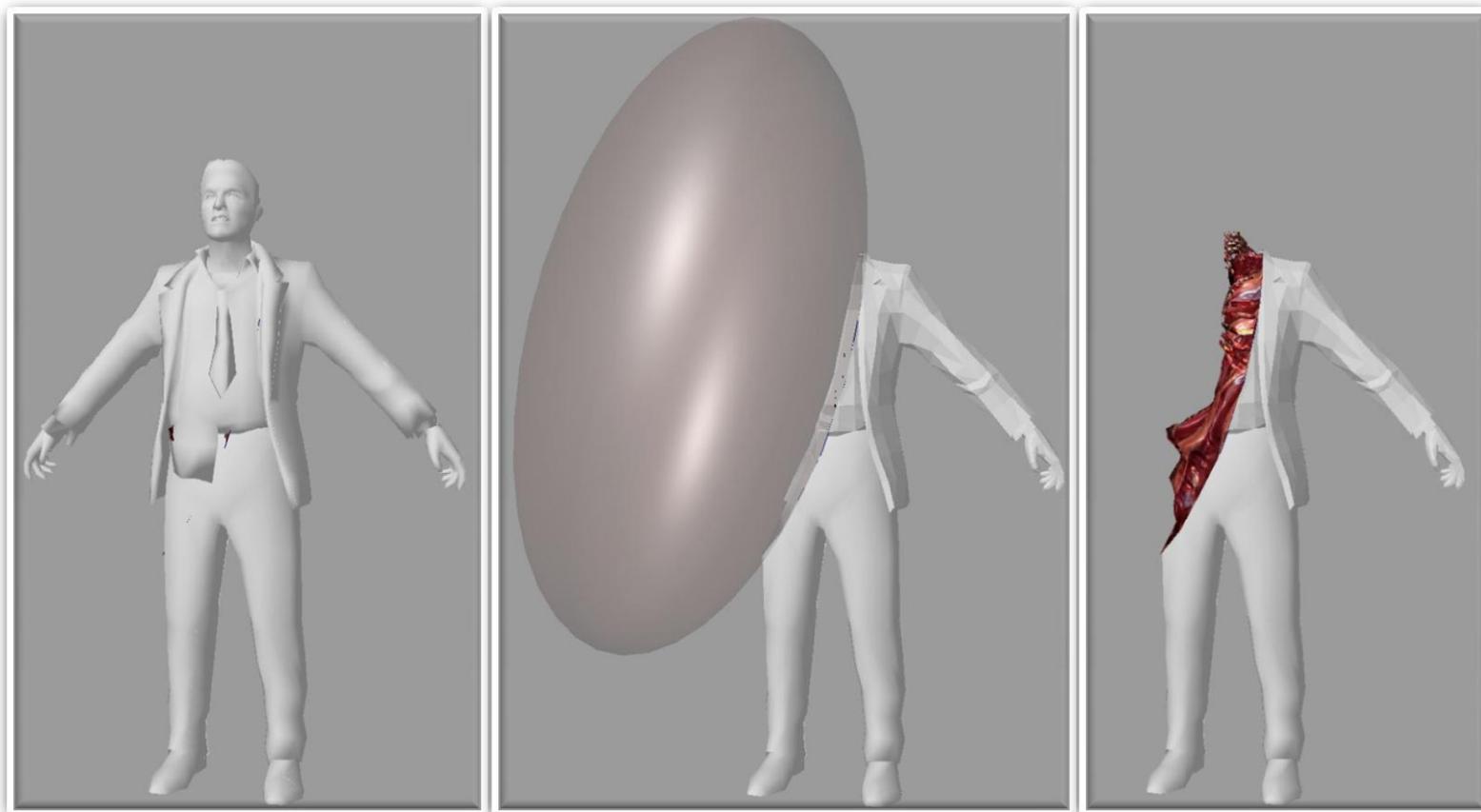
Things We Didn't/Couldn't Do

- Model variations of each infected with all combinations of 1 and 2 wounds
- Use different index buffers to cull polygons – not friendly with LOD and low quality wound silhouettes
- Auto-generate new polygonal meshes with holes cut for wound models
- Author different body parts/sections with different wound variations



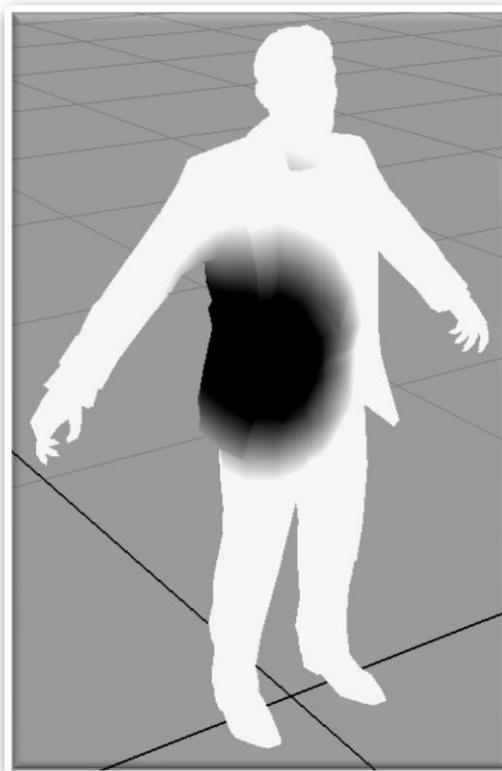
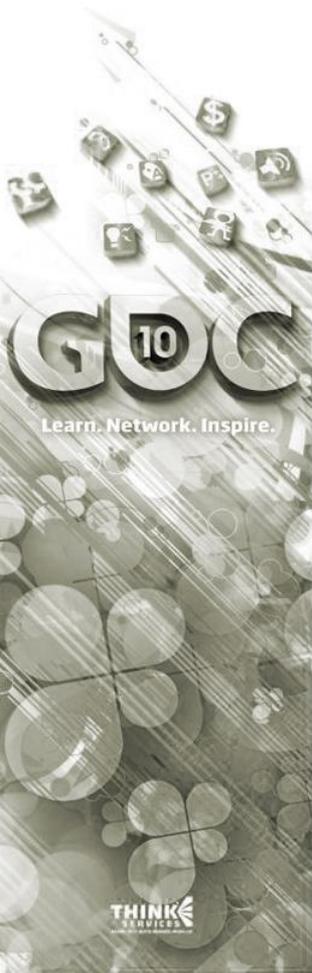
Initial Prototype

- Use pose-space ellipsoids to cull pixels
- Fill hole with wound model



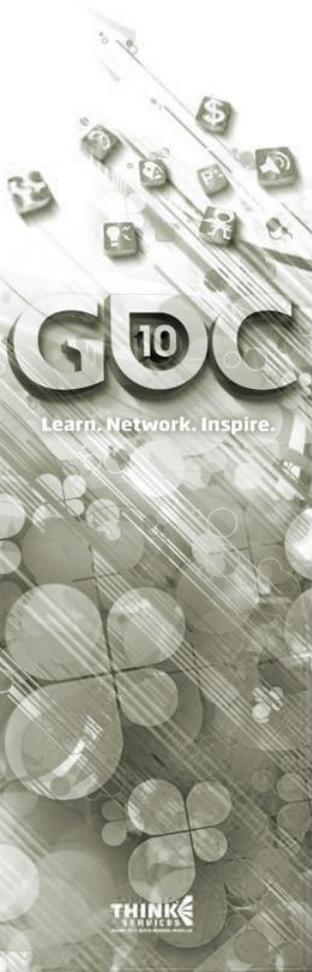
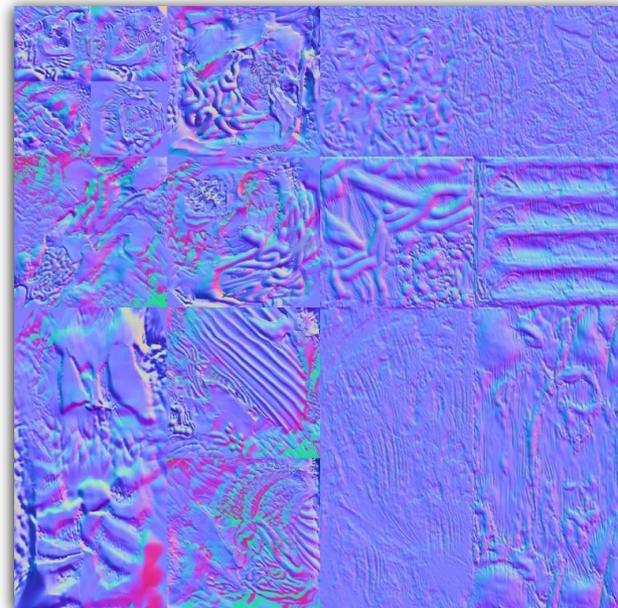
Culling Inside an Ellipsoid

- Vertex Shader calculates relative distance
- Interpolate this value and clip / texkill



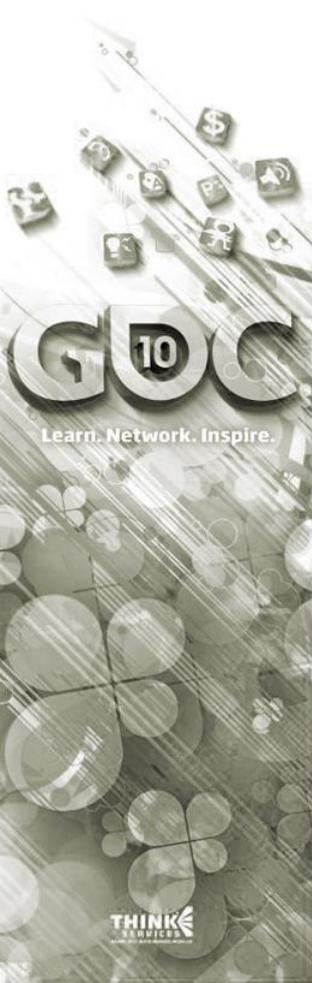
Benefits

- No additional vertex buffer data
- Still only one draw call for full model
- Wounds are a separate draw call with their own textures:



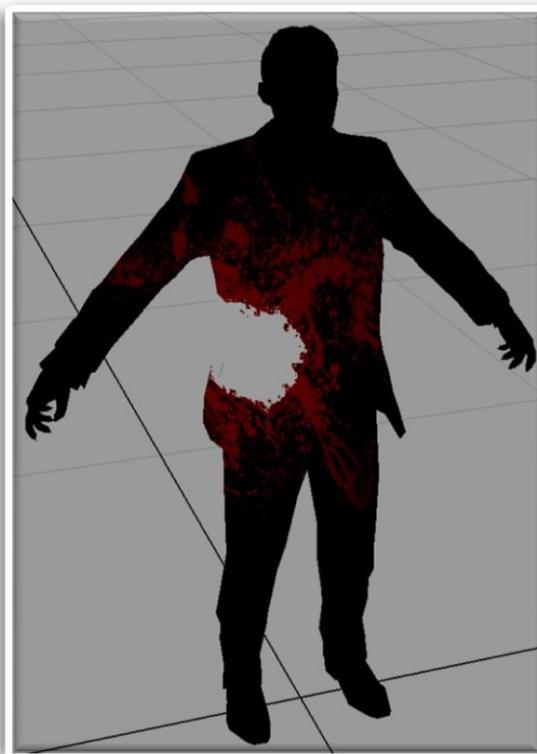
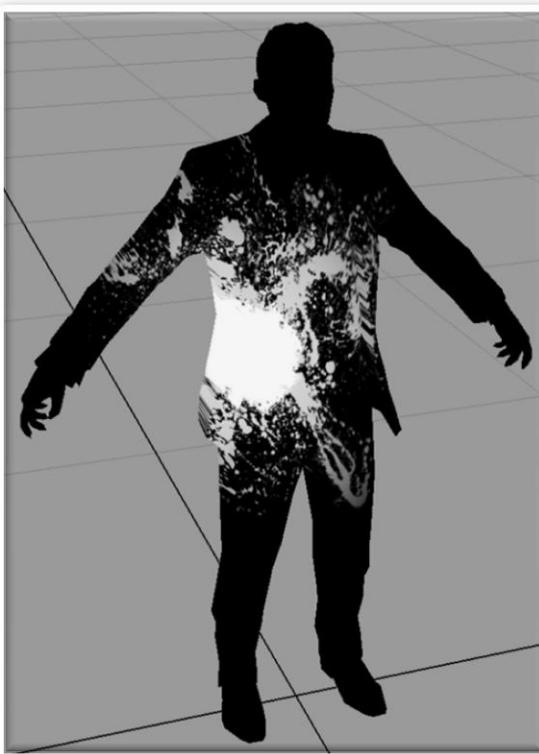
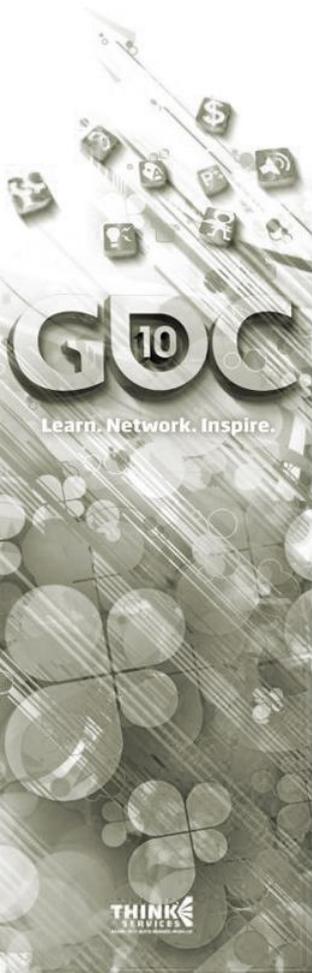
Problems

- Hard cut looked unnatural
- Wound models looked strange because they required a lip around the wound border
- Lacked blood on the clothes and skin near the border of the wound
- Required an exact geometric fit with the model

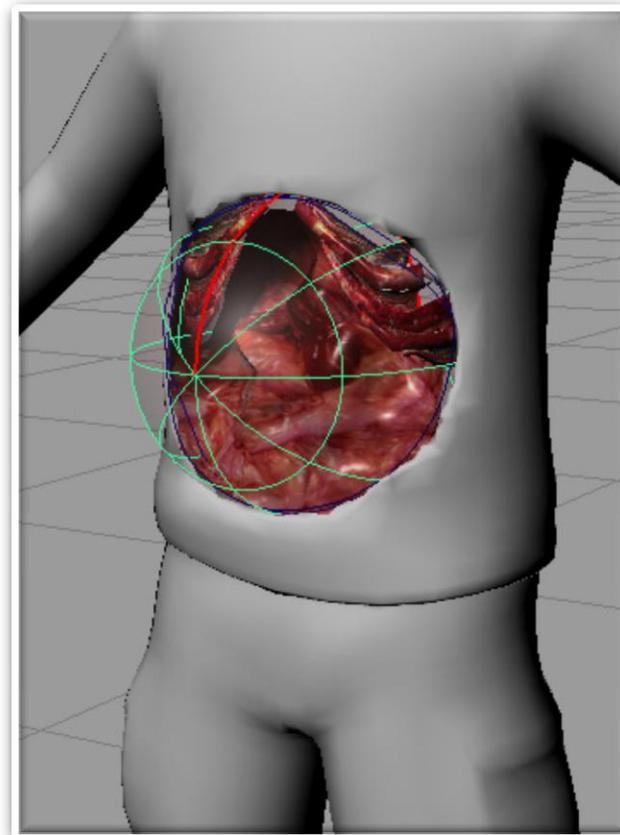


Projected Texture Experiment

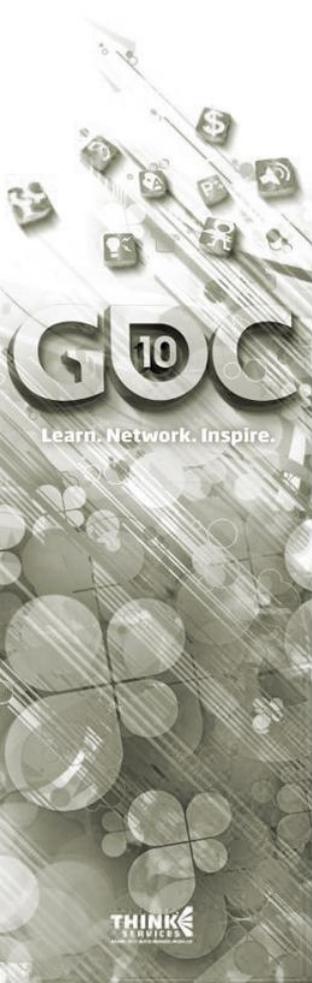
Try using a projected texture and use alpha to kill pixels



Abdominal Wounds

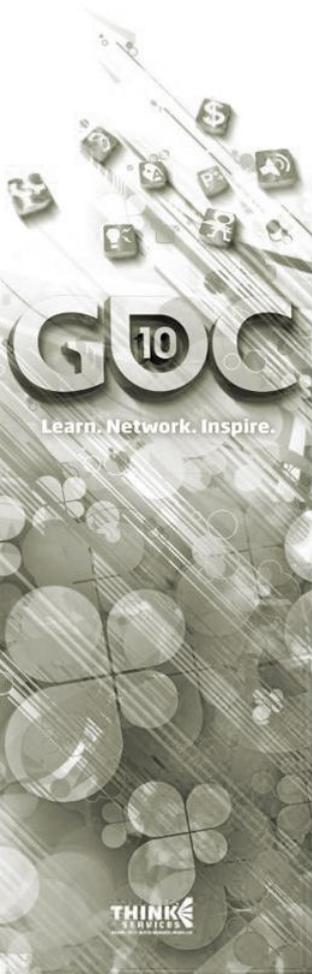


- Projected texture will affect his back
- So let's combine the texture and ellipsoid



Blood Layer

- The texture projection is aligned with an axis of the ellipse
- We multiply the blood layer by a gradient to prevent the blood from spraying too far



Vertex Shader Code

// Subtract off ellipsoid center

```
float3 vLocalPosition = ( vPreSkinnedPosition.xyz - vEllipsoidCenter.xyz );
```

// Apply rotation and ellipsoid scale. Ellipsoid basis is the orthonormal basis
// of the ellipsoid divided by the per-axis ellipsoid size.

```
float3 vEllipsoidPosition;
```

```
vEllipsoidPosition.x = dot( vEllipsoidSide.xyz, vLocalPosition.xyz );
```

```
vEllipsoidPosition.y = dot( vEllipsoidUp.xyz, vLocalPosition.xyz );
```

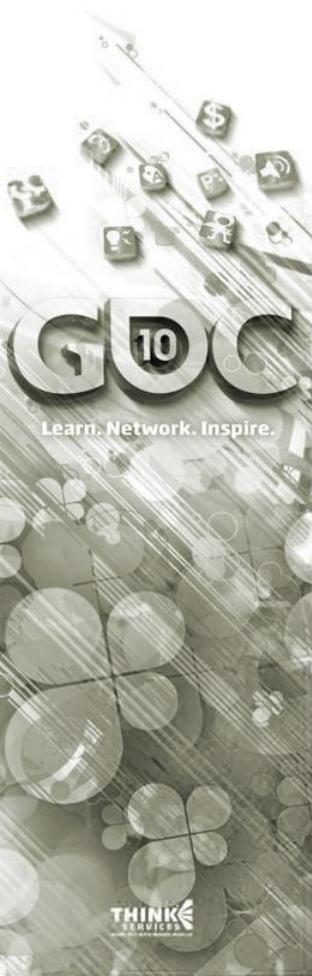
```
vEllipsoidPosition.z = dot( vEllipsoidForward.xyz, vLocalPosition.xyz );
```

// Use the length of the position in ellipsoid space as input to texkill/clip

```
float fTexkillInput = length( vEllipsoidPosition.xyz );
```

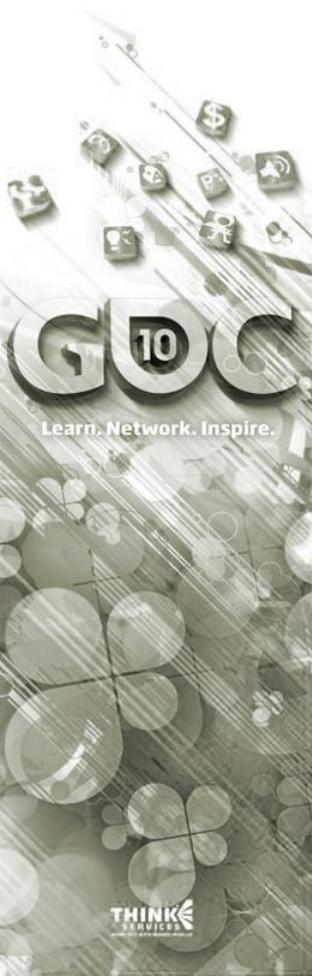
// We use the xy of the position in ellipsoid space as the texture uv

```
float2 vTextureCoords = vEllipsoidPosition.xy;
```



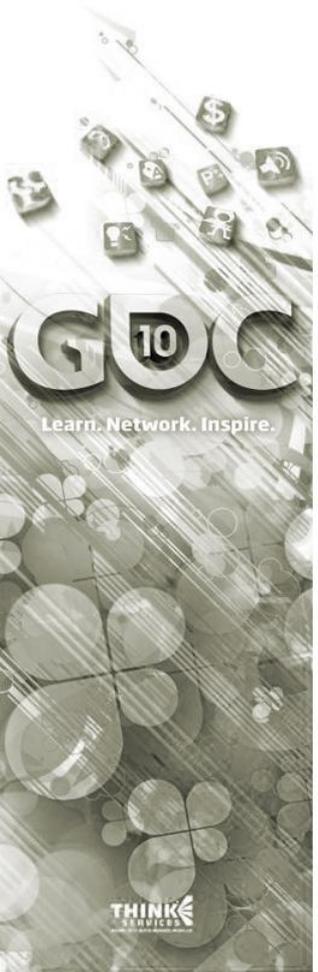
Other

- Depth-only and shadow render passes
 - You don't want phantom shadows
- Hi-Z performance issues
- Wound models are attached to base skeleton of infected model

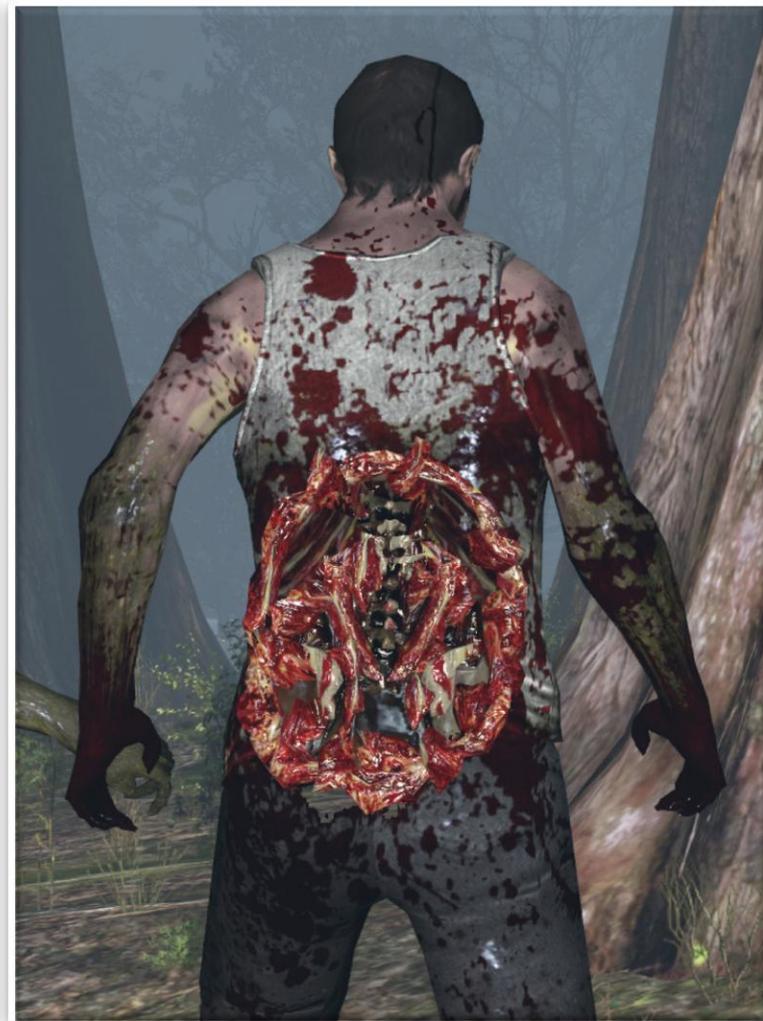


Multiple Wounds

We limited the final solution to 2 active wounds

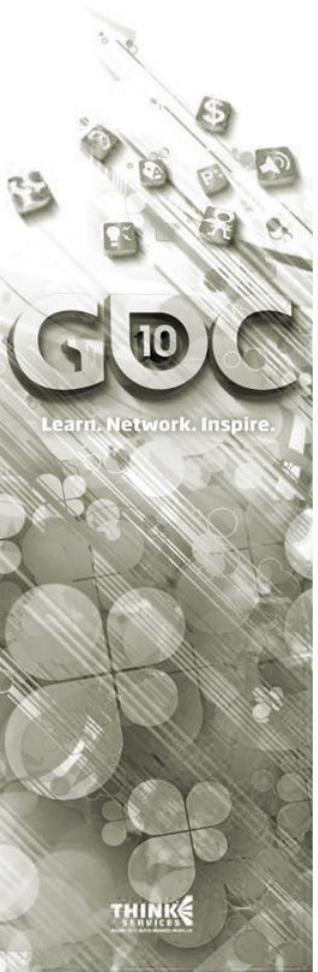


Upper & Lower Back



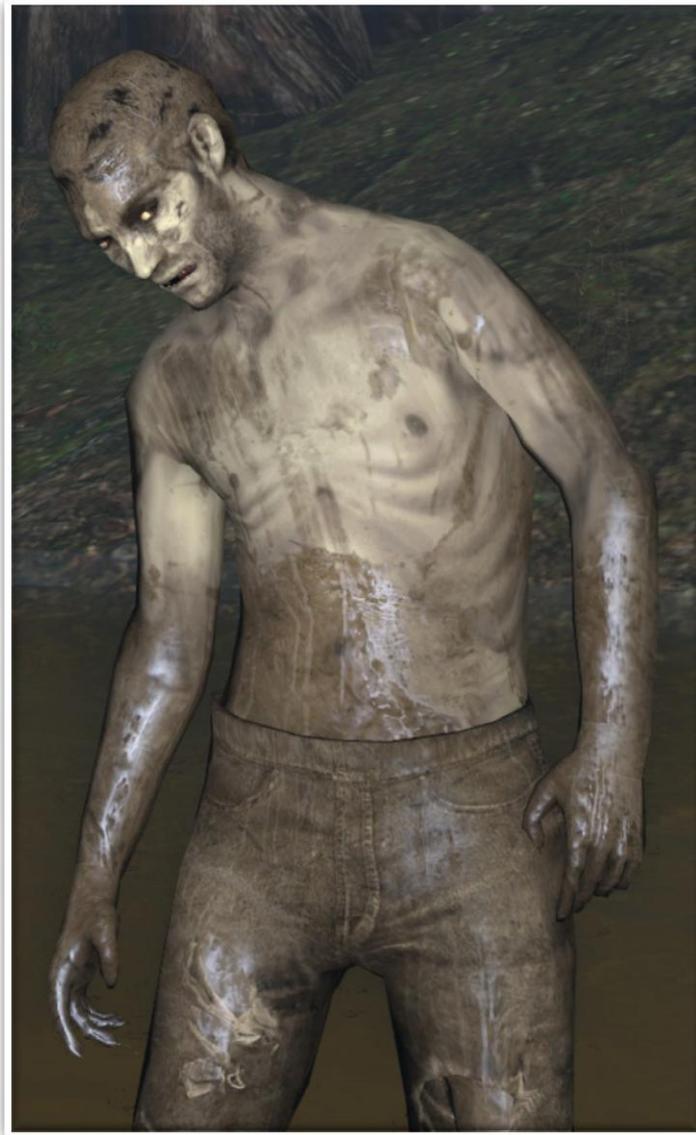
GDC 10
Learn. Network. Inspire.

Groin

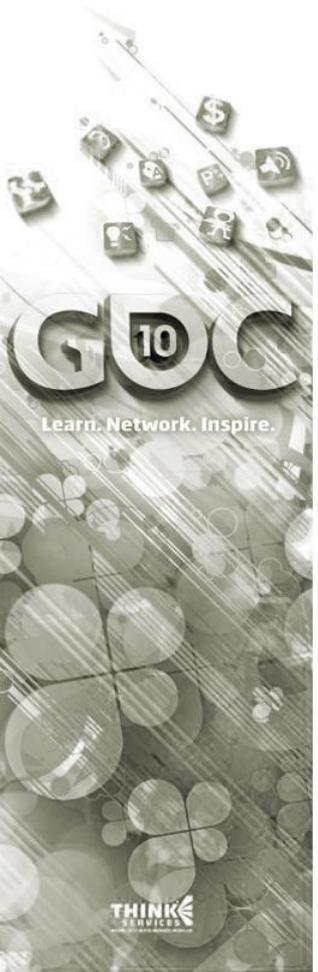


GDC 10
Learn. Network. Inspire.

THINK
SERVICES



Arms & Legs



GDC 10
Learn. Network. Inspire.

THINK
STUDIO

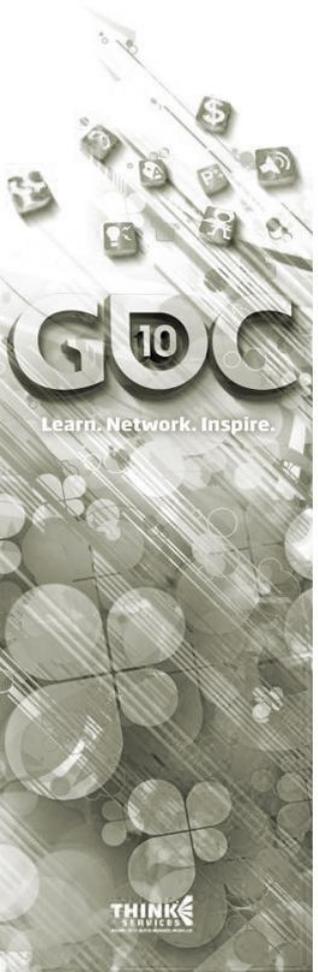


Abdomen

GDC 10
Learn. Network. Inspire.

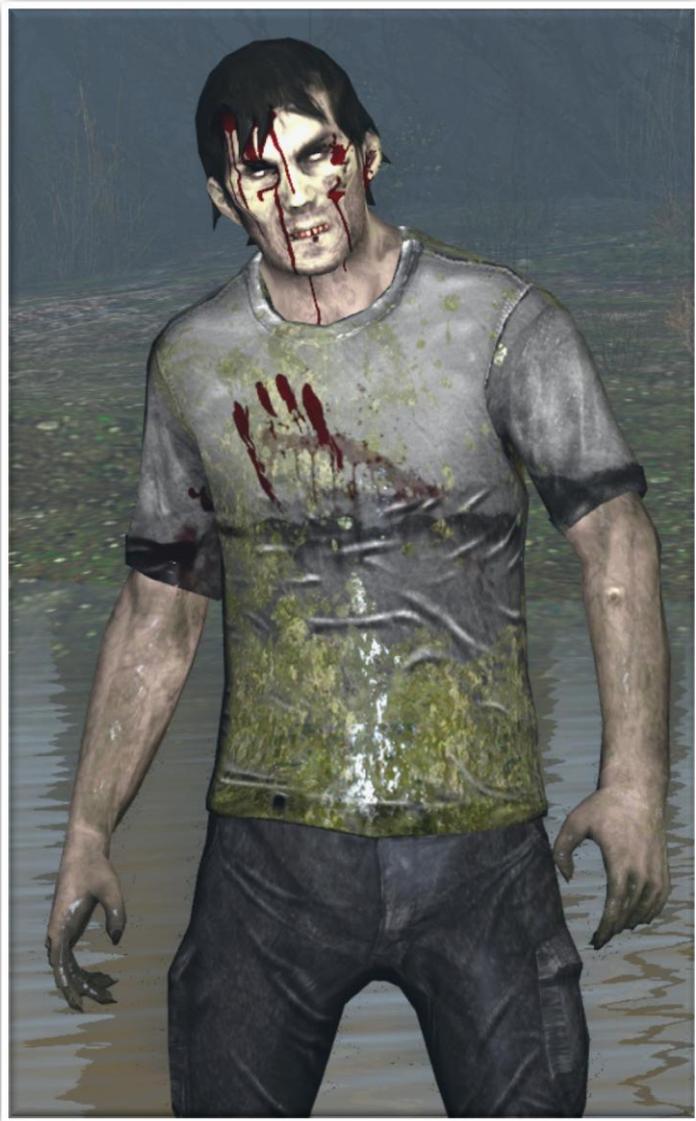


Head Wounds

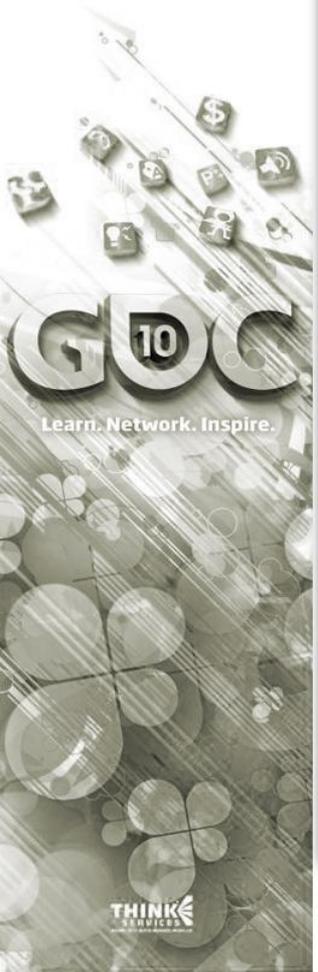


GDC 10
Learn. Network. Inspire.

THINK
SERVICES



Half Body



GDC 10
Learn. Network. Inspire.

THINK
STUDIO

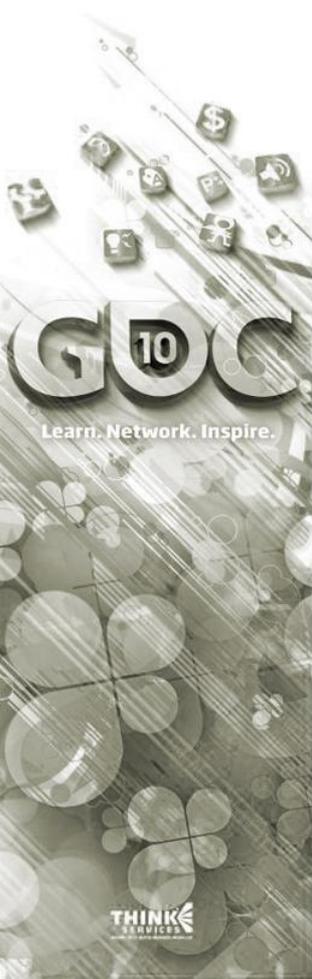


Axe & Sword Slashes



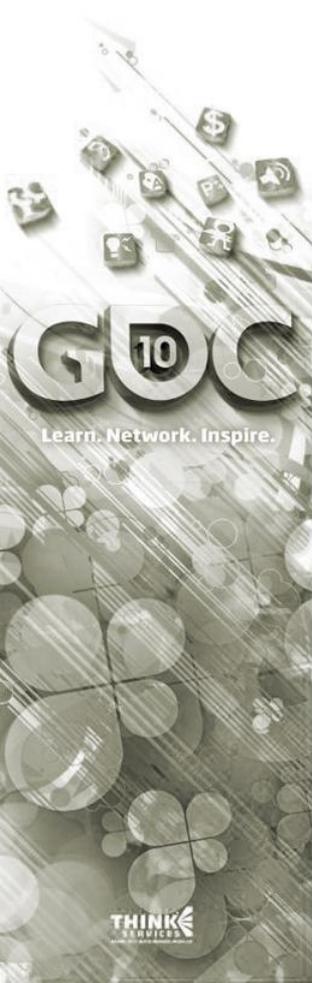
The GDC 10 logo is prominently displayed in the center, with the text "Learn. Network. Inspire." below it. The logo is surrounded by various decorative elements, including a cluster of dice and a stylized arrow pointing upwards. The background features a pattern of overlapping circles and lines, creating a dynamic, geometric look.

Upper Body



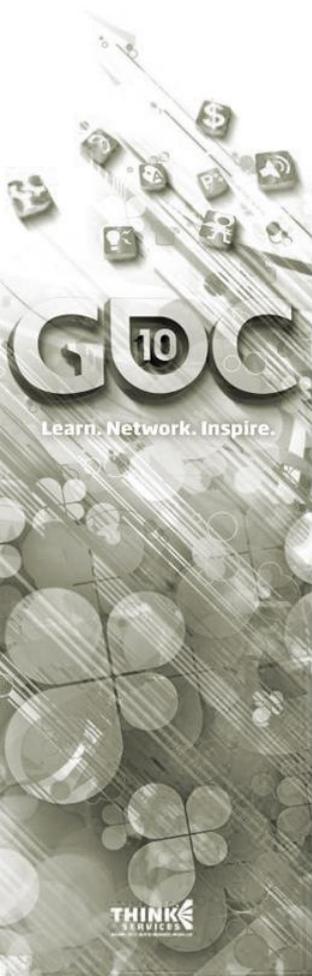
Stats

- Up to 54 unique wounds per model
- Each wound is only 13% of the memory cost of the old system in Left 4 Dead 1
- Vertex shader costs 15 instructions
 - Fill-bound, so rendering perf impacted minimally
- Pixel Shader costs 7 instructions

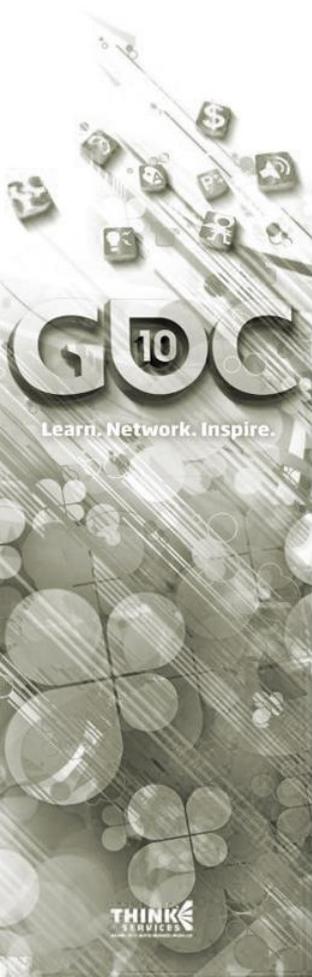


Summary

- Wound models separate from base mesh
- Use pose-space ellipsoids for outer limiting cull volume
- Use projected texture for rough edges and blood layer
- Additional details about our rendering:
<http://www.valvesoftware.com/publications.html>



Thank you!



Alex Vlachos, Valve
alex@valvesoftware.com