Adaptative Placement of Probes for Global Illumination

Taking full advantage of your CPU power using procedural techniques

Diego Garzon
Procedural Technical Lead

FORZA MOTORSPORT

XBOX
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EXCLUSIVE

Adaptative Placement of Probes for Global Illumination

Taking full advantage of your CPU power using procedural techniques

Overview

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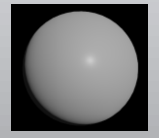
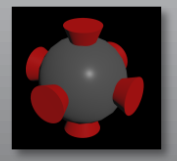
Global Illumination (in a nutshell)

Global Illumination (in a nutshell)

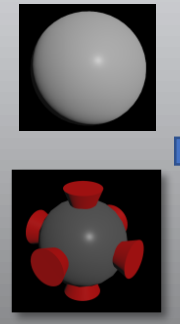
Probes



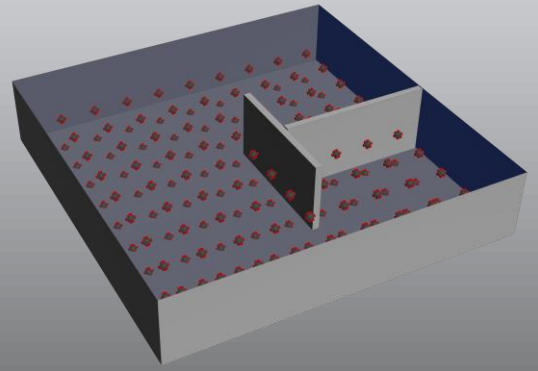


Global Illumination (in a nutshell)

Probes



Placement



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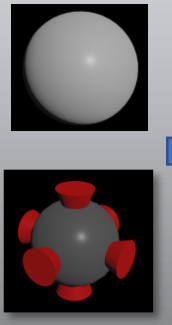
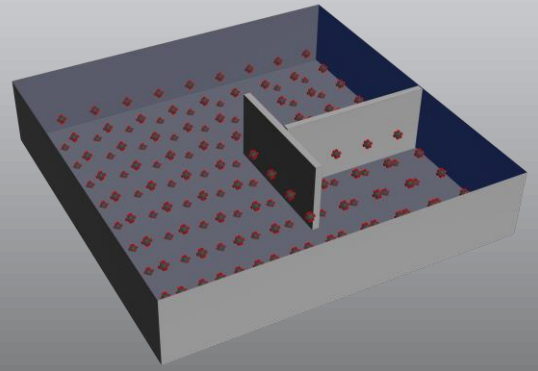
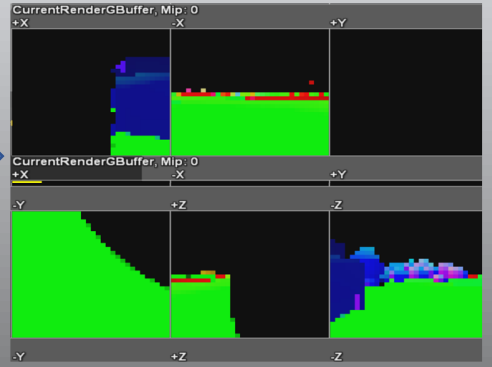


Placement

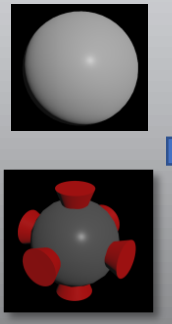


Baking

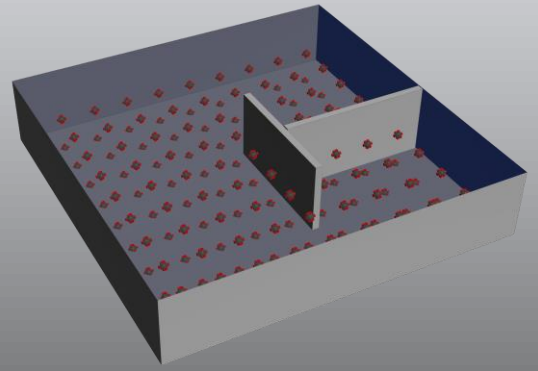


Global Illumination (in a nutshell)

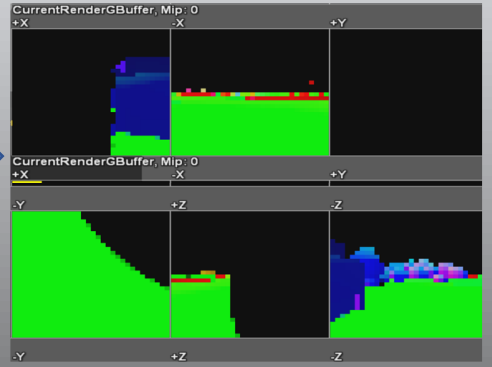
Probes



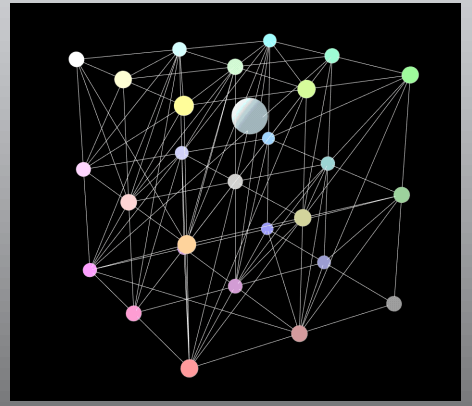
Placement



Baking

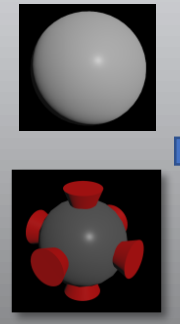


3D Texture Data

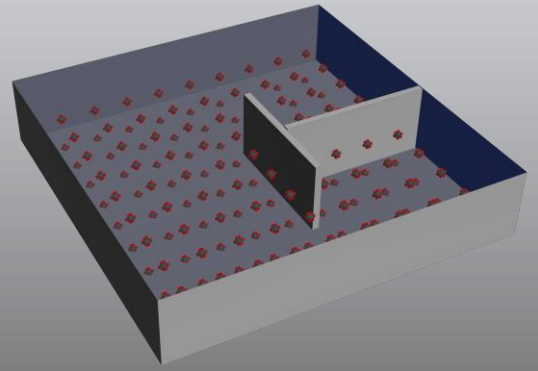


Global Illumination (in a nutshell)

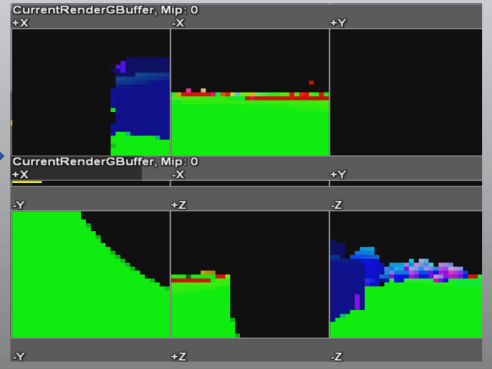
Probes



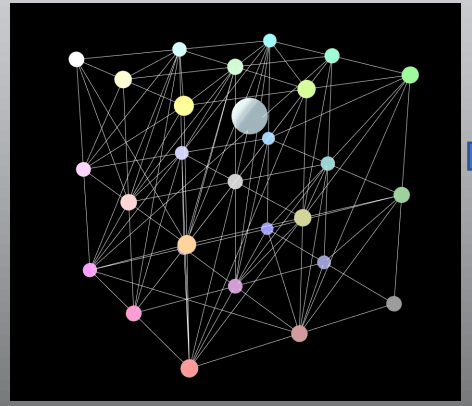
Placement



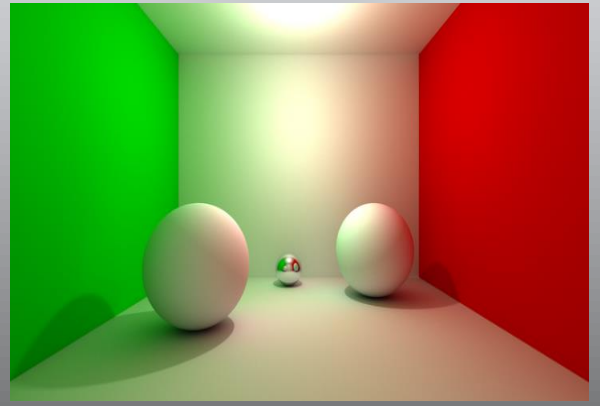
Baking



3D Texture Data



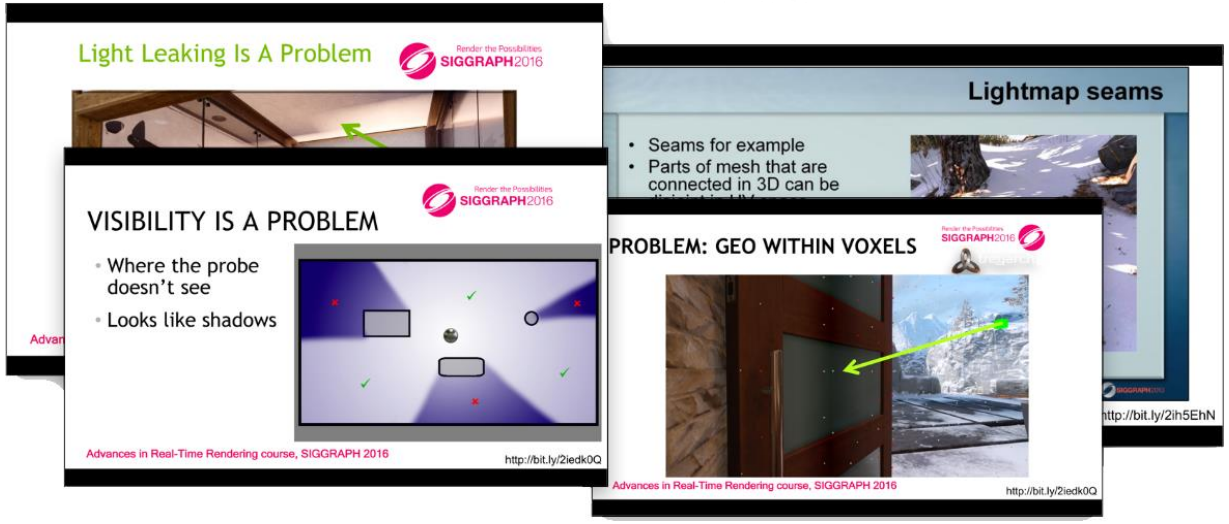
Applied data at runtime



The Challenges

The Challenges

- **Probes need to be strategically placed to avoid problems**
  - **Rule set driven**



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The Challenges

- **Increasing complexity of building AAA environments**

The Challenges

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  - Manual probe placing would require an immense amount of effort on some poor soul.

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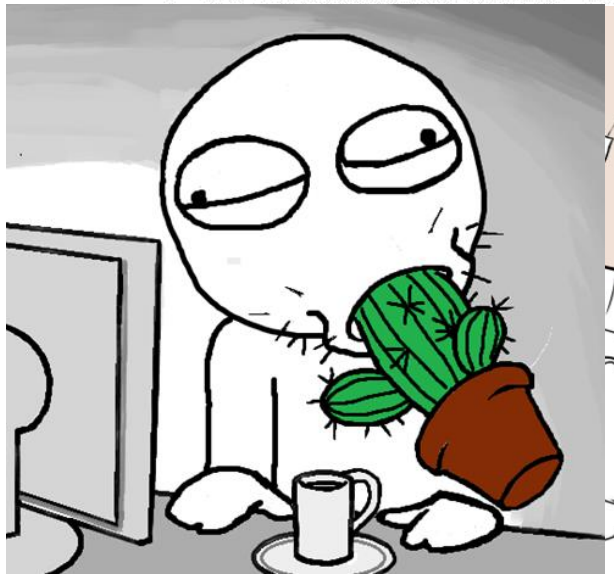
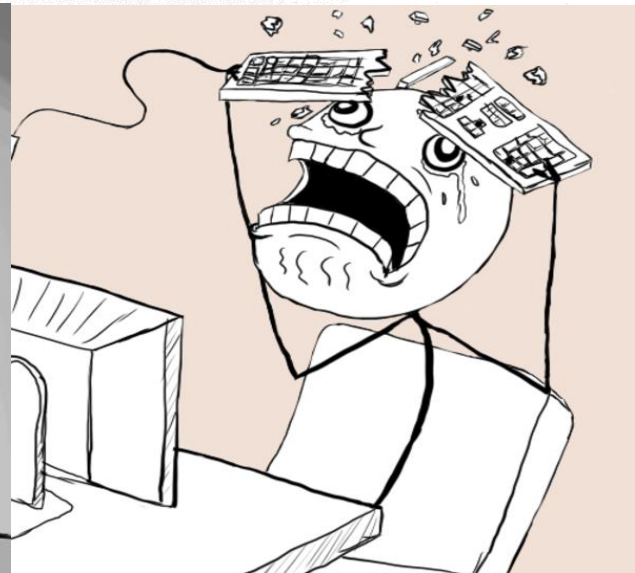
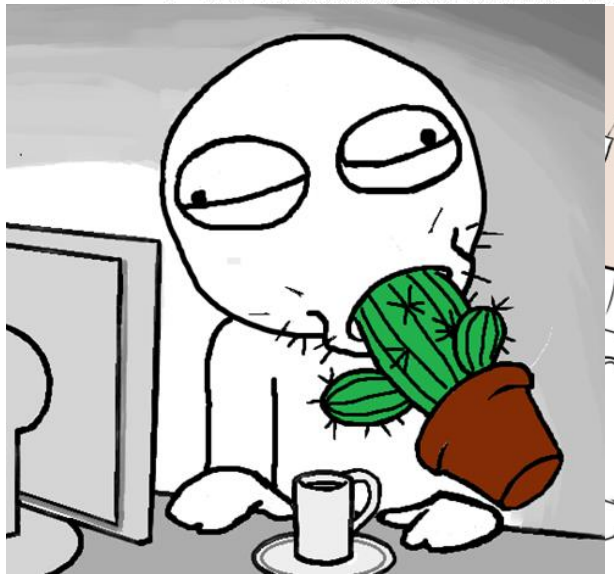
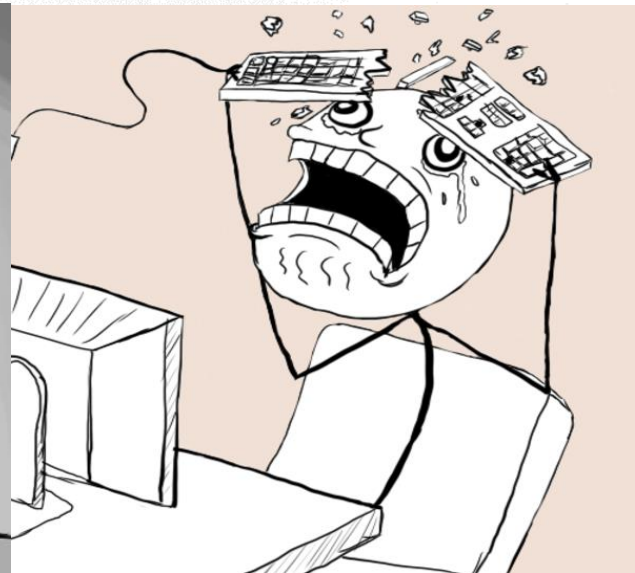




The Challenges

- Increasing complexity of building AAA environments
  - Manual probe placing would require an immense amount of effort on some poor soul.
  - Not sustainable





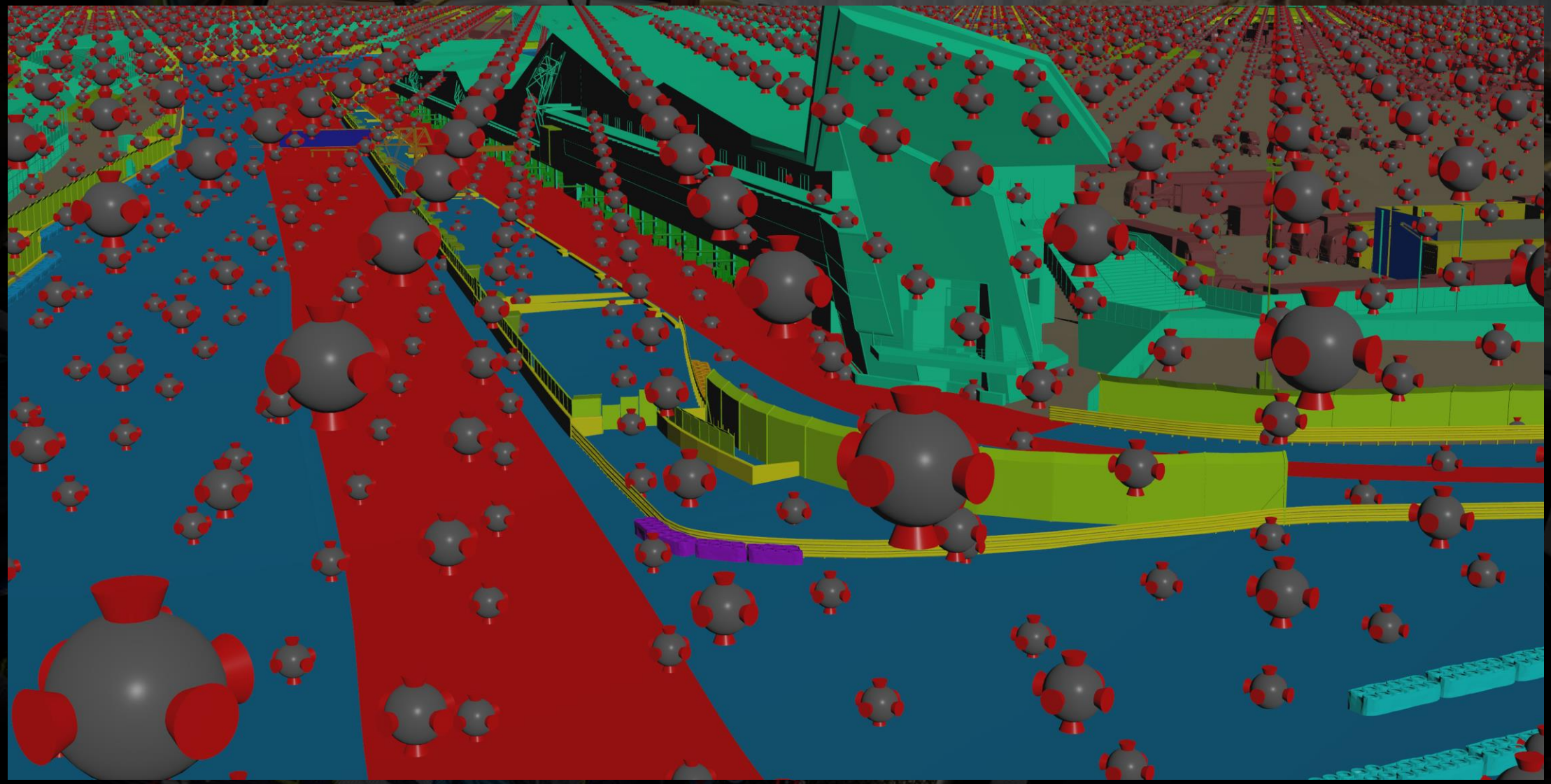
The Challenges

- Photorealistic visuals and running at 60 FPS at native resolution
  - Memory and disk space constraints

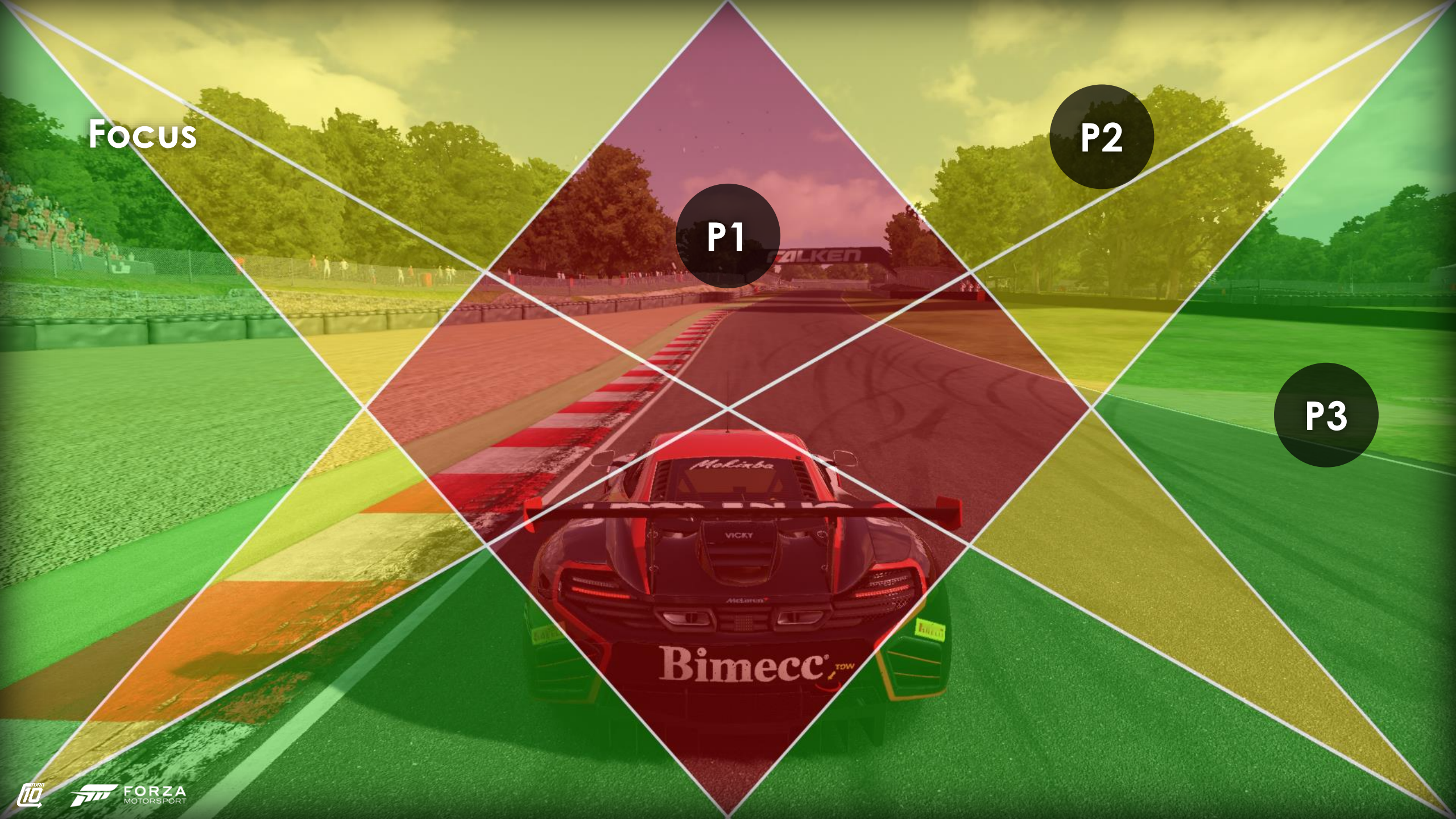
The Challenges

- **Flexible and scalable**

One size fits all solution



Adaptive


Focus
P1
P2
P3
Bimecc
FORZA
MOTORSPORT

Art Directing for 100 MPH

Balancing visuals with performance for Forza Motorsport

Matt Collins
CG Supervisor

Turn 10 Studios
Microsoft

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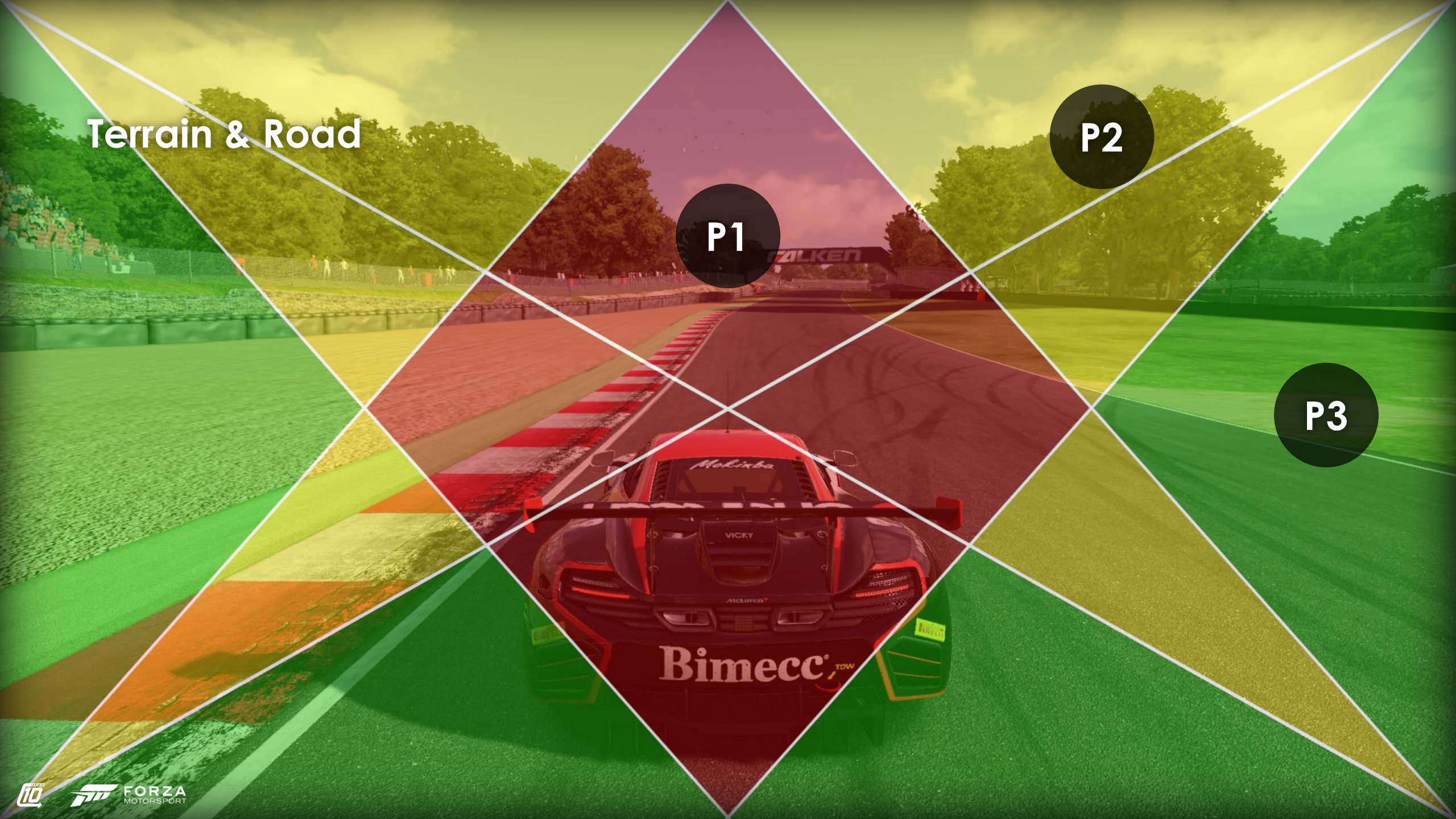
Approach

Terrain & Road



Global Coarse Envelope

Terrain + Road

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Load
Track

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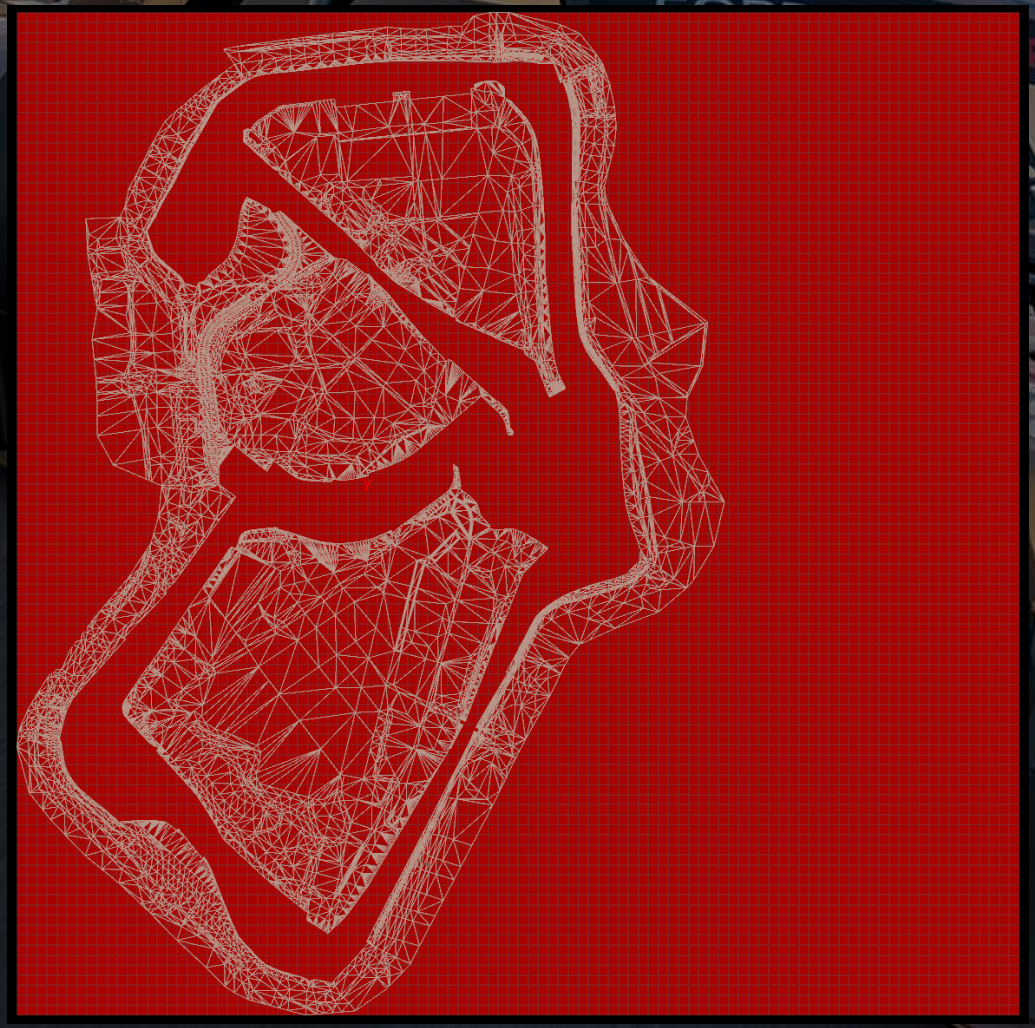
Create tiles on a square domain

Trace to Identify Active tiles



Only Active tiles

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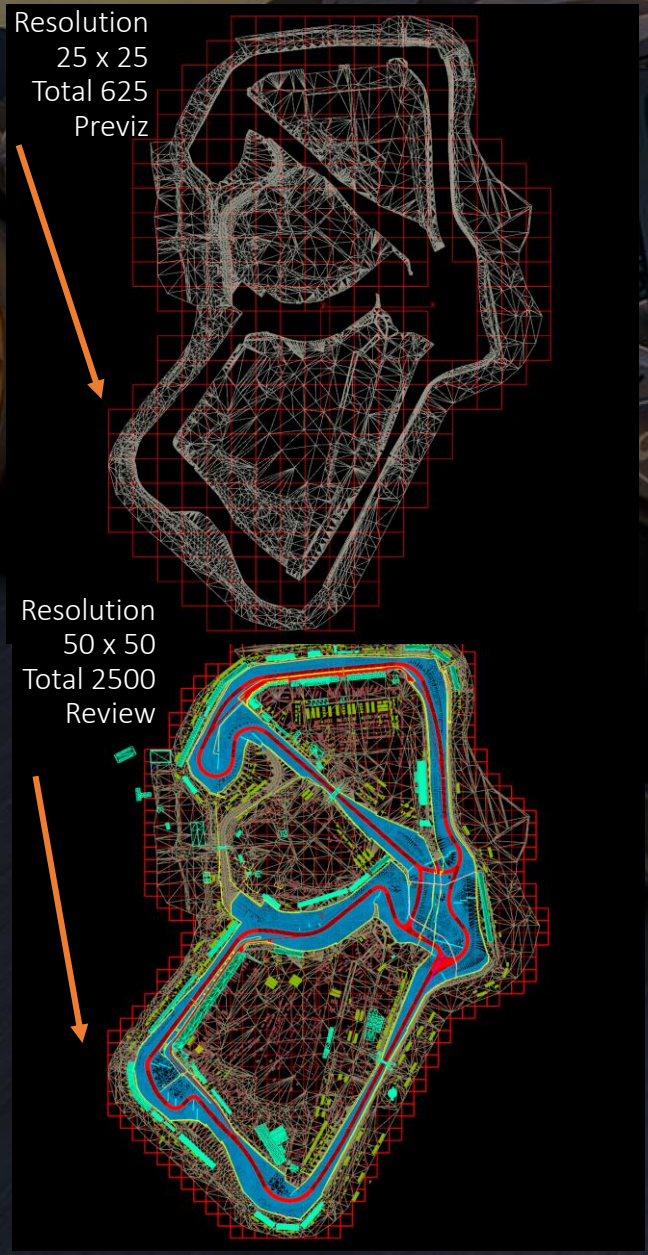
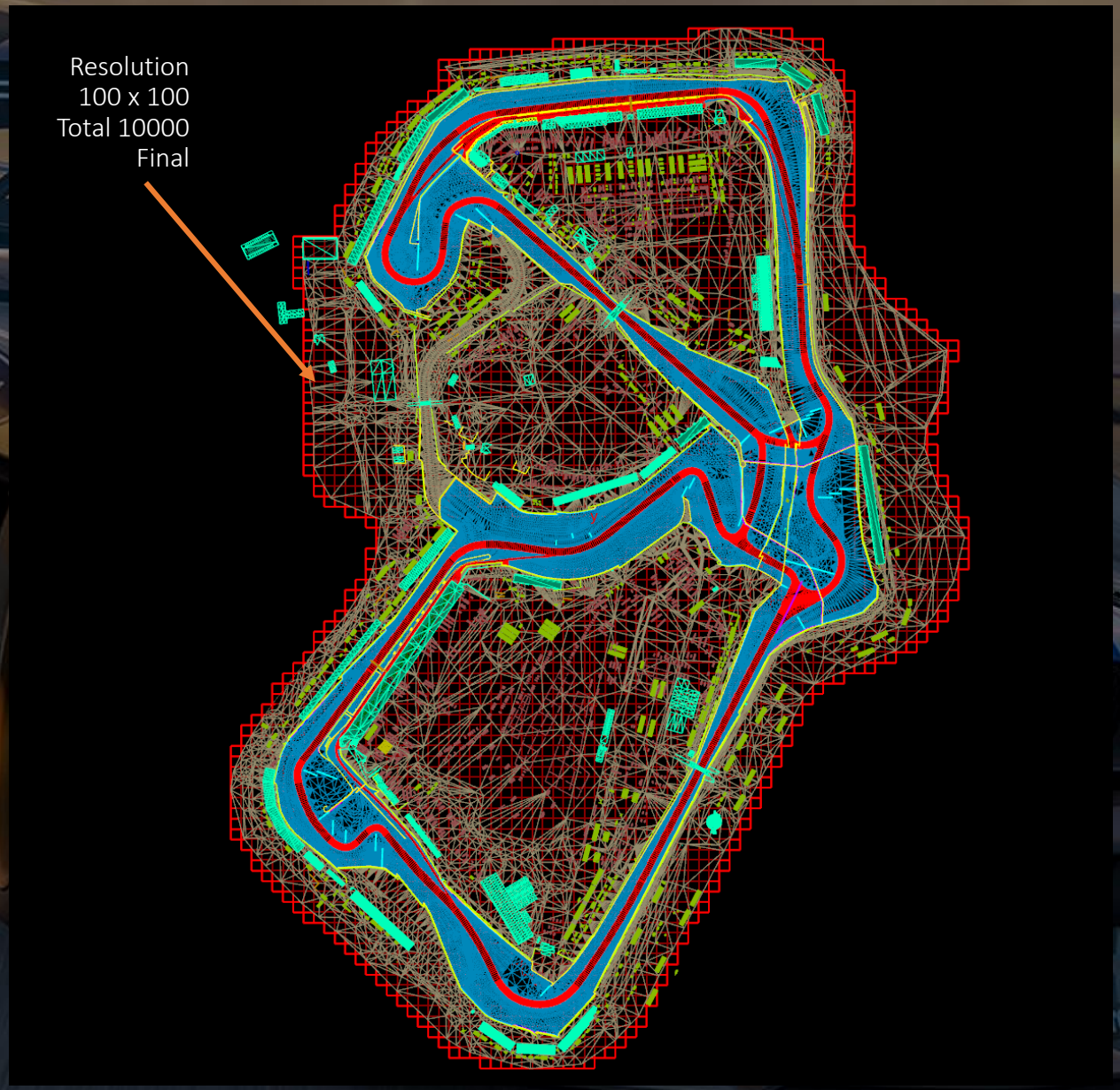
Tile Resolution





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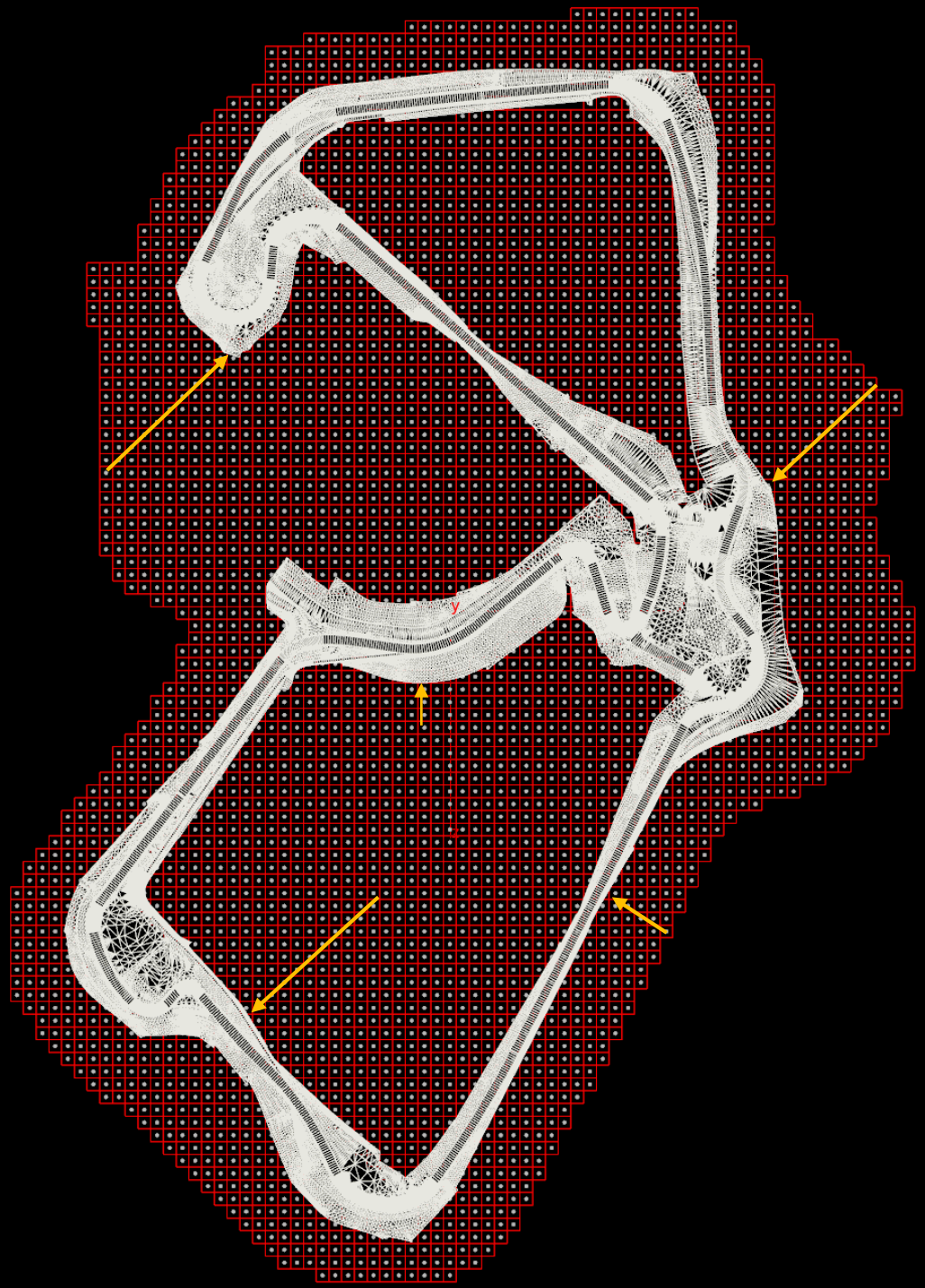
Trace tile midpoint to closet point on road surface



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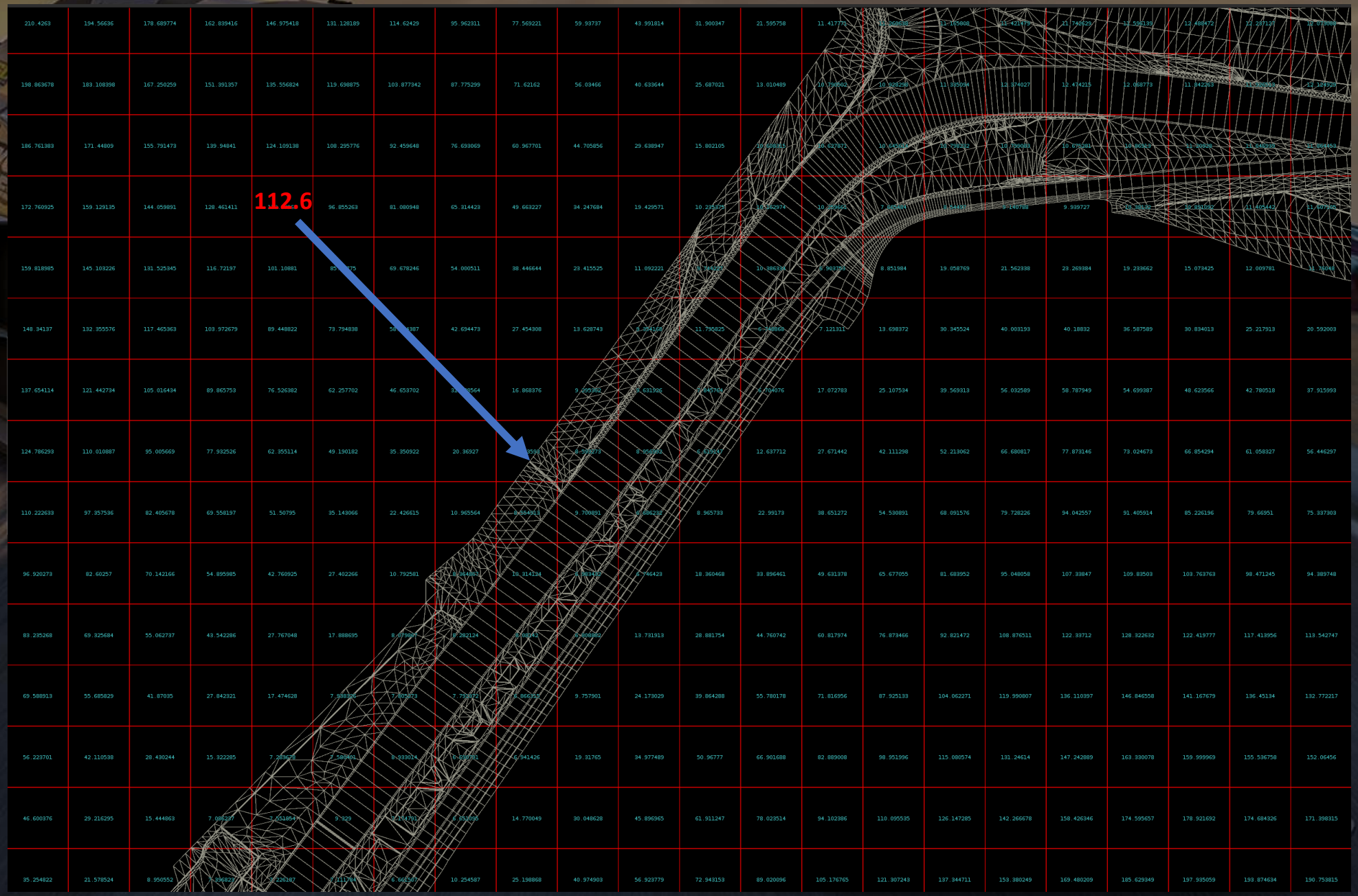
Each tile is measured to the closest edge on the road



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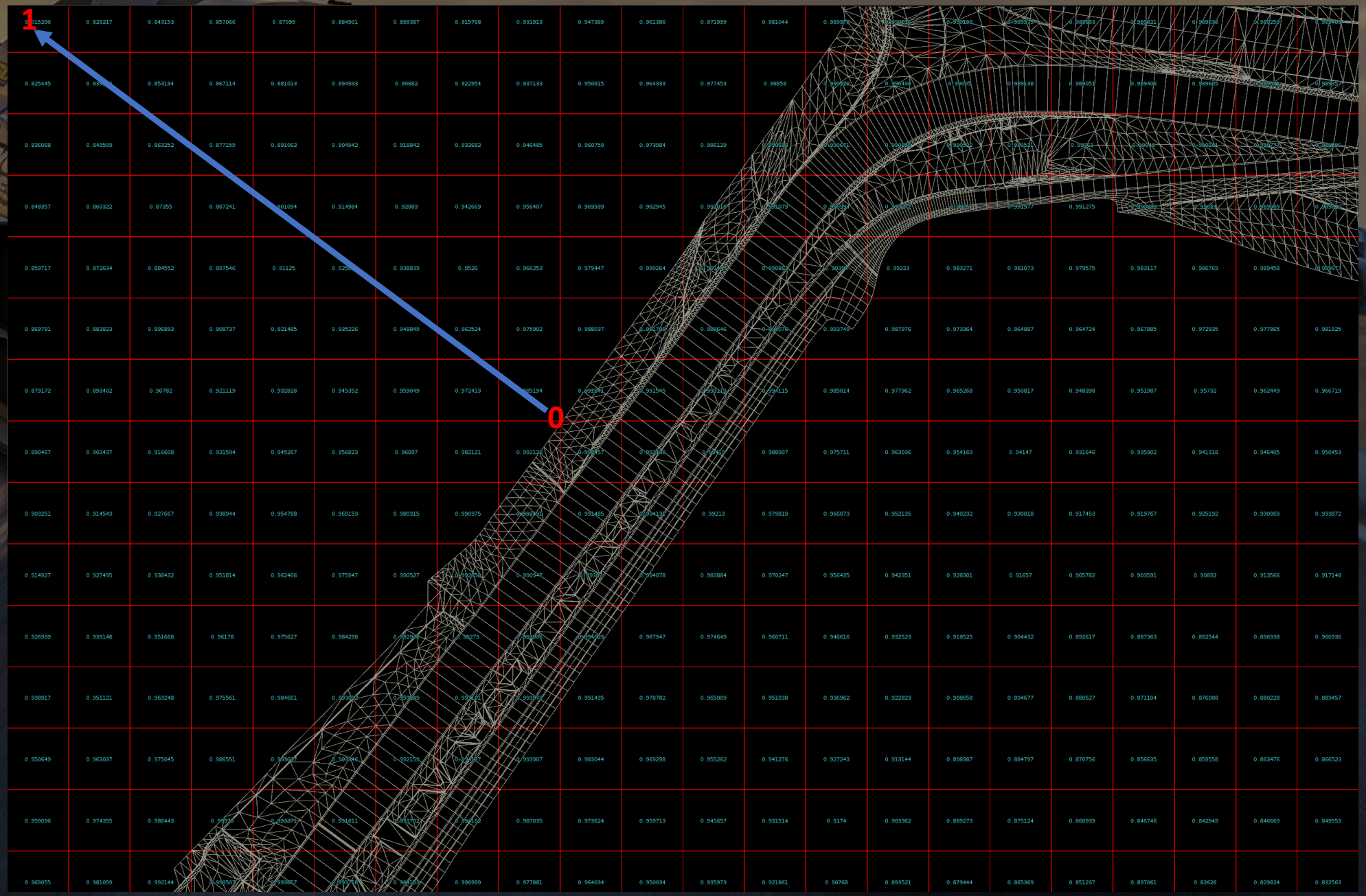
Distance is normalized among all tiles



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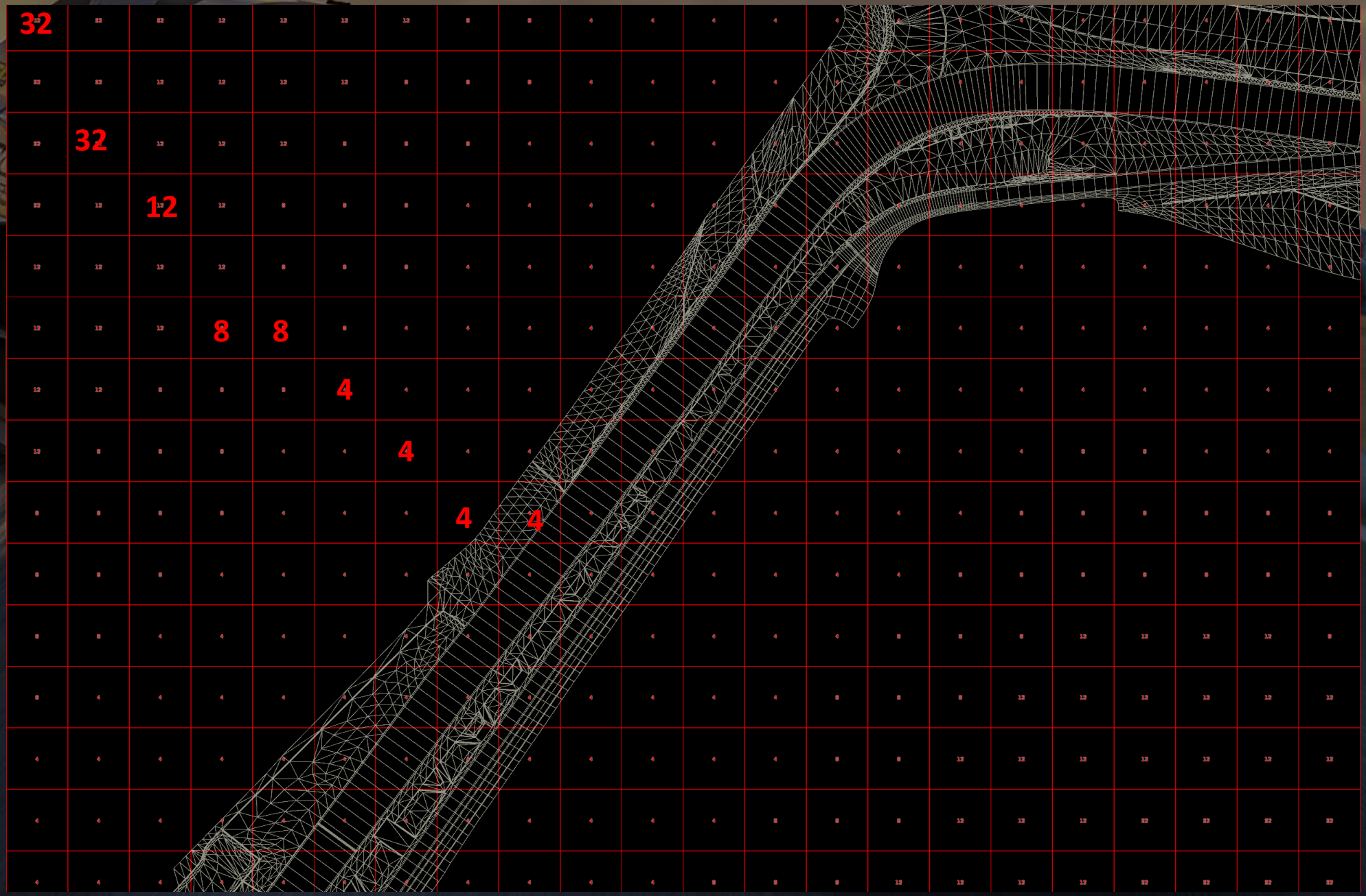
Normalized distance is re-mapped to user defined probes per meter



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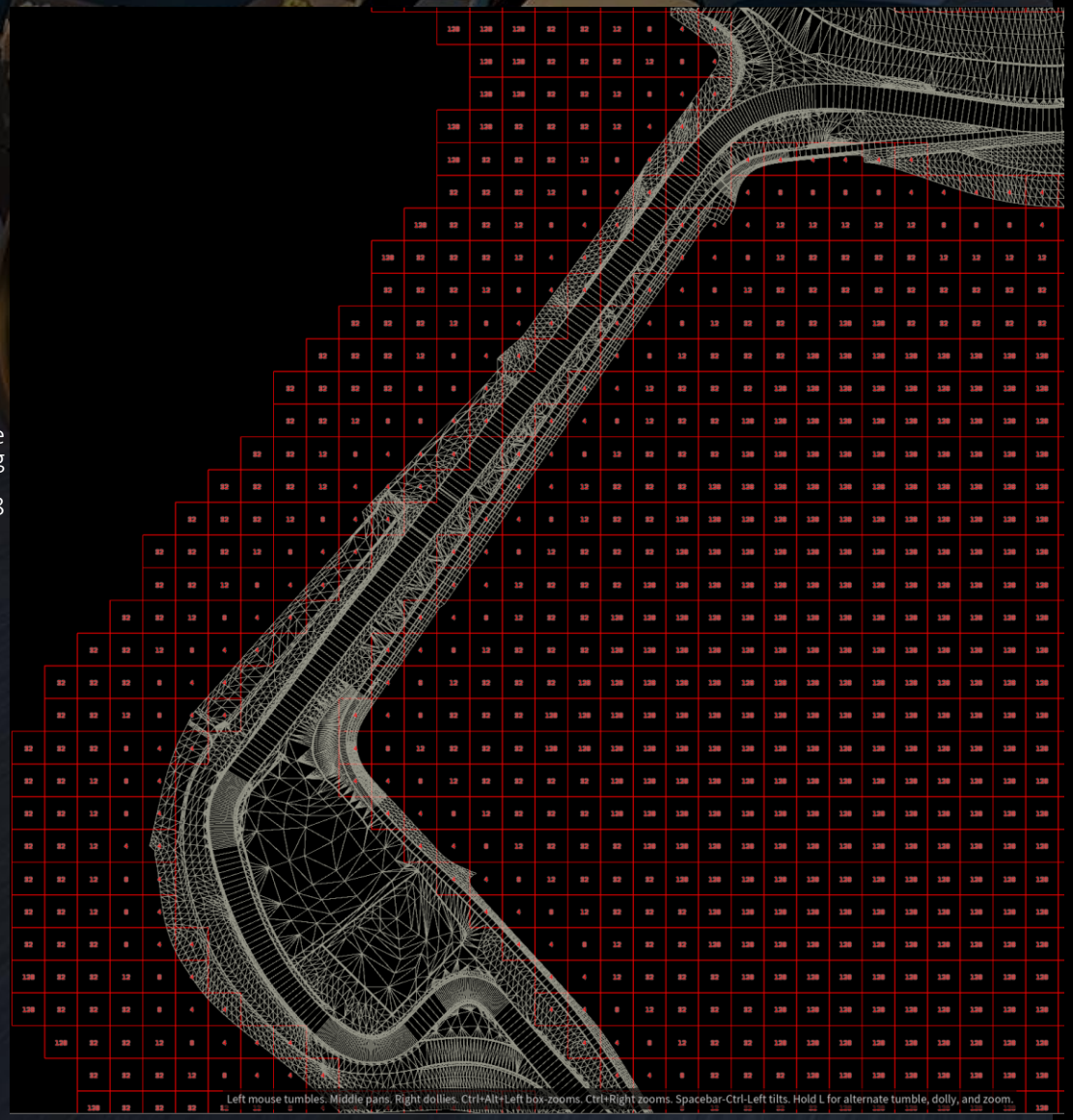
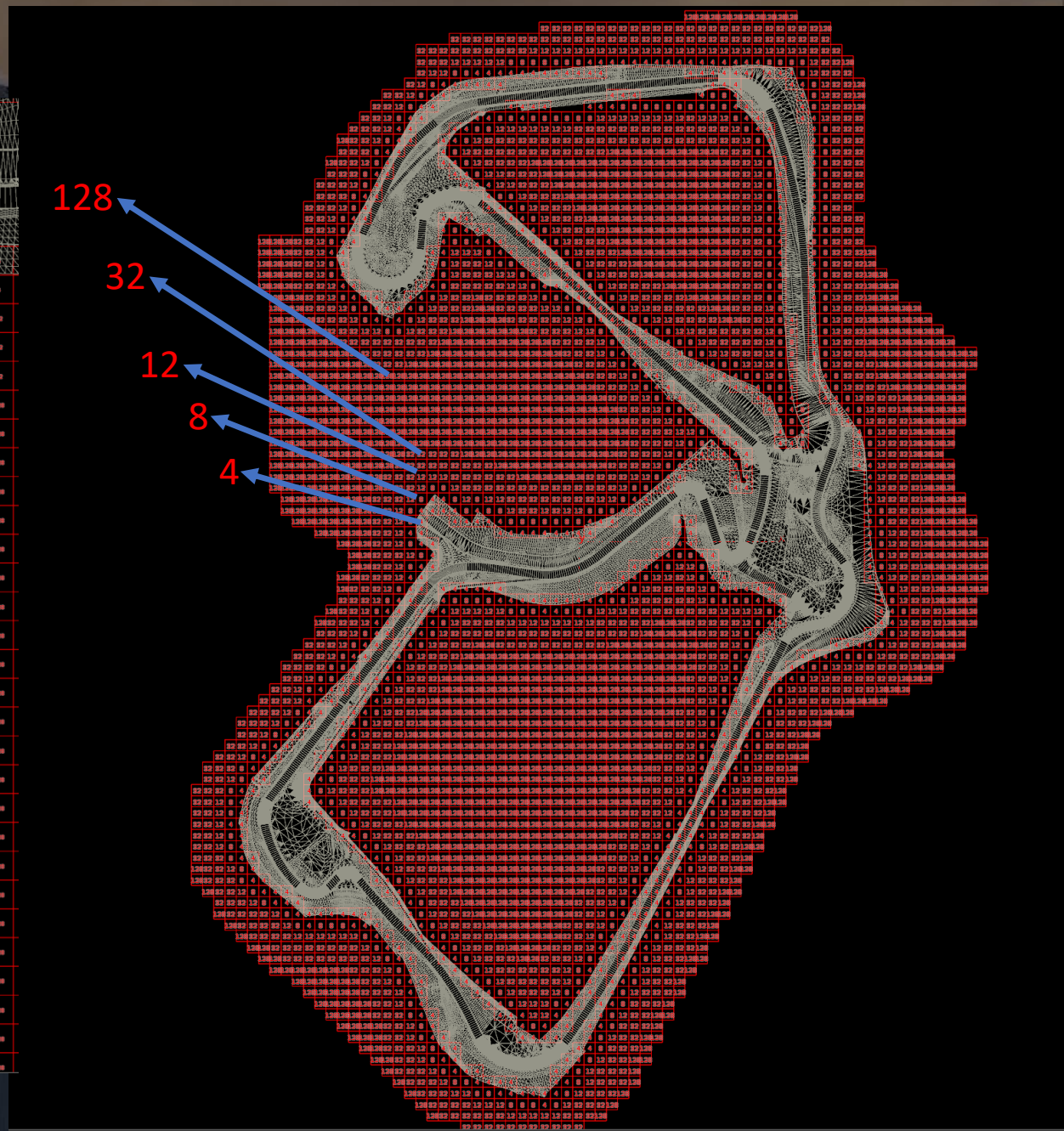
In this example
we are using

4 8 12 32 128





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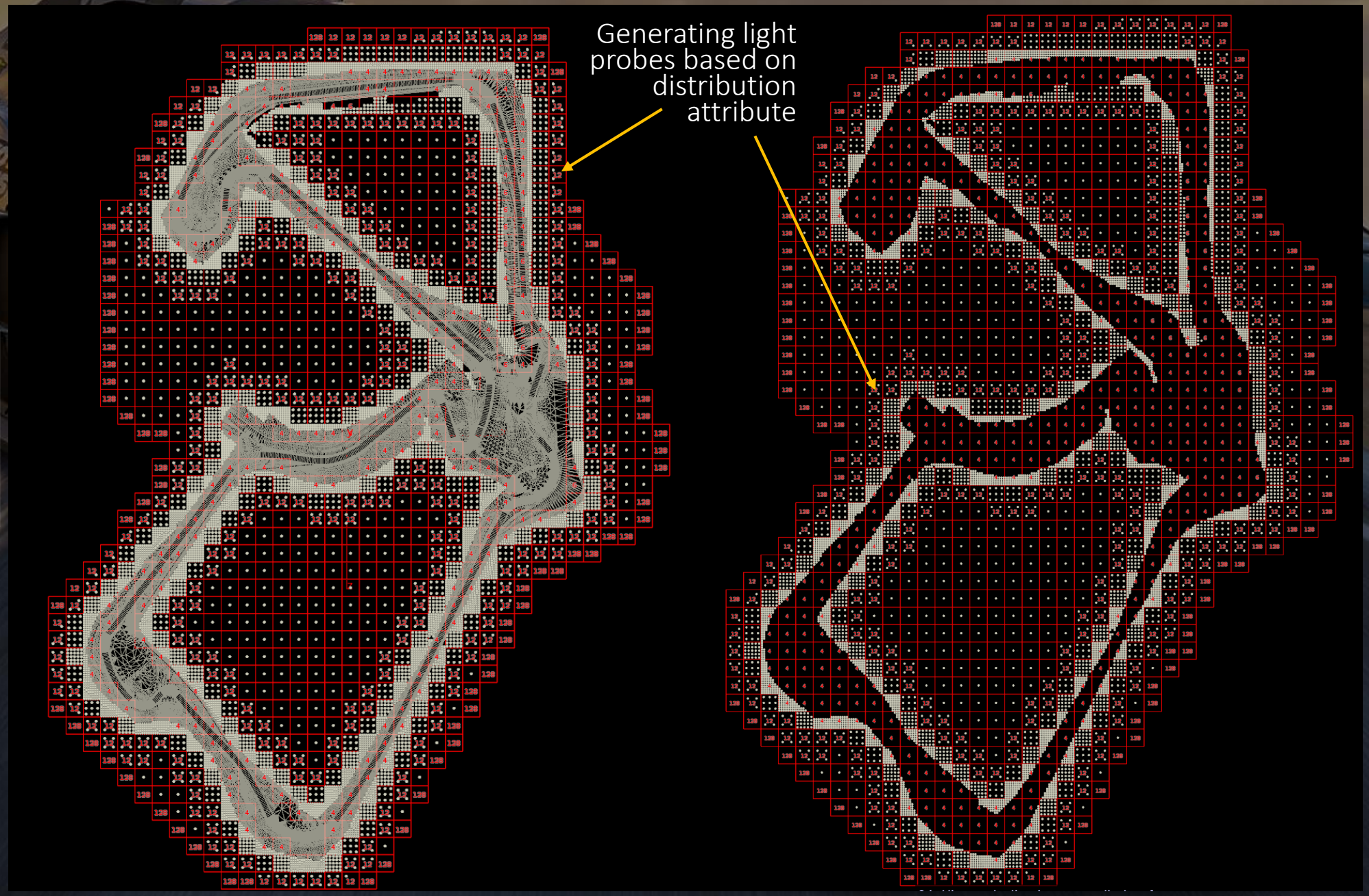
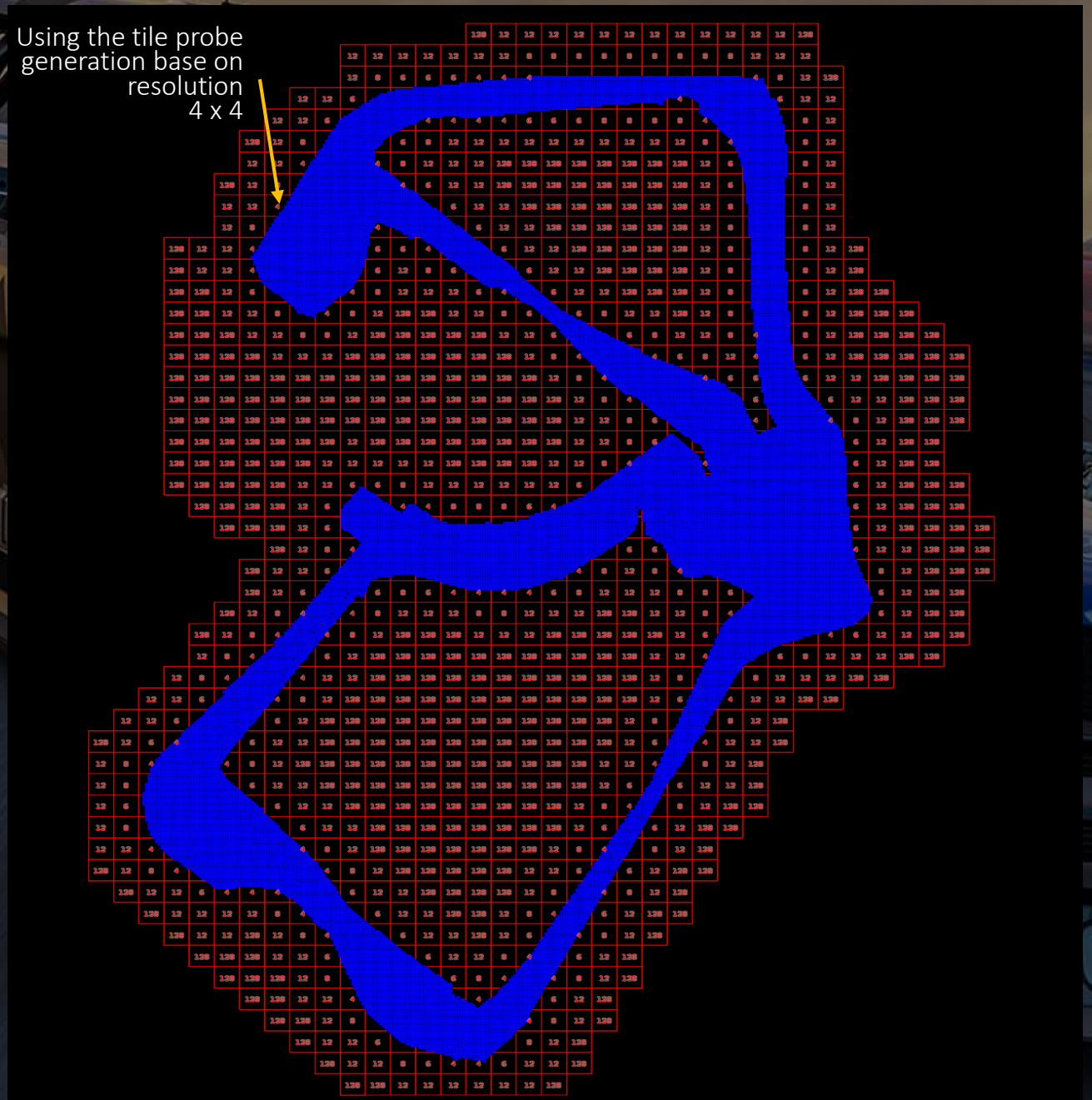
First, we process the terrain



We then process the road



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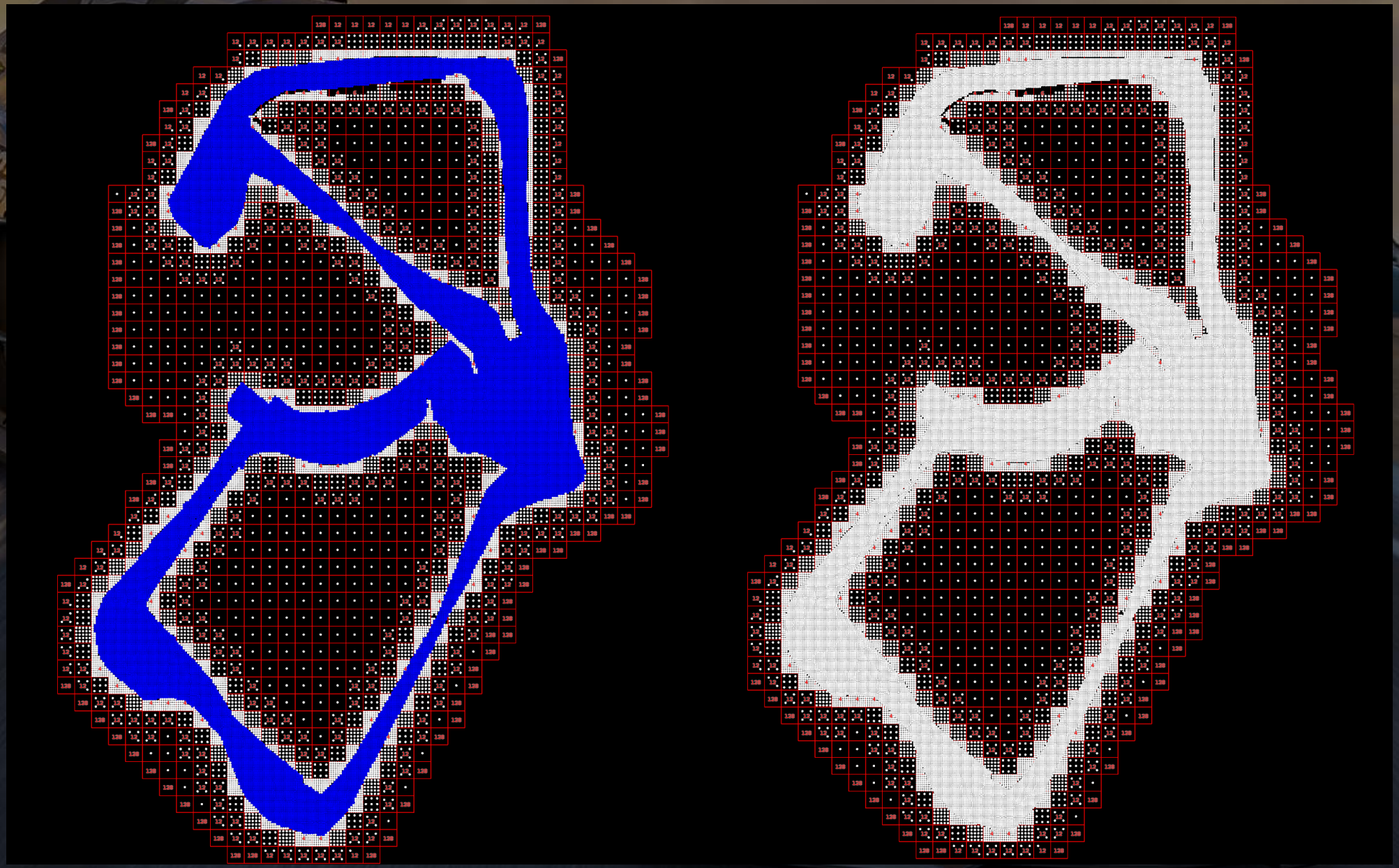
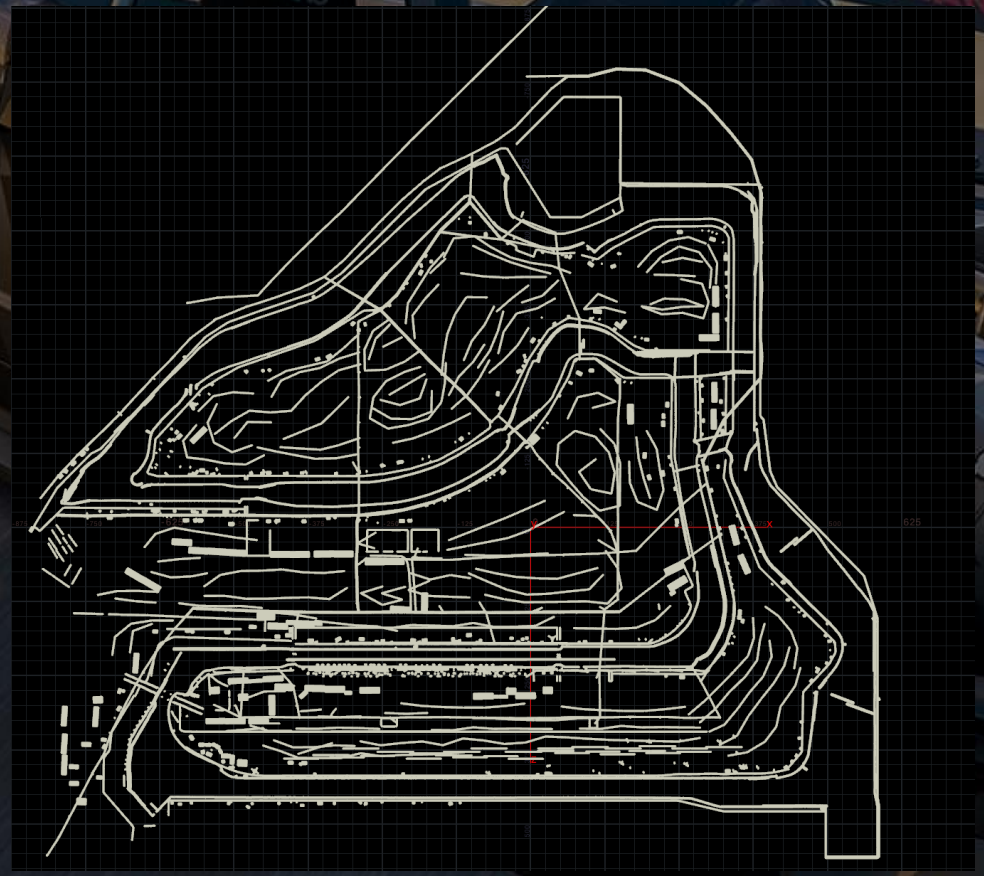
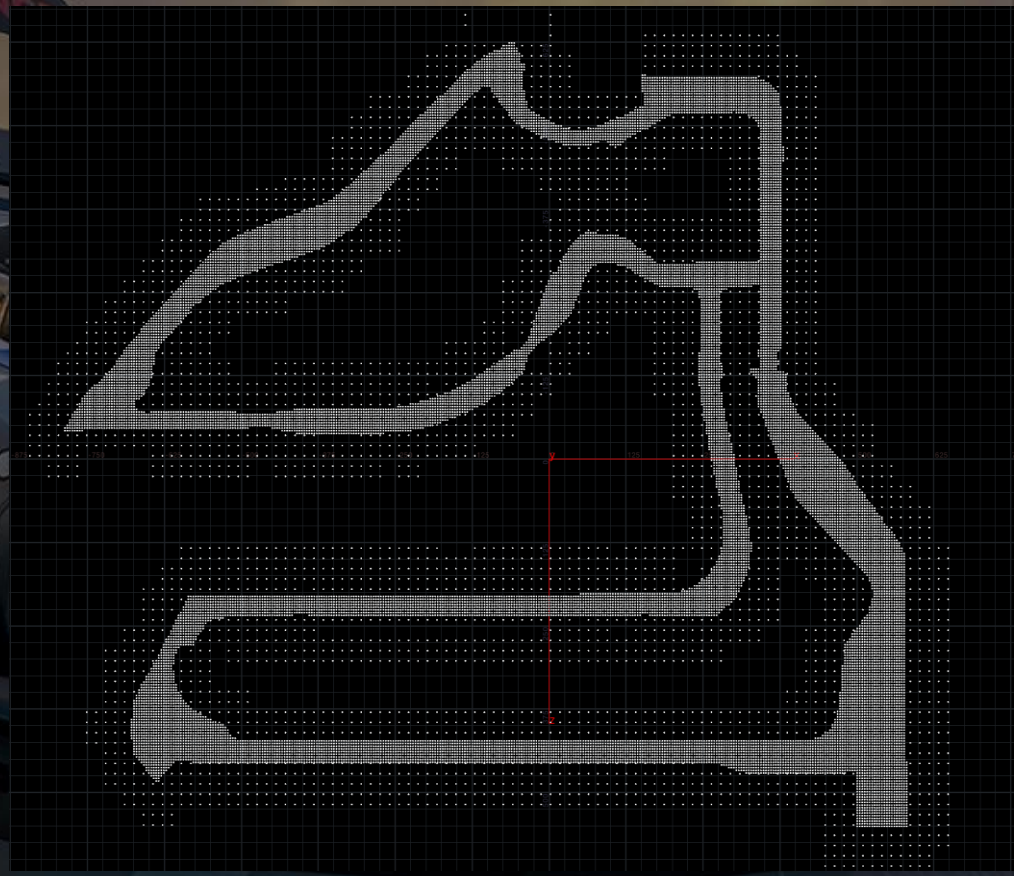
We merge our results
This gives us our
World Envelope



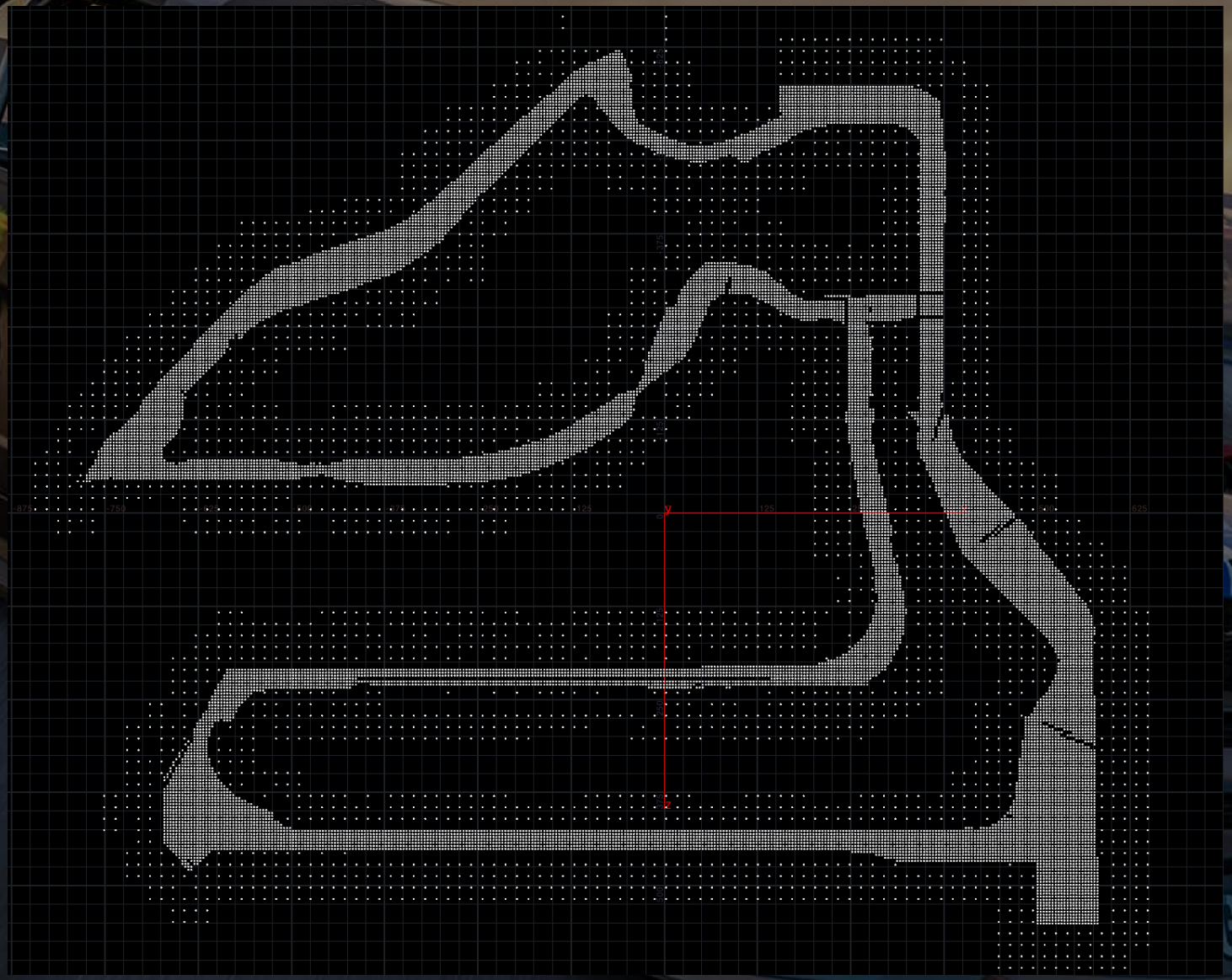
Intersections?

Remove Intersections





Result



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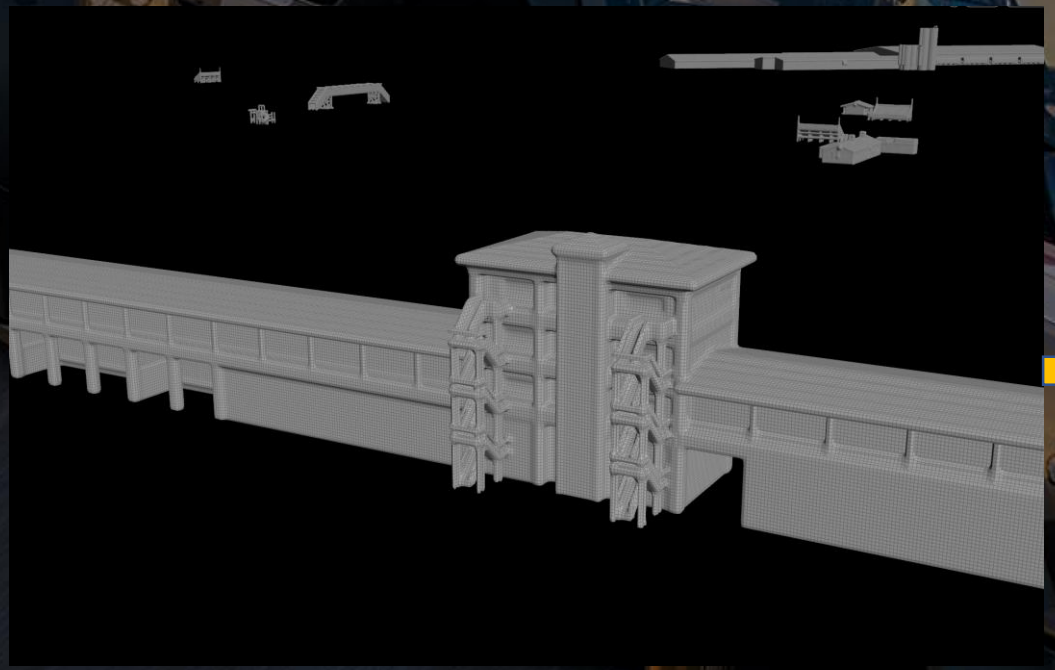
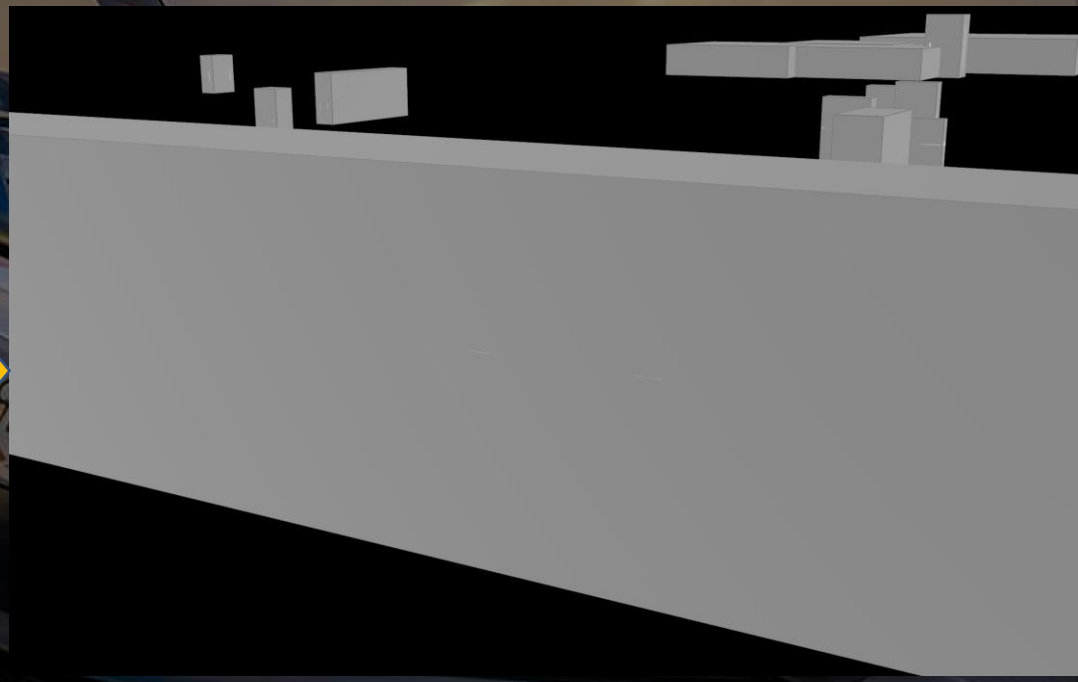
What about the rest of the track?

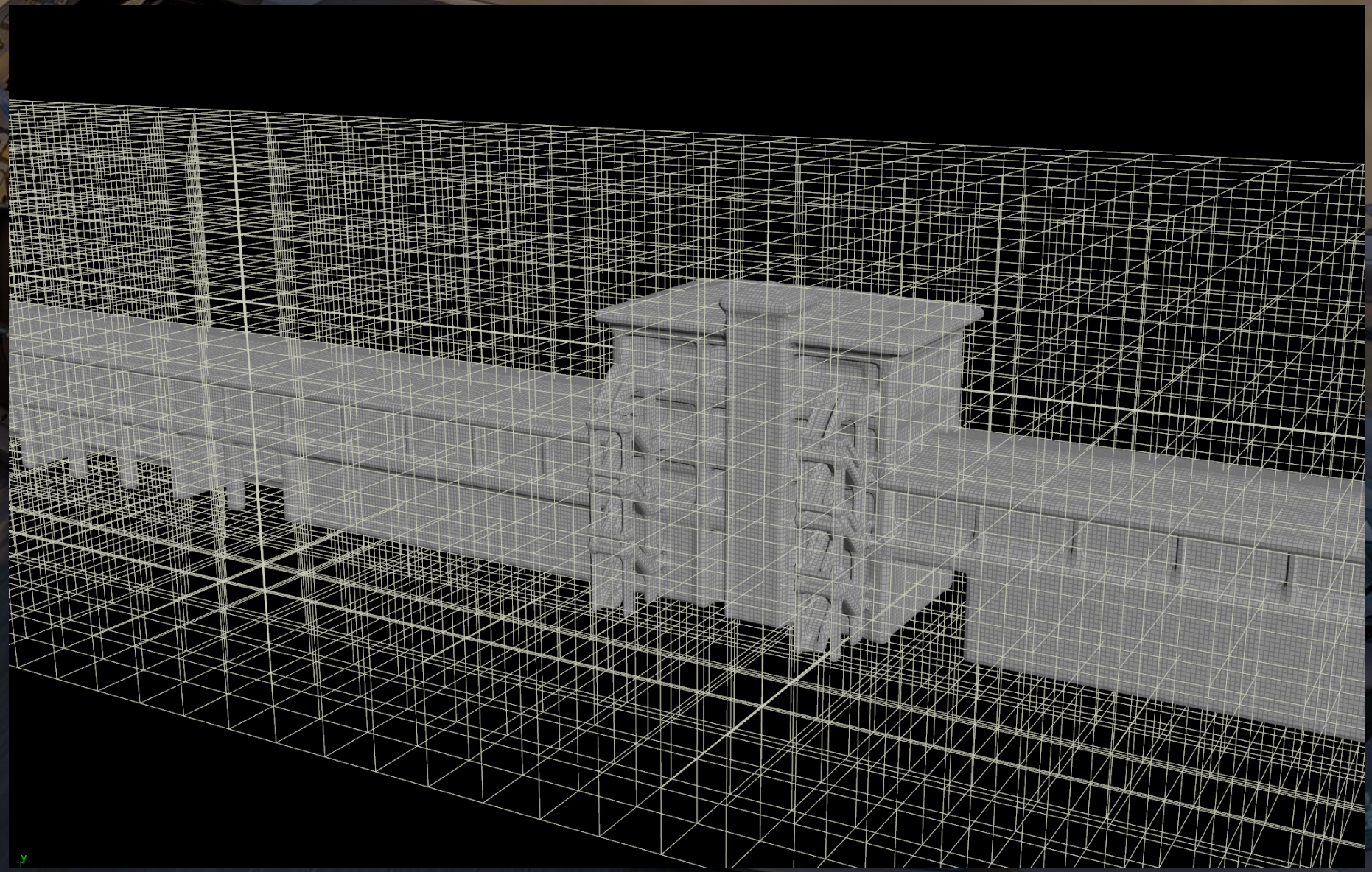
Local Fine Envelope

VDBs are your friend

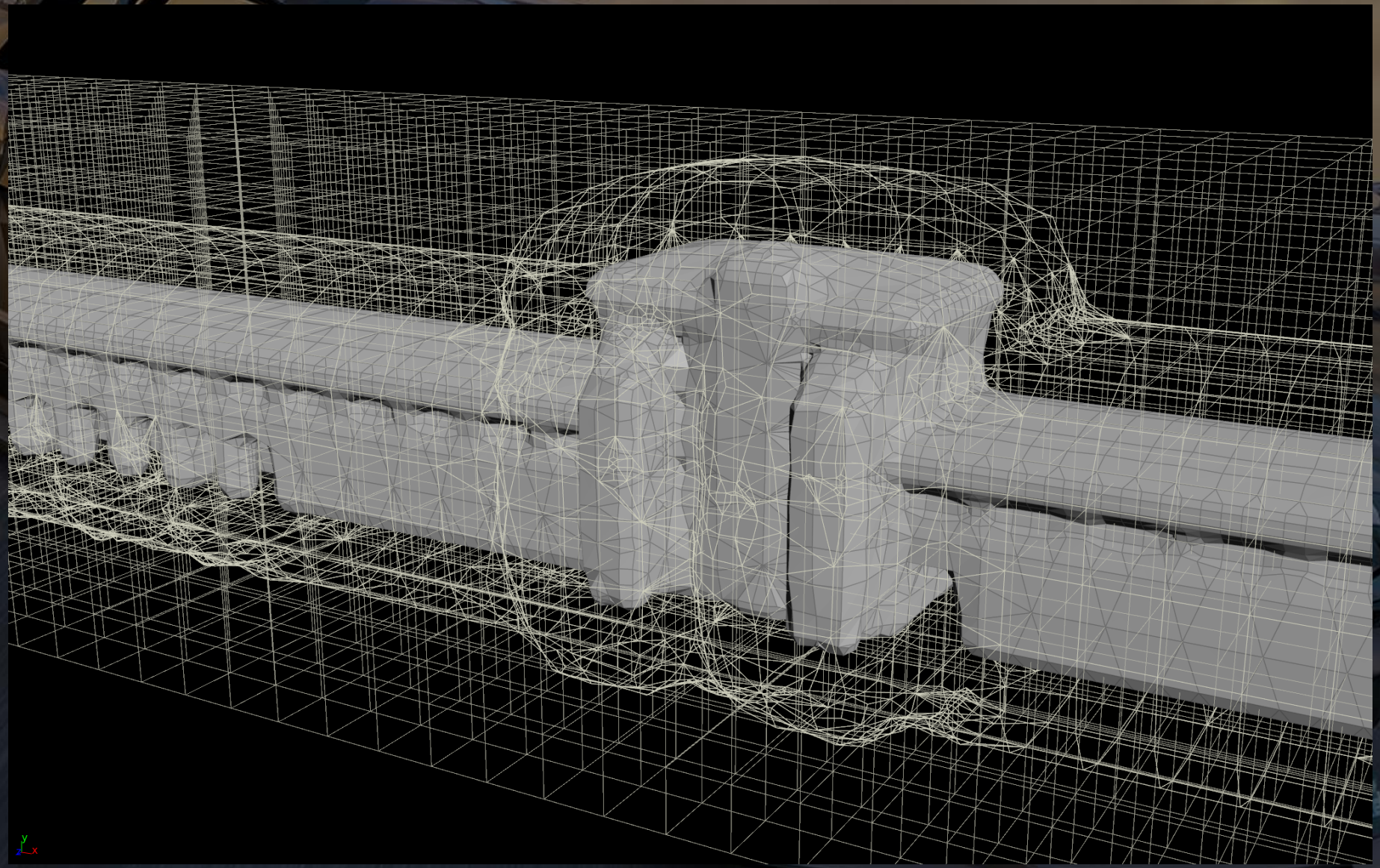




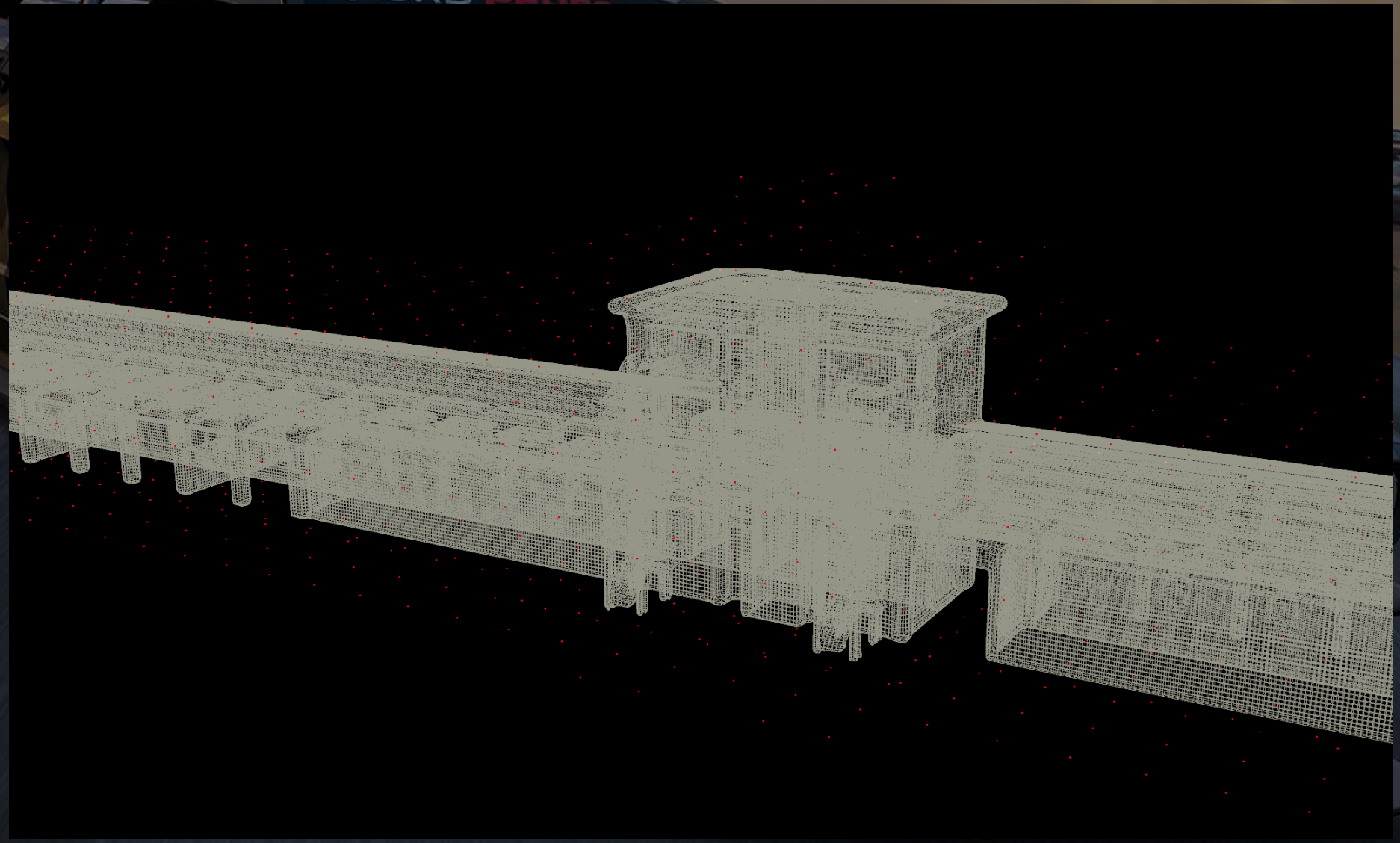
Create a Voxelizer solver over the sparce volume



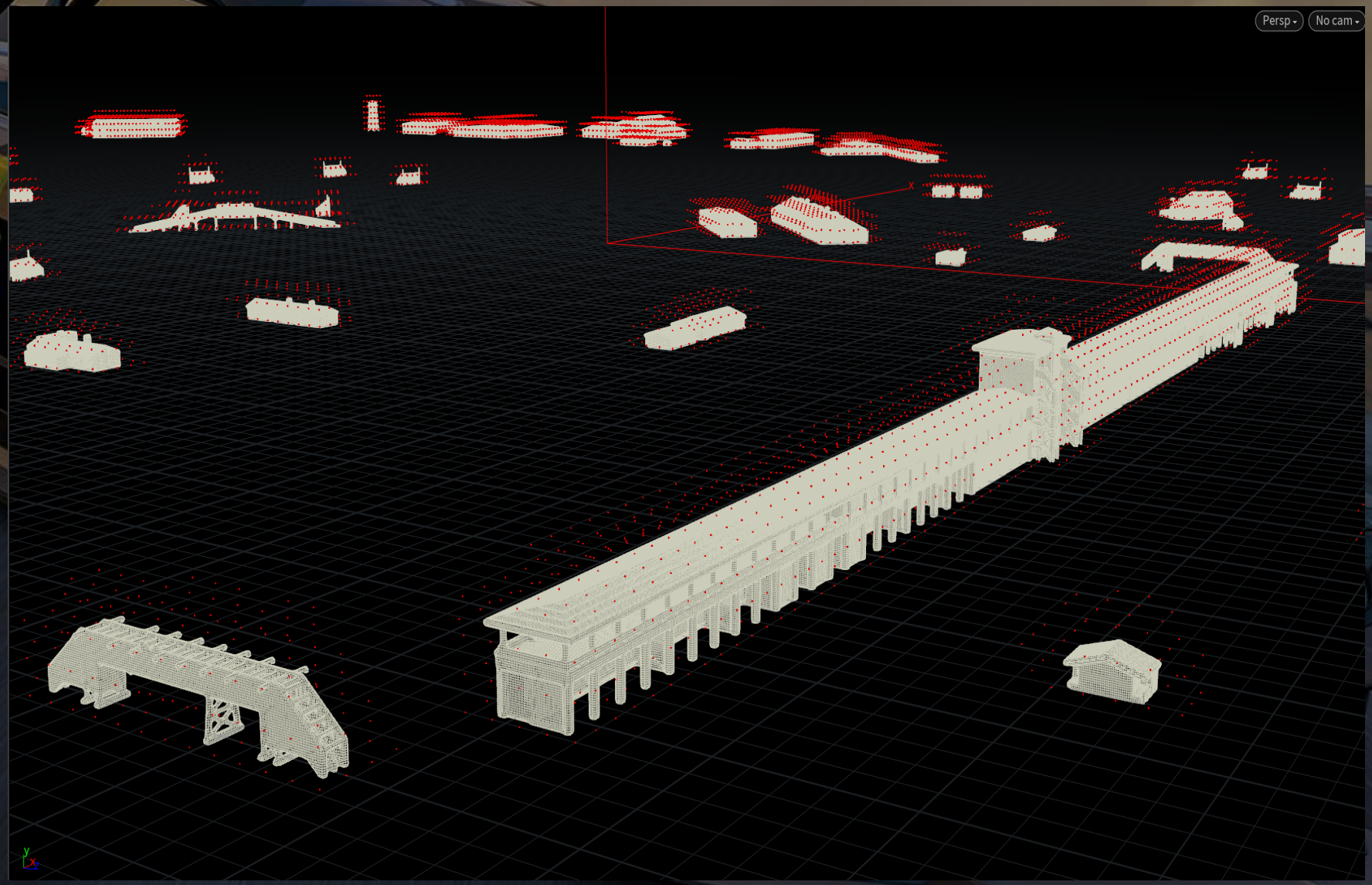
Voxel activation dual-envelope solver

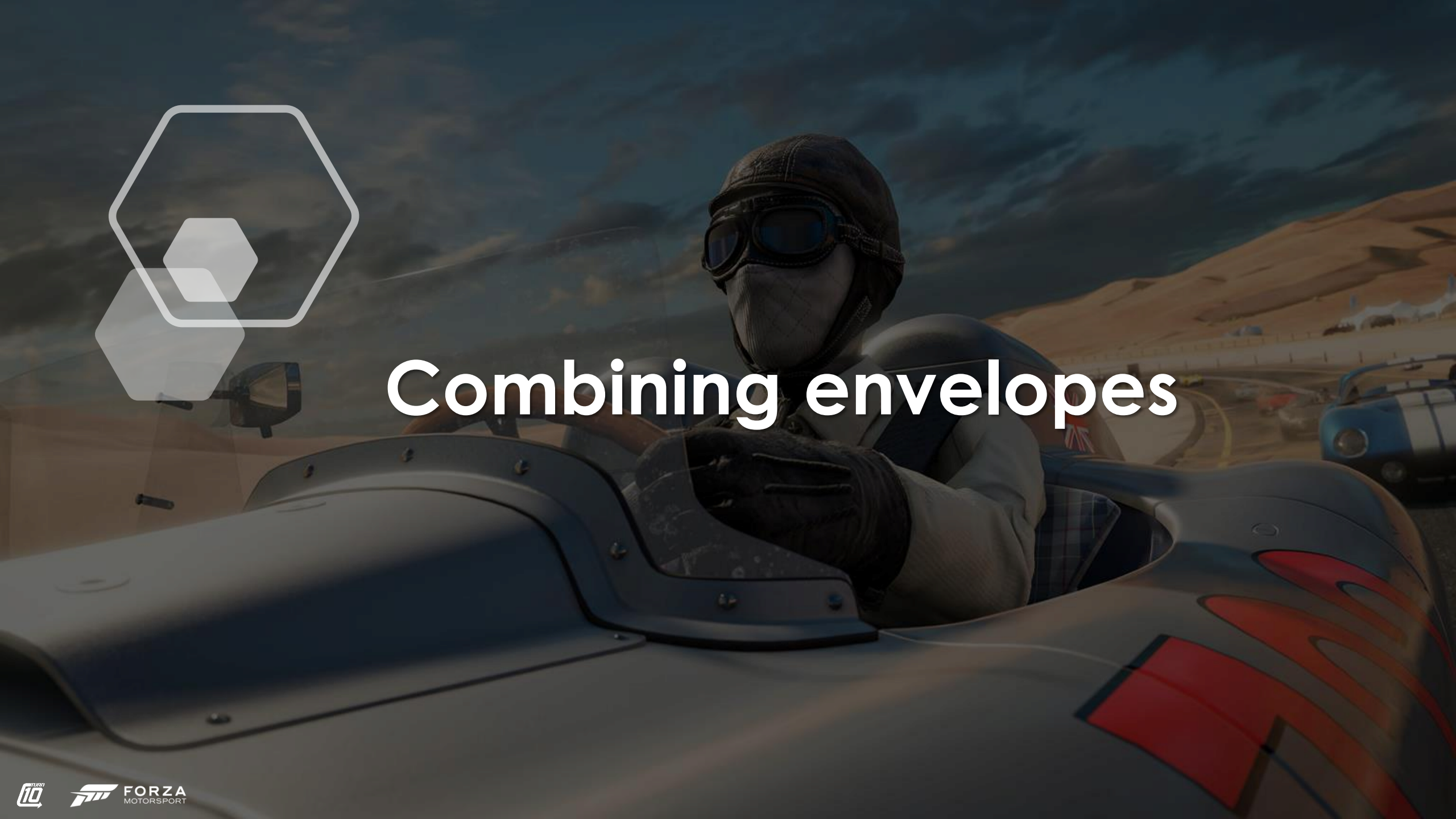


We generate probes on active voxels



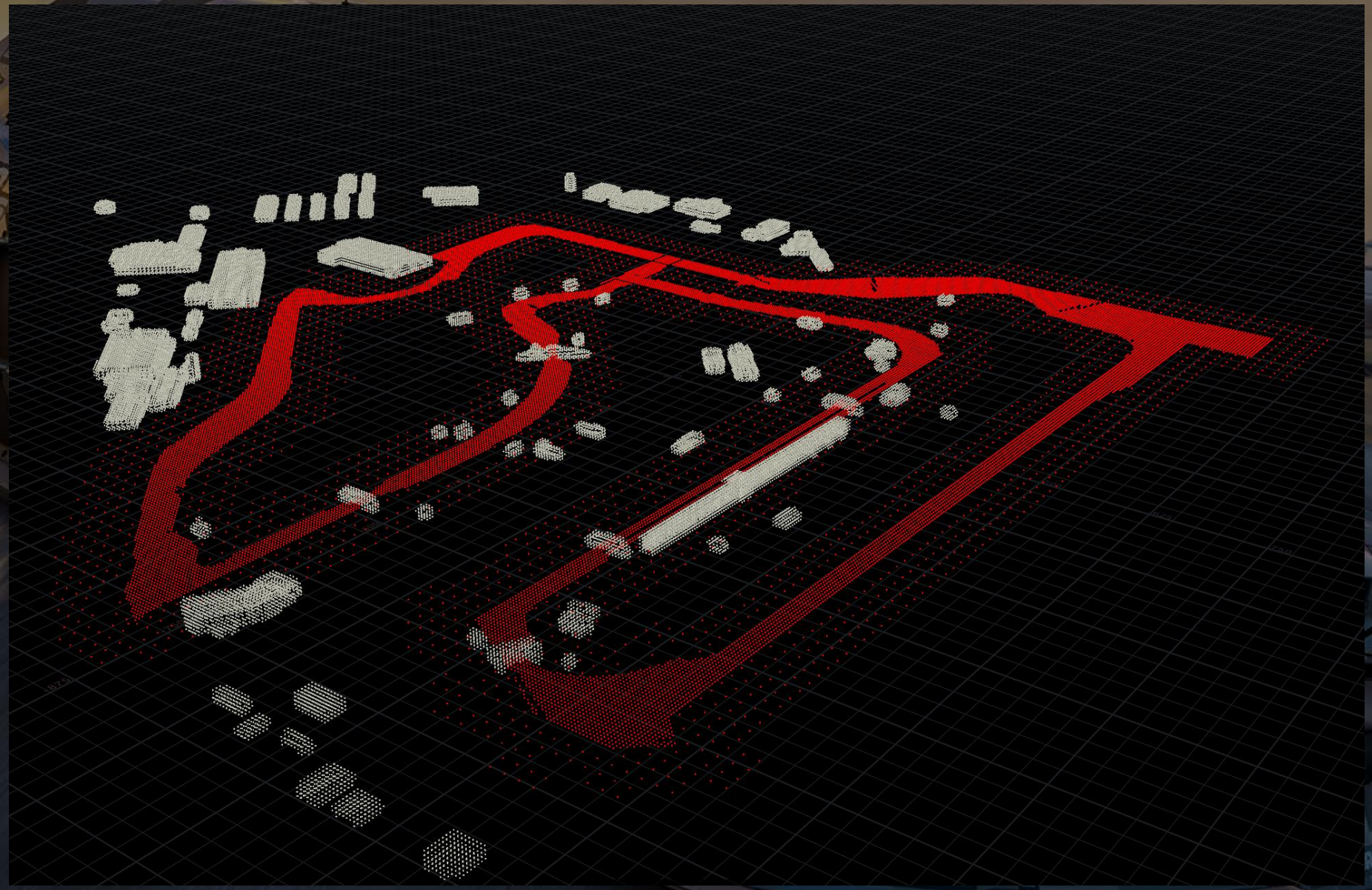
Result Local Envelop



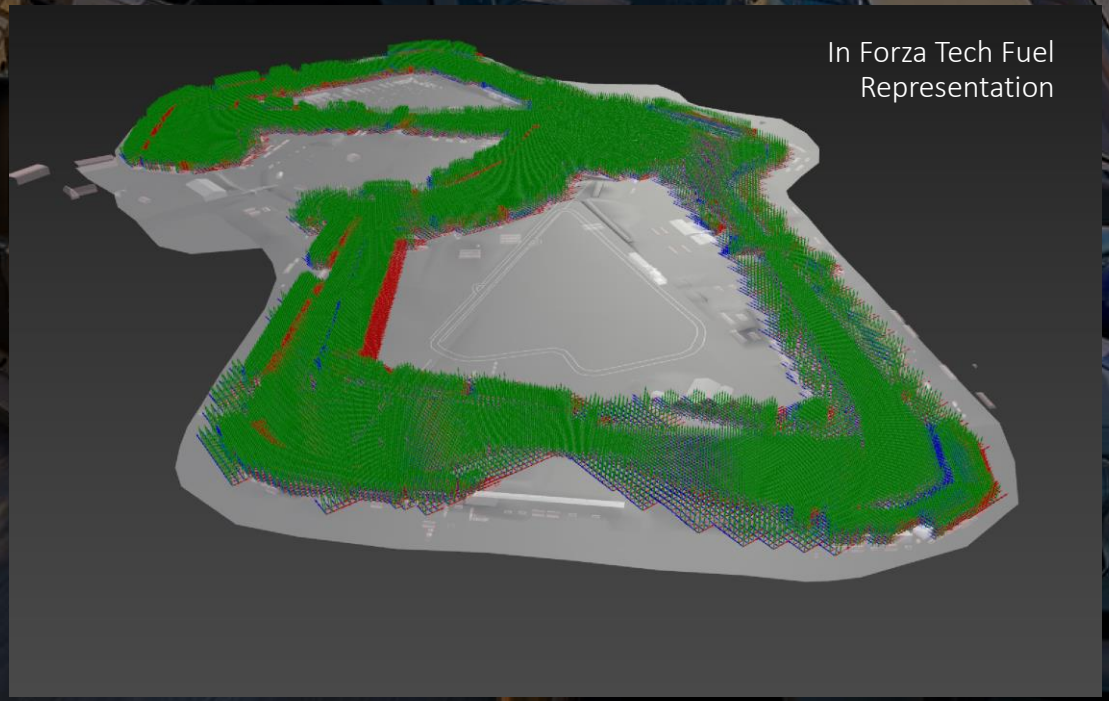


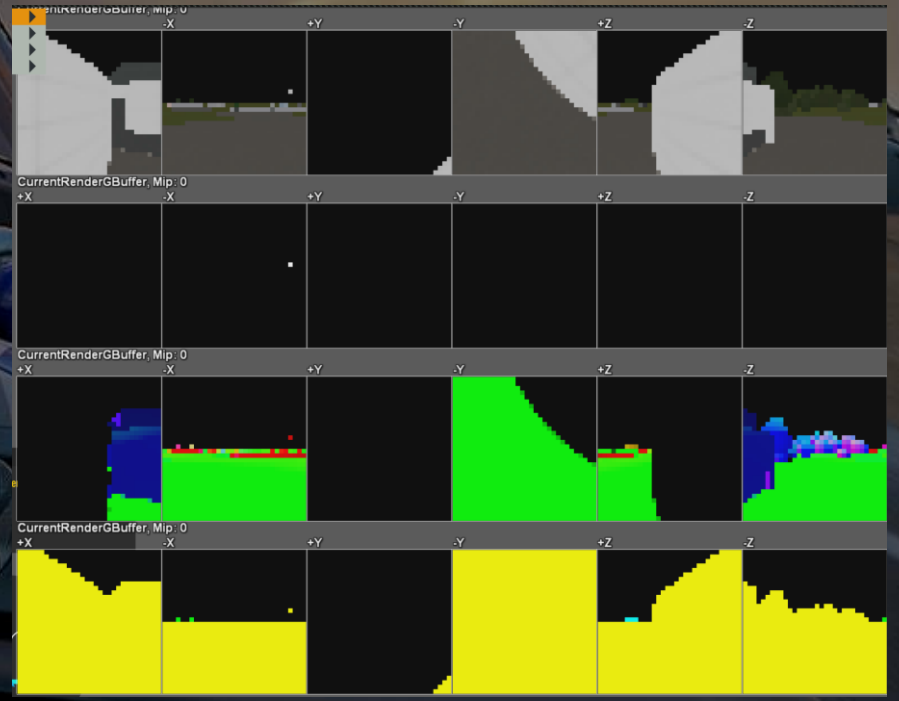
Combining envelopes

Final Light Probe Cloud

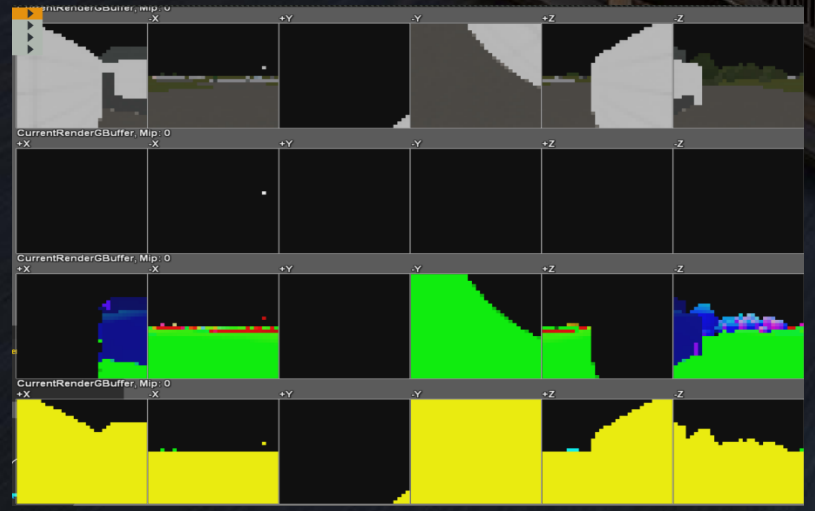


We export and bake





Baking Stats



- Number of probes has a direct impact on baking times
  - 3,500 probes
    - 2 minutes
  - 10,000
    - 5 minutes
  - A full track
    - Ranges between 90,000 to 150,000
      - As of writing our highest bake time is around 1 hour on a high end Xbox
- 125k probes = 38MB compressed on disk

Result

Global Envelope
No Gi

FORZA MOTORSPORT

Global Envelope
GI

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Global Envelope Probes

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Global Envelope
Just GI

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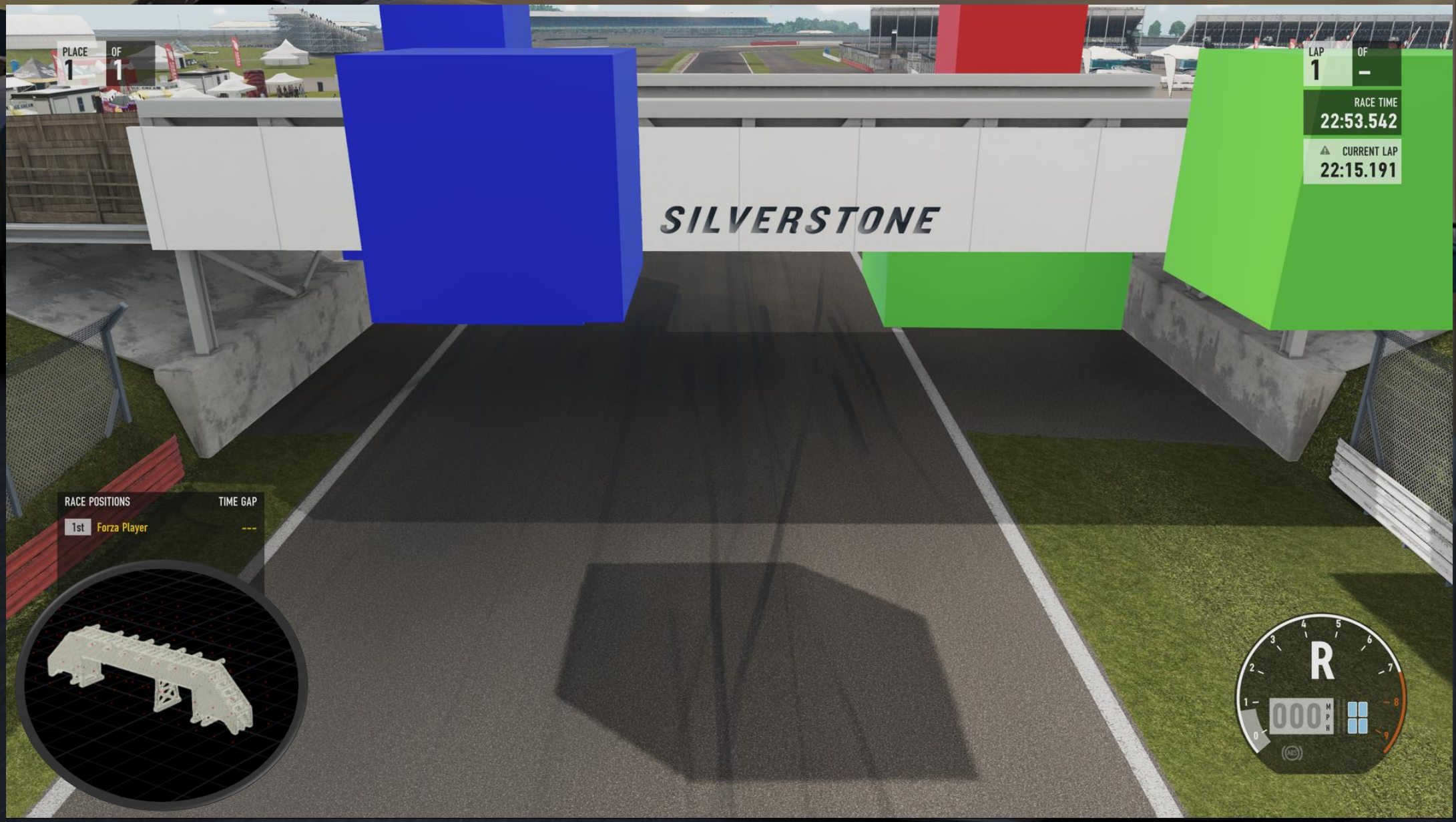
Local Envelope
No Gi



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Local Envelope
GI

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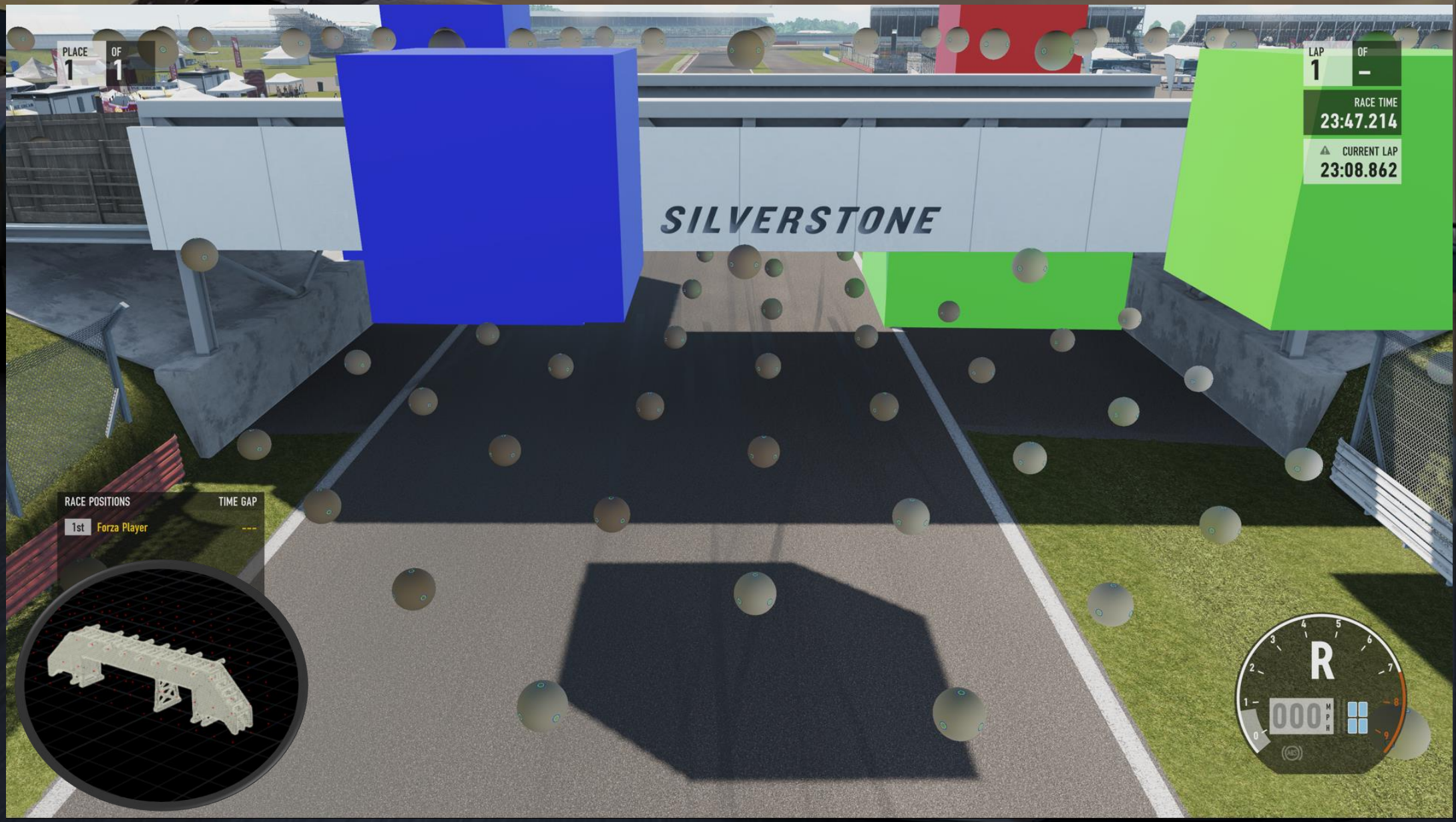
Local Envelope Probes



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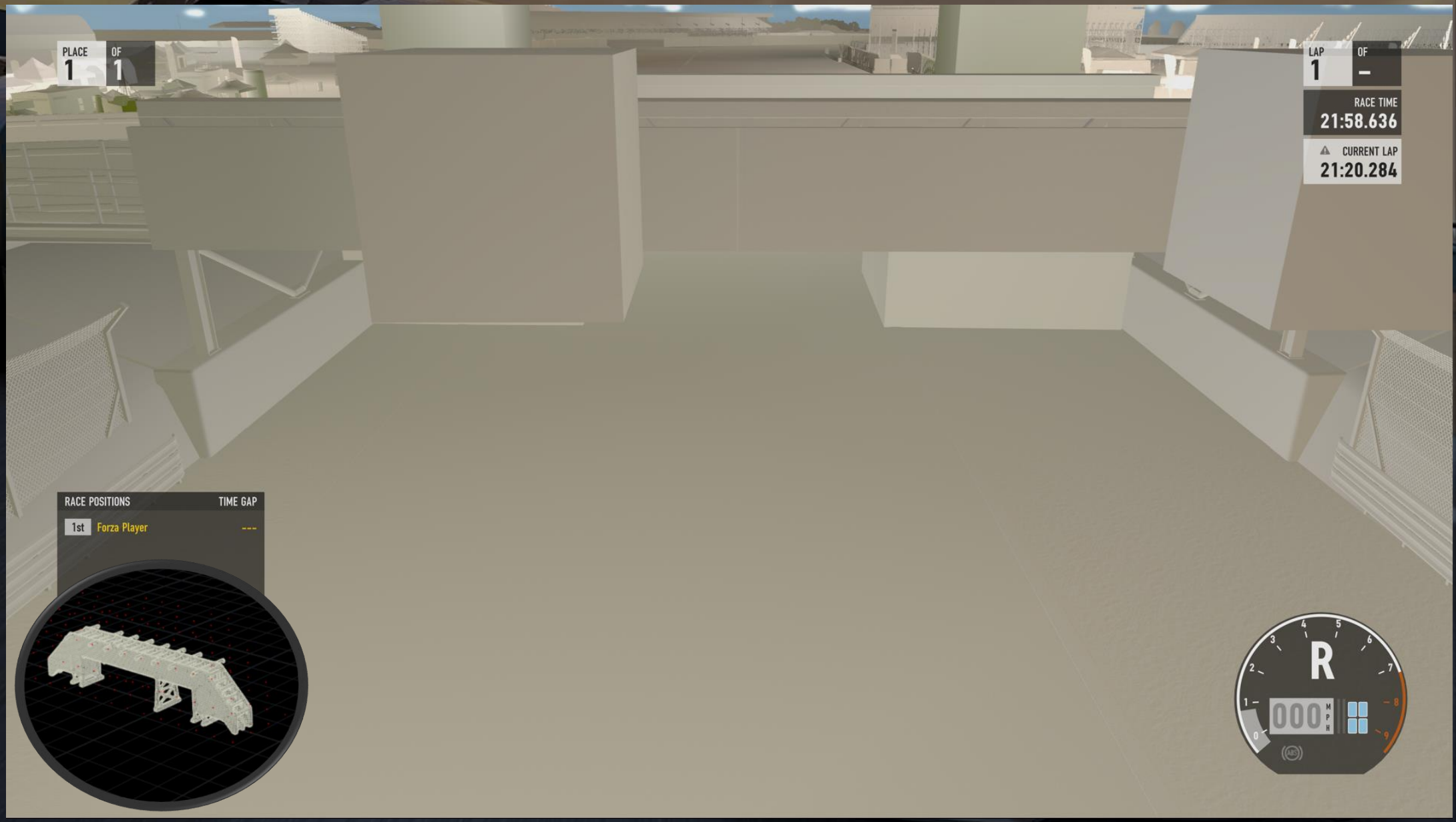

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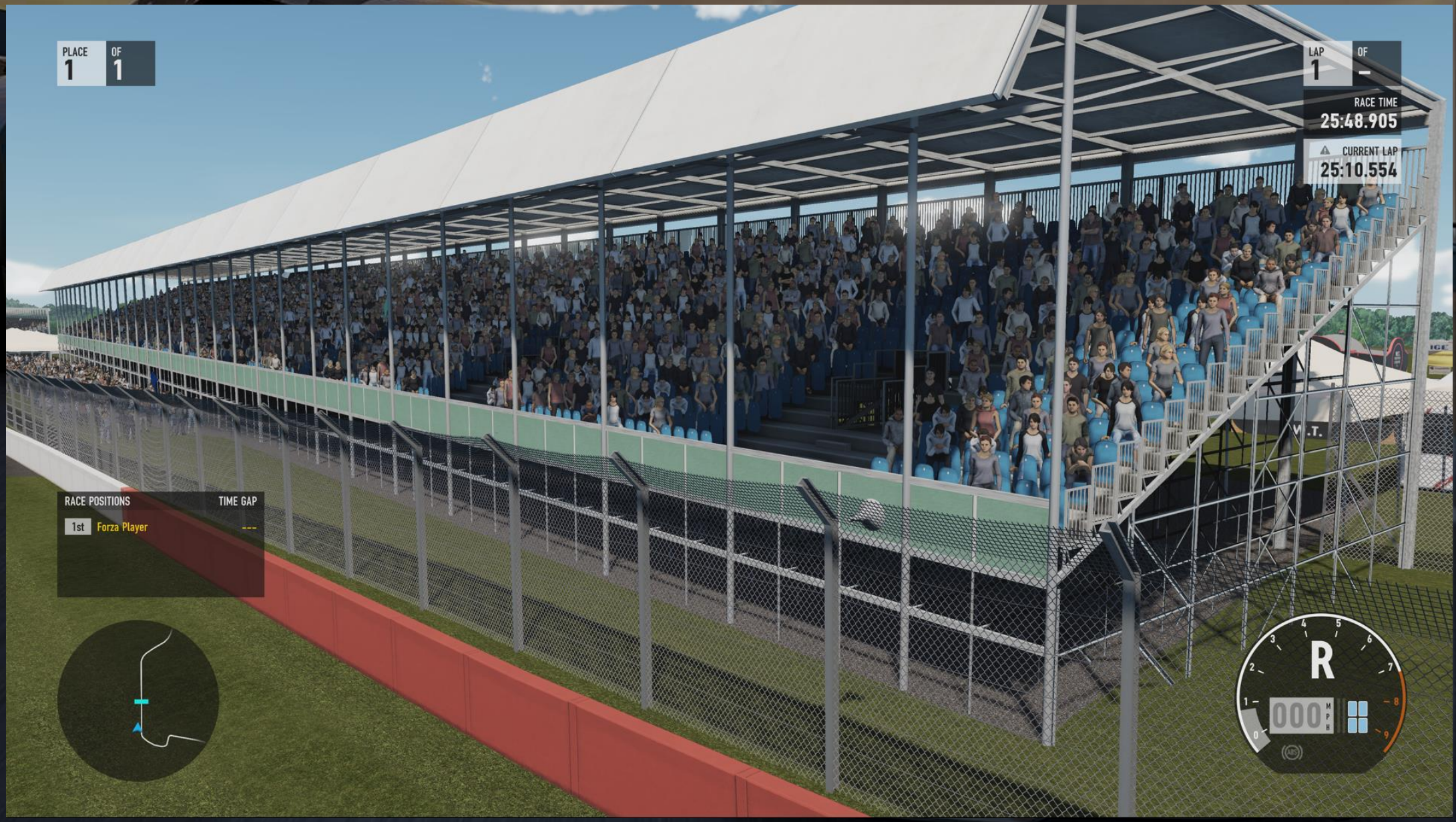

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Local Envelope
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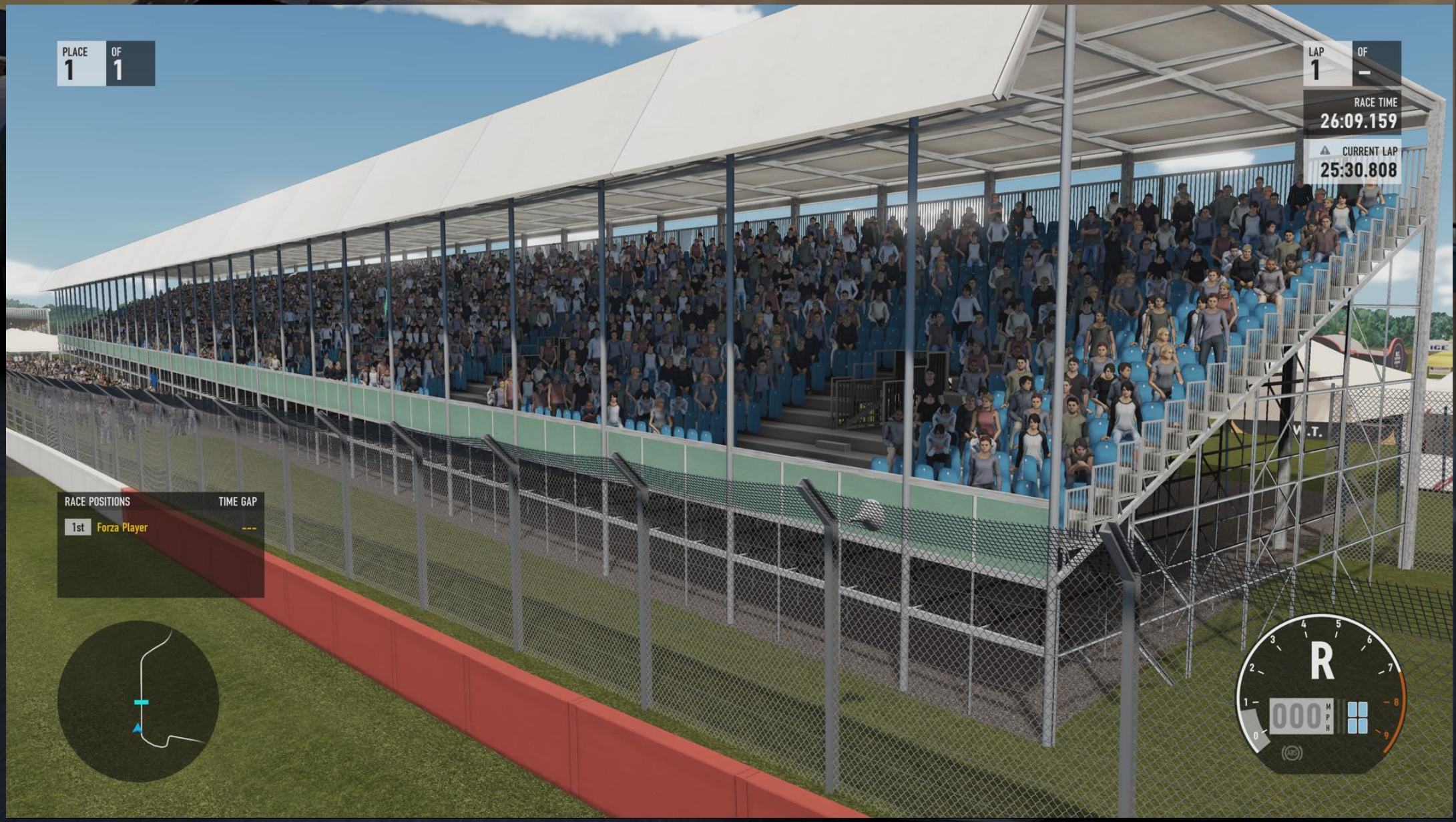

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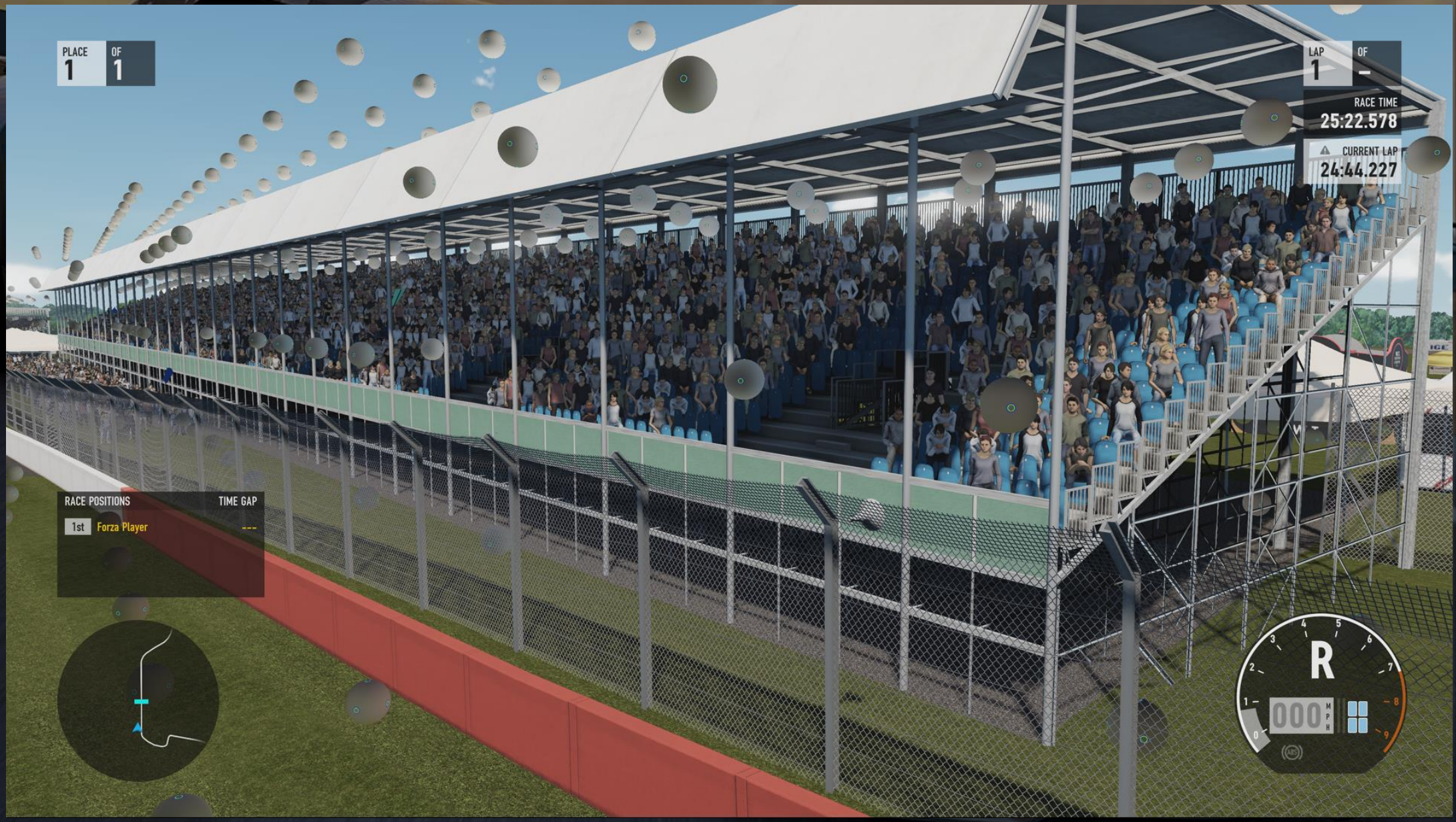
Local Envelope Probes



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Local Envelope
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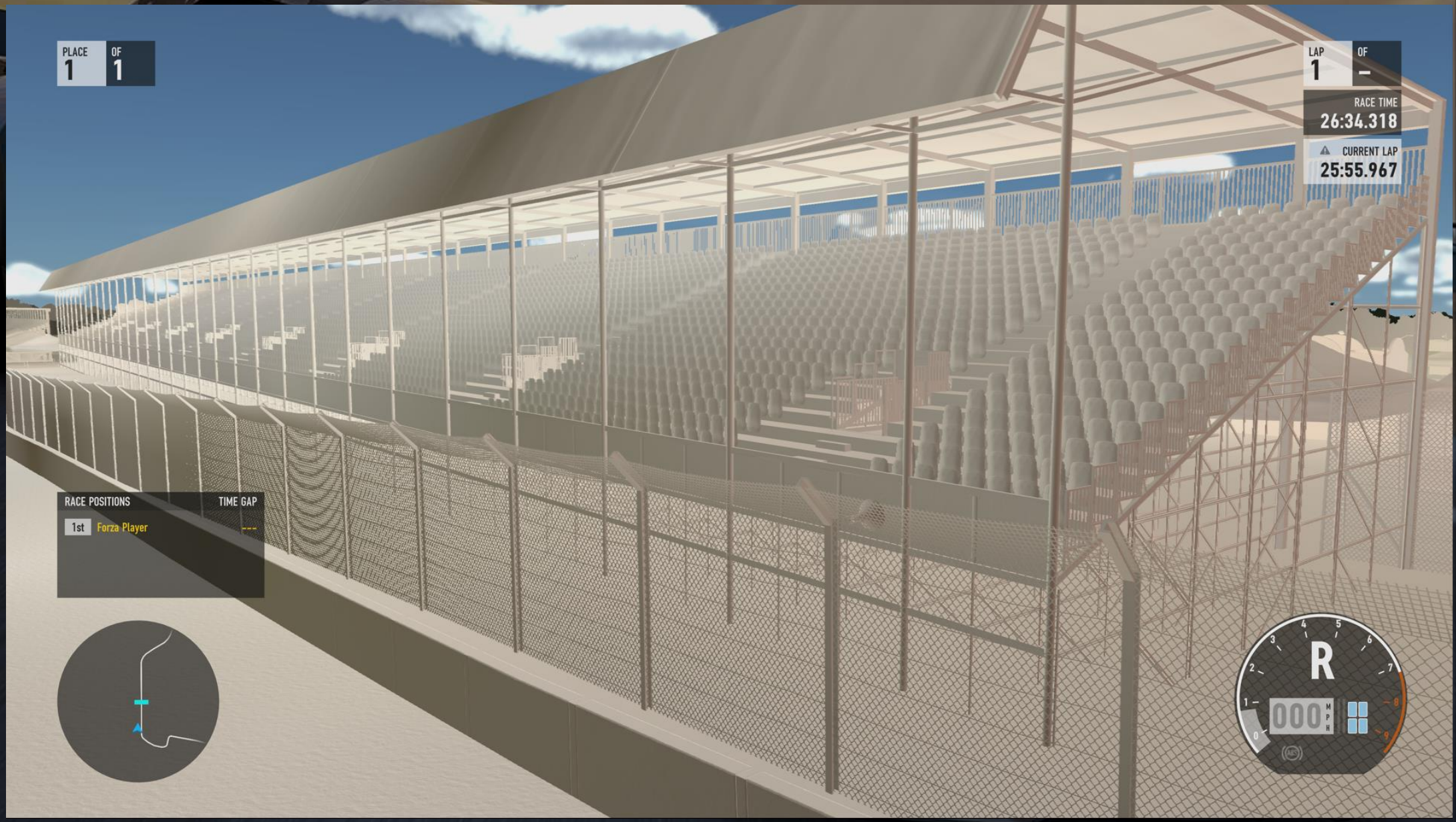

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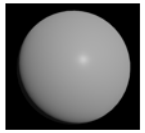
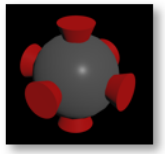
What exactly did we just do?

Remember?

Probes





A point in space

Review

Layered Point Cloud approach

Review

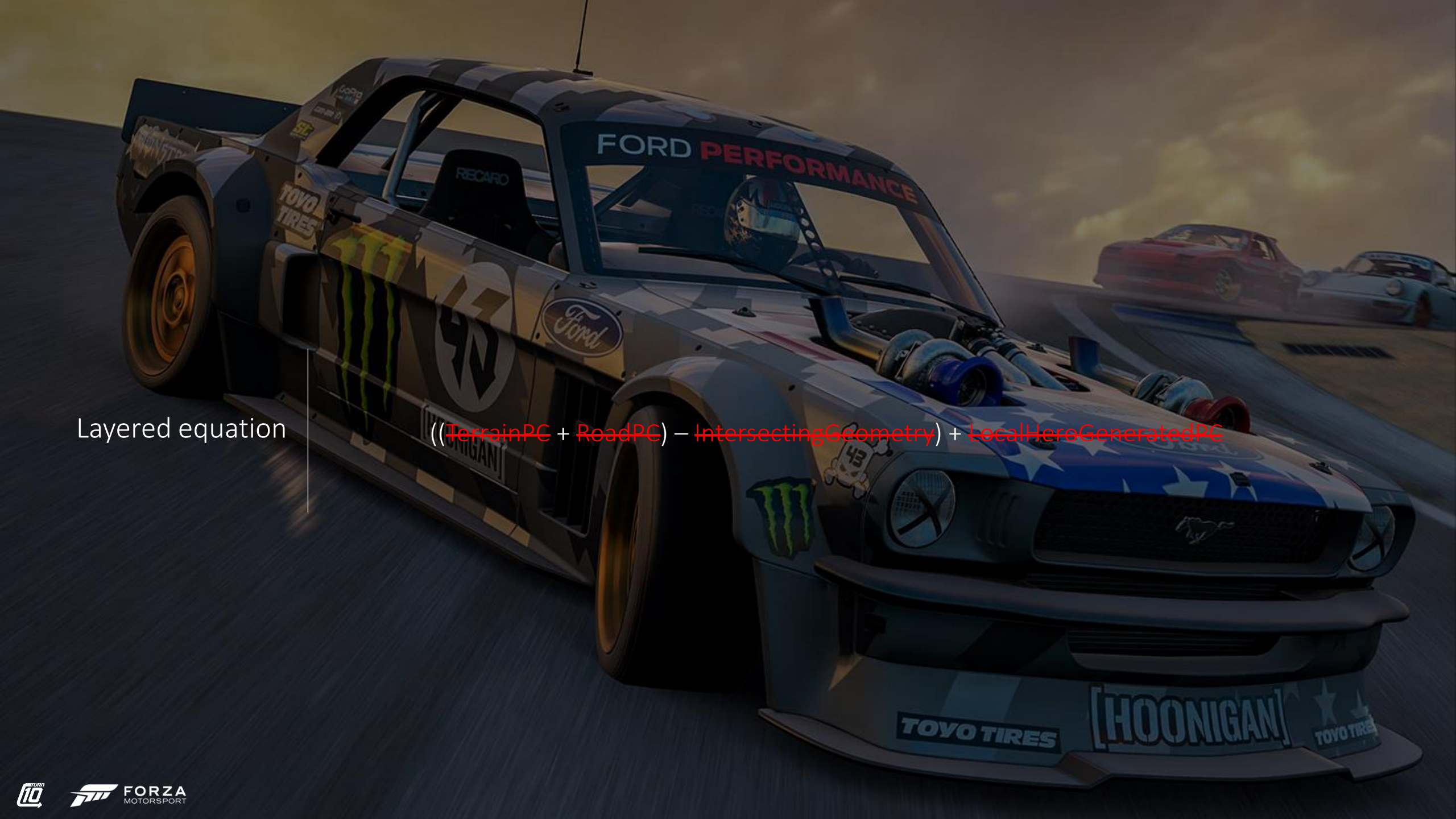
Layered Point Cloud approach

- What does a Point Cloud compositing approach mean?
  - Since we cannot generate heuristics that will solve for every scenario
  - We split the generation of the point cloud into layer steps that can be merged.
    - Global Coarse Envelope
      - TerrainPC + RoadPC – Intersection geometry
    - Local Fine Envelope
      - LocalGeneratedPC
        - Hero Buildings Barrier, trucks, race day assets etc..

Review

These two steps give us our layered equation

((TerrainPC + RoadPC) – IntersectingGeometry) + LocalGeneratedPC

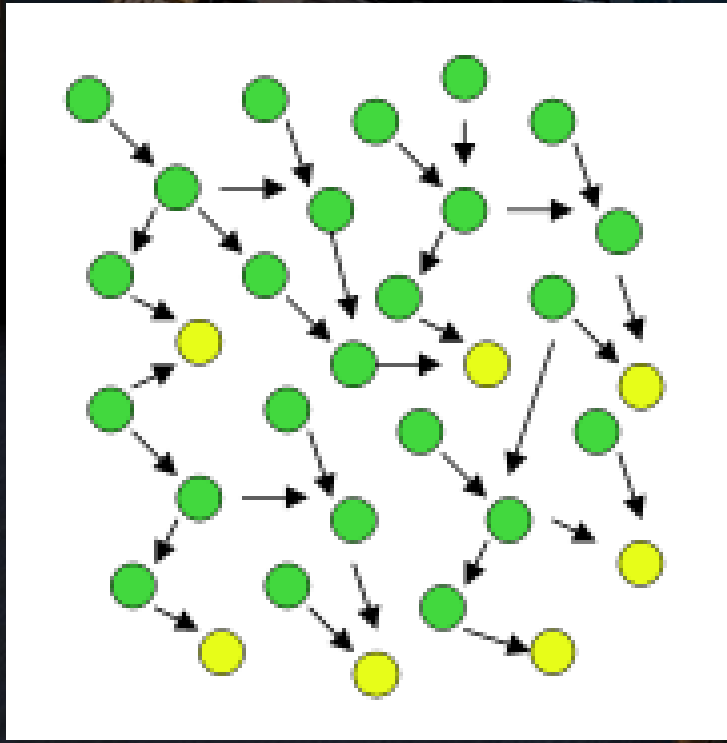


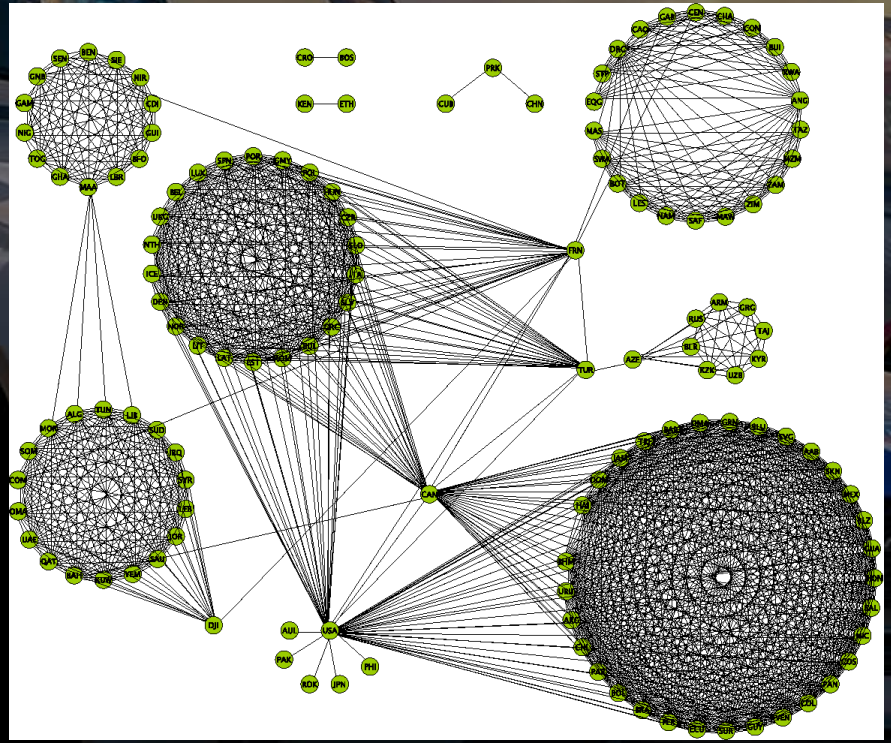
Layered equation

((~~TerrainPC~~ + ~~RoadPC~~) – ~~IntersectingGeometry~~) + ~~LocalHeroGeneratedPC~~

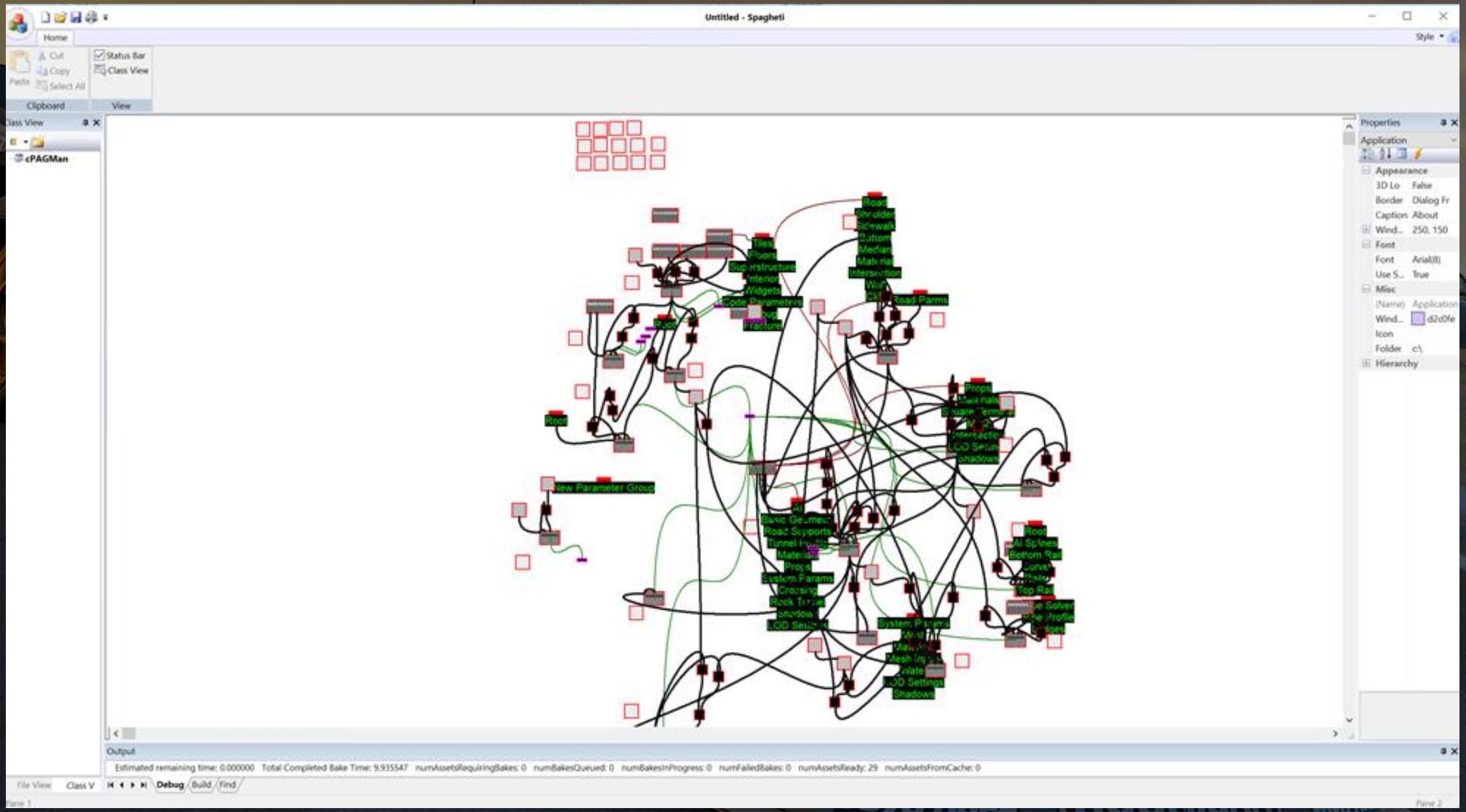
Scale to take full use of your cpu power

We use a Procedural Dependency Graph

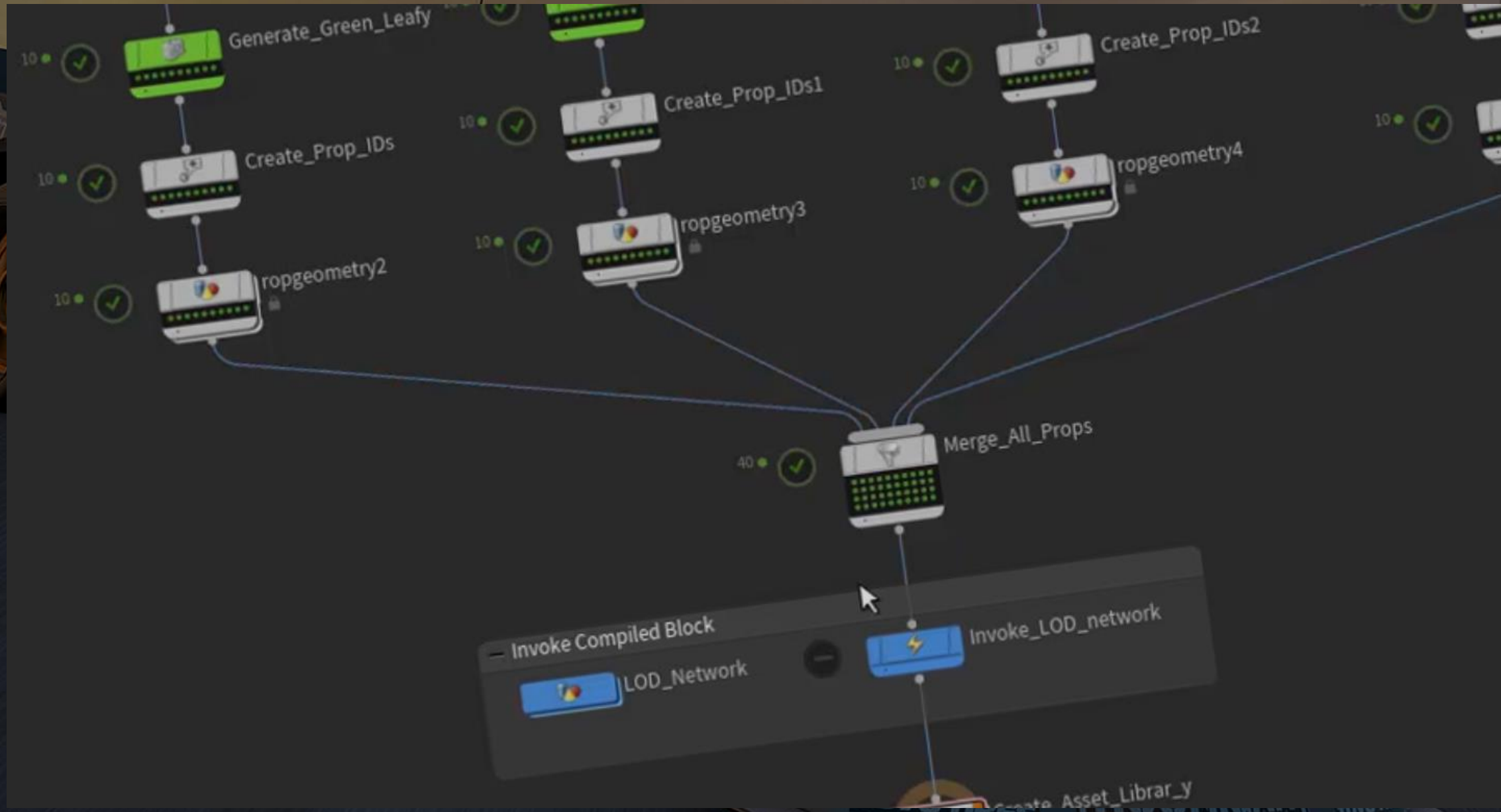




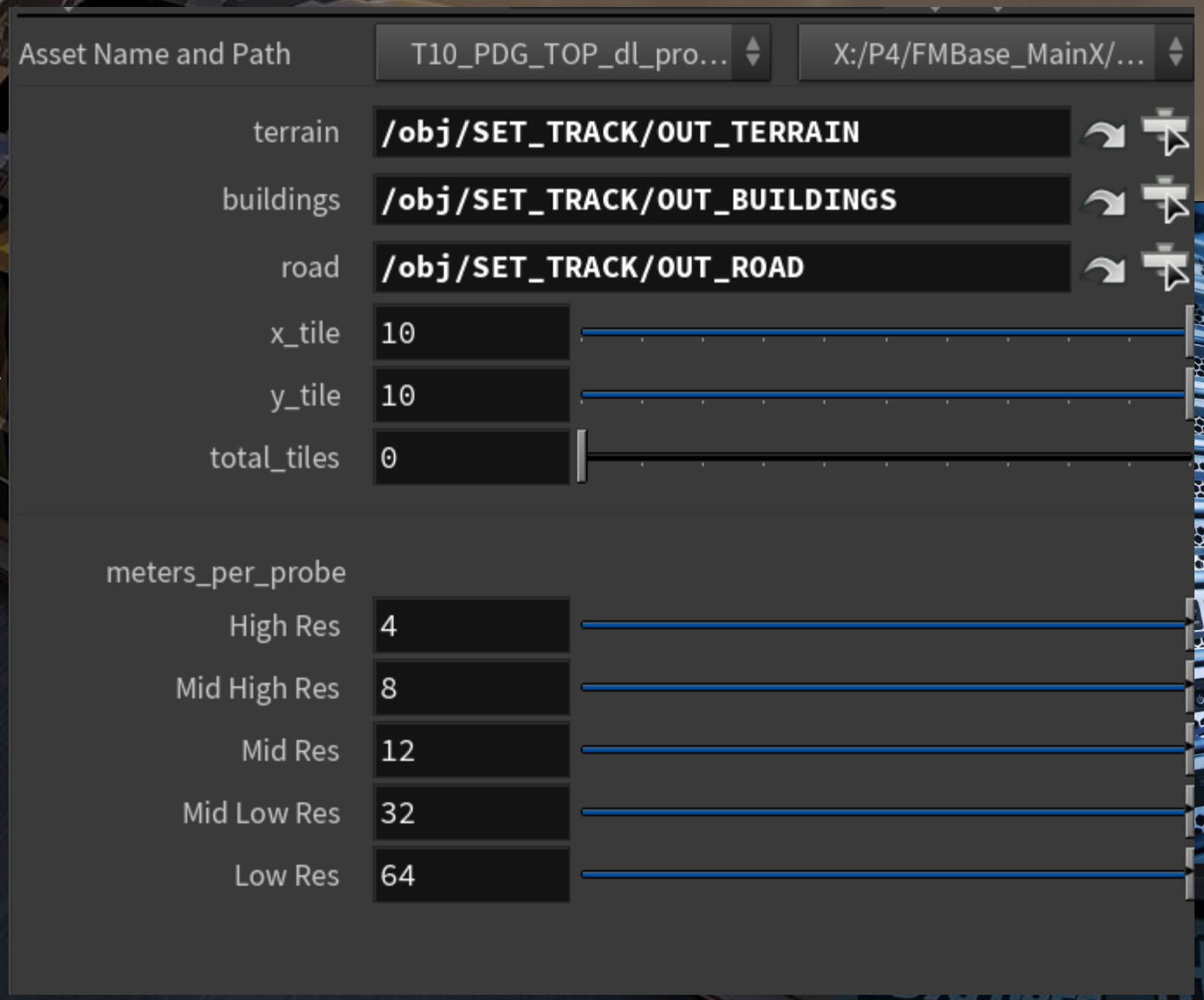
We use a Procedural Dependency Graph

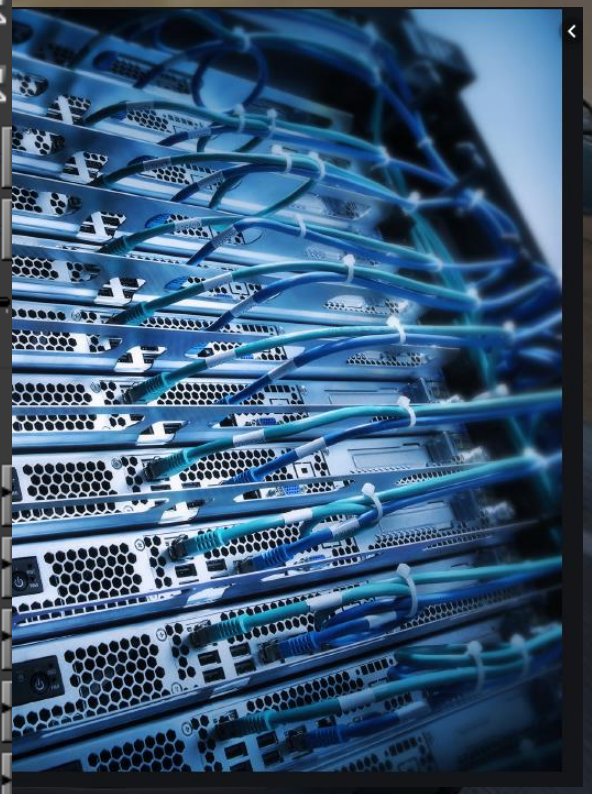


We use a SideFx PDG

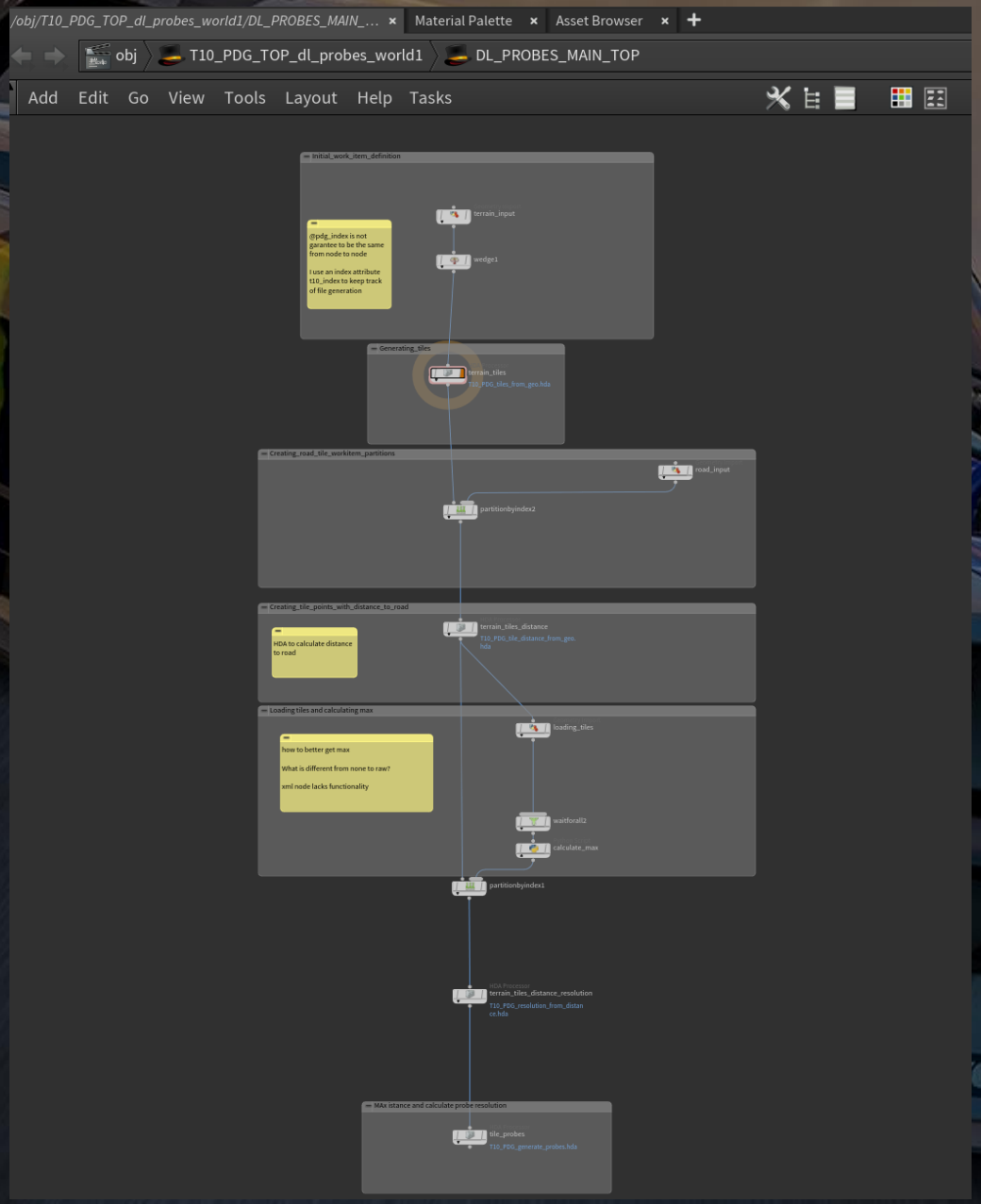


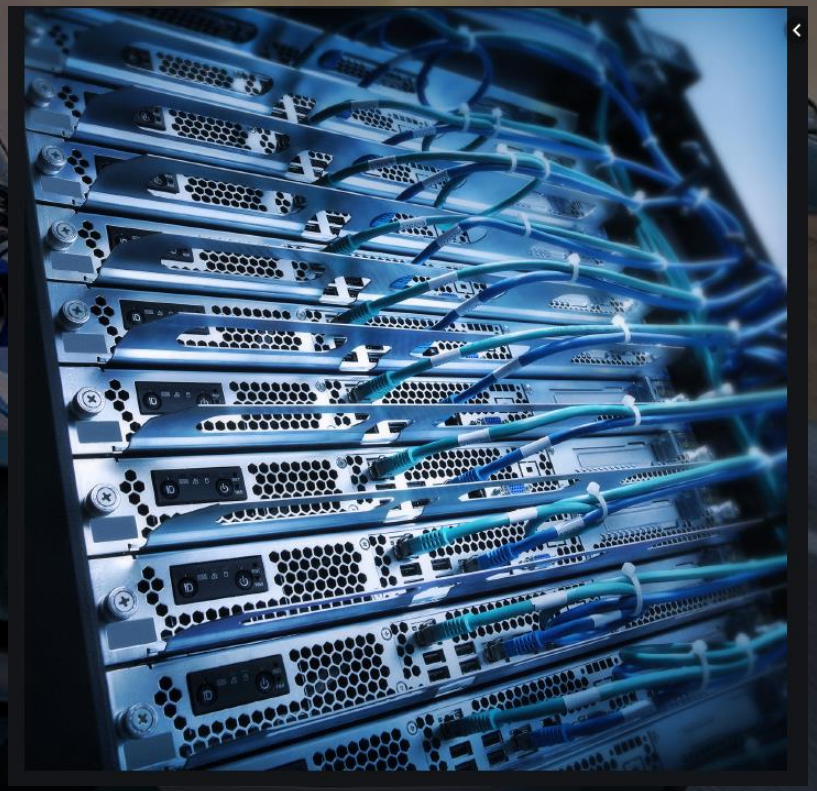
PDGying your setup for farm use
(Procedural Dependency Graph)





PDGying your setup for farm use
(Procedural Dependency Graph)





Recap

- We had a need to place light probes with a set of guidelines
- We cannot generate heuristics that will solve for every scenario
- We used a point cloud layer approach
  - We broke the problem more digestible parts
  - This allow for flexibility
- We take the setup and PDGfyIT to make our voxelization solve on a the farm

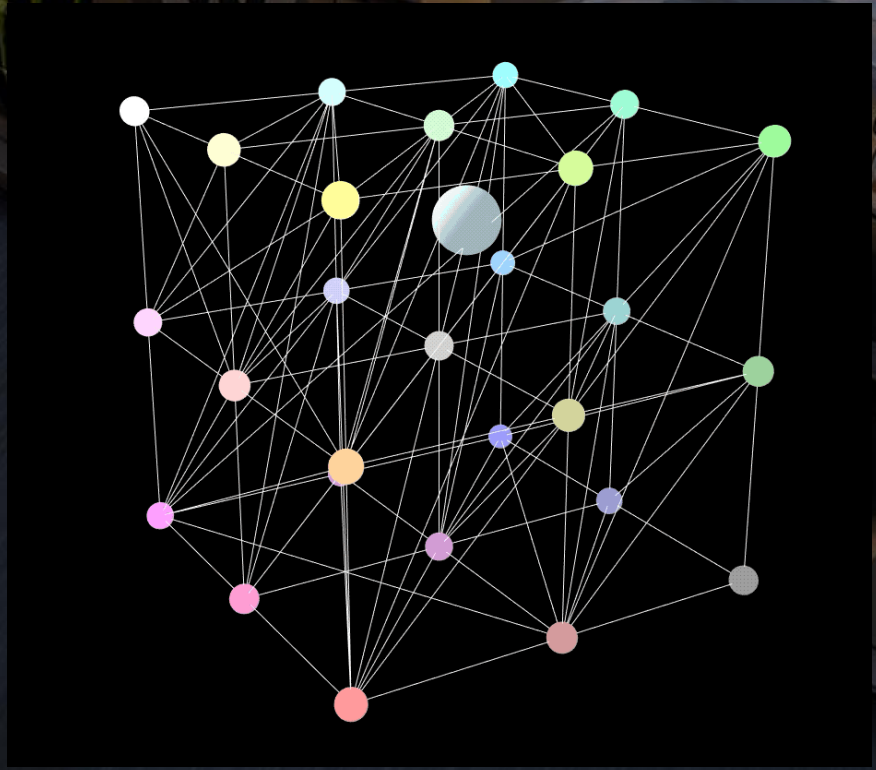
The

- We found this technique to be valid for indoor and outdoor lighting conditions
- Probe resolution matters
  - Sweet spot between probes/memory/diskspace
- For our scenario specific scenario“ Racing Game”
  - An adaptive solution works well
- While this technique gives the optimal adaptive probe distribution
  - The underlying data still low res at a 32 x 32 texture across the world

- While adaptative placing probes where detail is needed gives good results
  - This is limited by the underlying structure using a 32 x 32 texture

Next steps

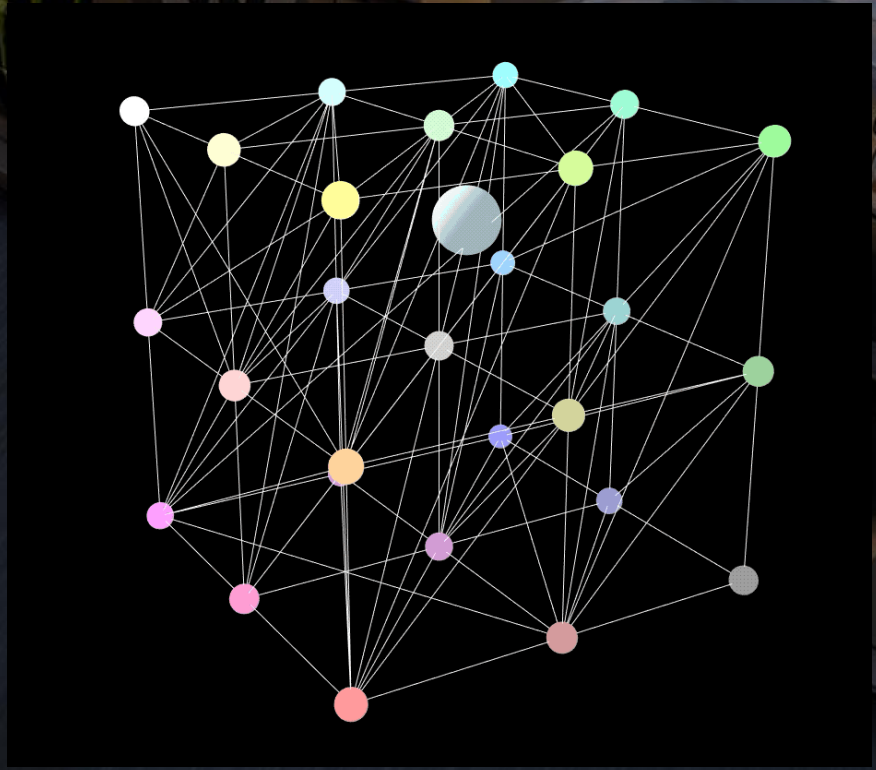
3D Texture Data

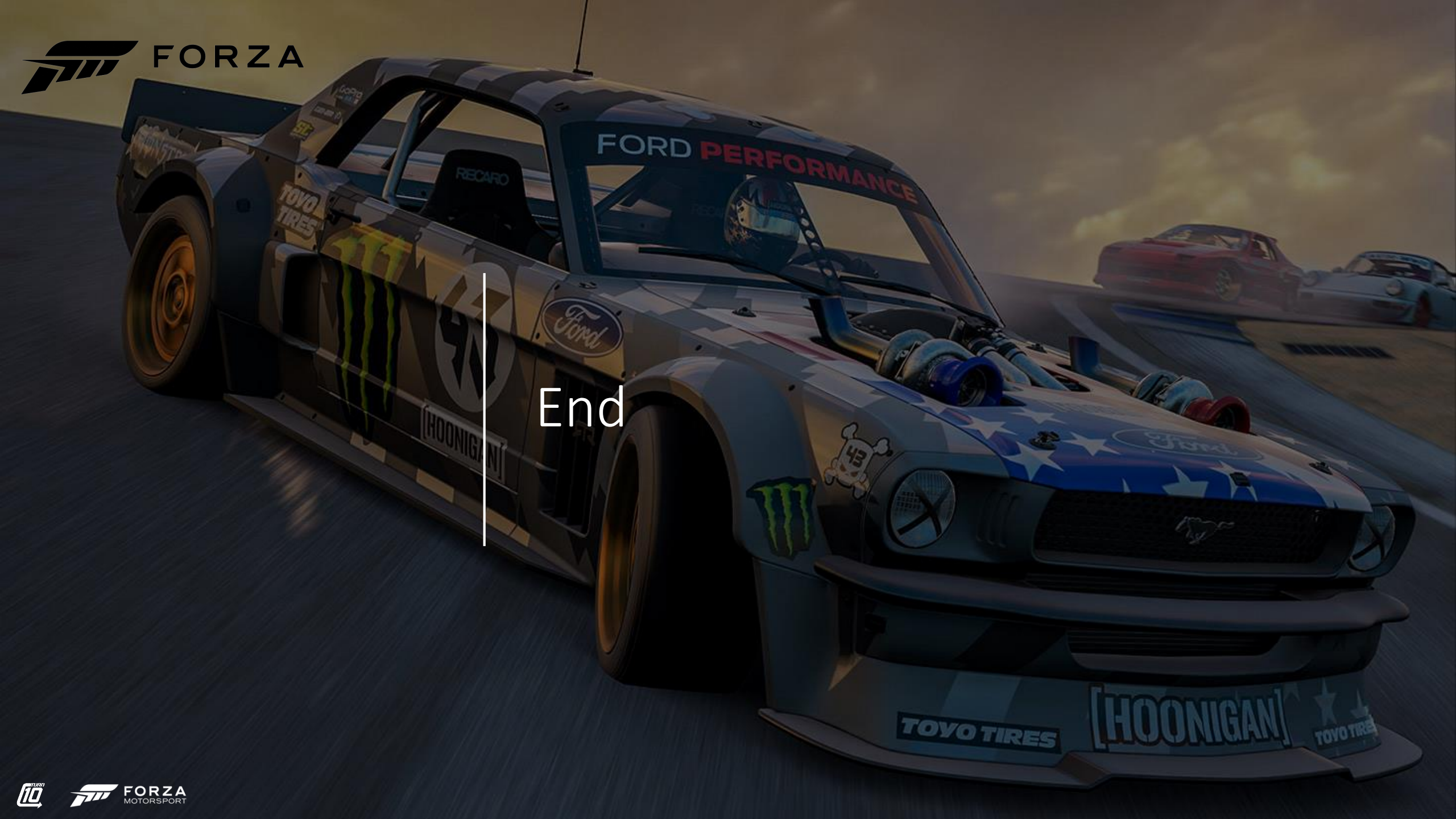


- While adaptative placing probes where detail is needed gives good results
  - This is limited by the underlying structure using a 32 x 32 texture
- We hope to take the same approach to define the underlying data structure
  - This will give the most optimal probe distribution and texture resolution

Next steps

3D Texture Data

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End

Special Thanks

Microsoft

- The great team at Turn 10

Xray Halpering

- ‘Marvel’s Spider-Man’: Procedural Lighting Tools

Gil Rosado

- Forza Tech Engine Developer

Chris Crosetto

- Lead Tools Developer

- Andrew Baker
  - Lighting Lead
- Procedural Department
  - Ali Nikkhouy
  - Alberto Panico

All the amazing Game-Developer community

- we build on each others' ideas

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Q&A

Please feel free to contact me with questions