

An aerial, top-down view of a dense urban area, likely New York City, showing a grid of streets and numerous skyscrapers. A semi-transparent digital grid is overlaid on the city, representing a digital twin. The grid lines are thin and light blue, following the street layout and building footprints. The overall color palette is muted, with greys, browns, and blues.

# Maps for Machines

A Persistent, Evolving Digital Twin of the Earth

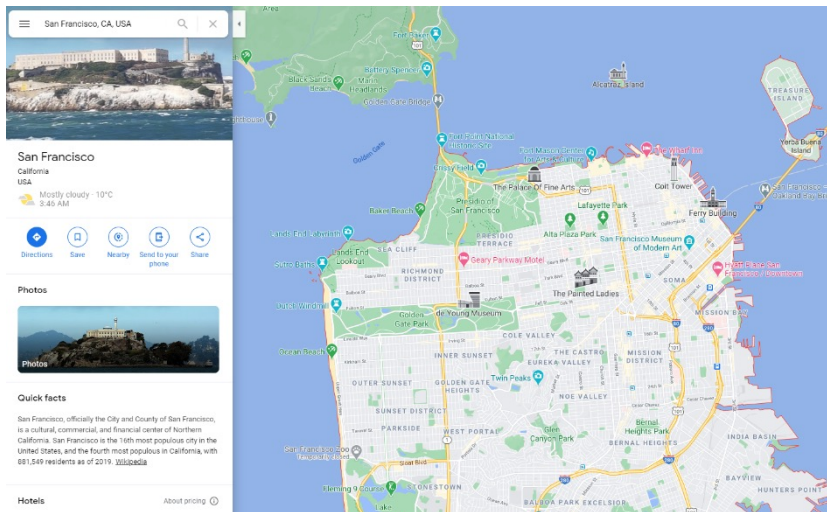


# Maps for Machines



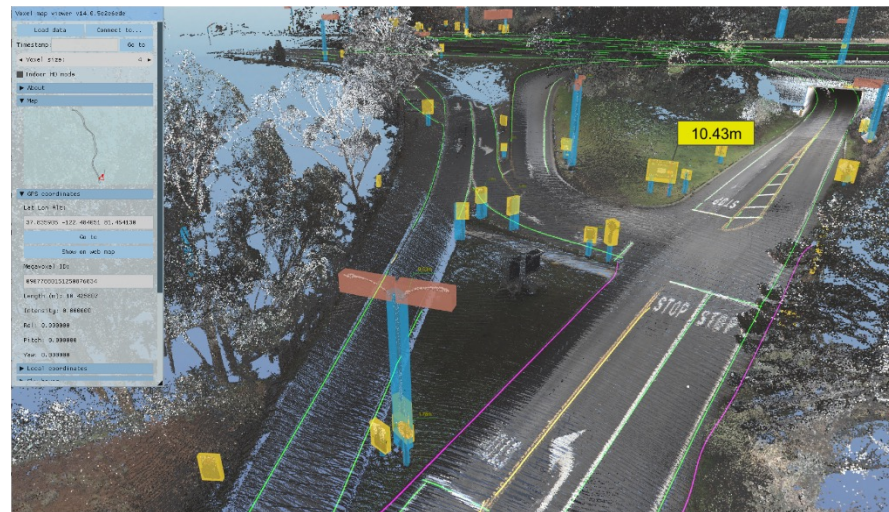
## Human Maps

- Navigation to Cities, Streets, Buildings
- Visualization of Geo-data
- 2-2.5D Data
- Low Resolution - 1-3m



## Machine Maps

- True 3D Spatial Data Models
- Analysis of Multiple Objects - Infrastructure, Telecoms, Utilities, Vegetation, Land Structures etc
- High Resolution - 1 - 4cm
- Not just location of Objects, but Measurements & Attributes
- Artificial Intelligence, Autonomous Cars, Delivery Robots, AMR Robots, Drones
- Requirement for Indoor, Outdoor, Subterranean & Ocean Data



# What is 4D Volumetric Data?



## 3D Maps

- Most 3D Maps are Approximate Visualizations of Cities
- Empty 3D Meshes, only virtualizes the surface or matter, they are not a true Digital Model of the World
- No ability to Incrementally Update

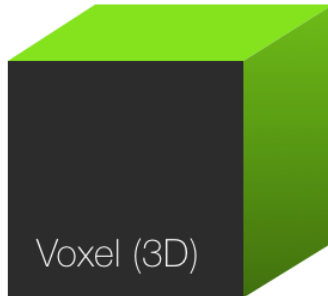
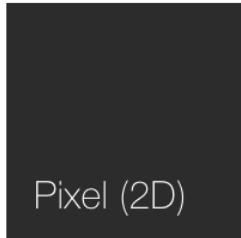


## 4D Volumetric Data

- Volumetric Maps are a complete 3D Model of Physical Matter, both Surface and Interior Data
- Enable Realtime Updates without Manual Post processing
- 4<sup>th</sup> Dimension of Time for Change Detection



## Pixel vs Voxel



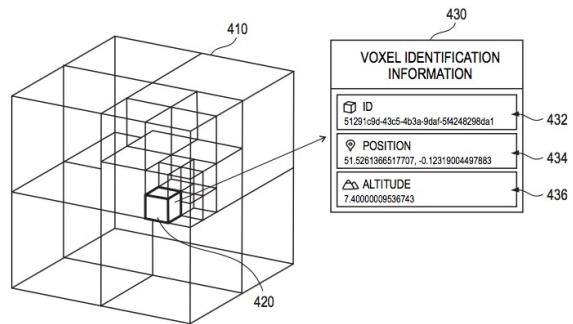
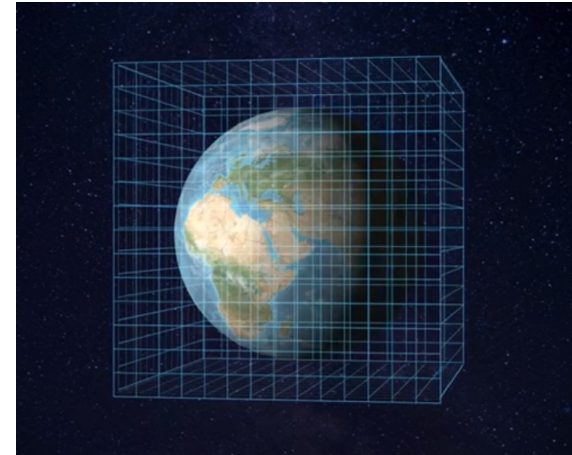
## Minecraft Voxel Based Computer Game



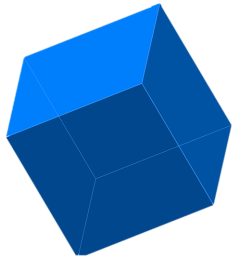




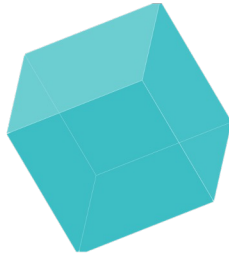
- The Planet is Placed Inside a Mega Voxel Structure
- The Mega Voxel is Comprised of Multi-Resolution Voxels through the Entire Planet - ECEF Model
- Voxel have Permanent Position and Unique Address
- Validate the Occupancy Status of the Voxels
- Creates a Global Spatial Database for 3D/4D Data
- Realtime, Persistent DB, Pb+ Scale, 5G Enabled



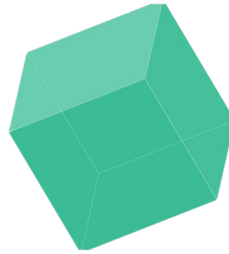
# Beyond Points & Meshes – Smart Voxel Features



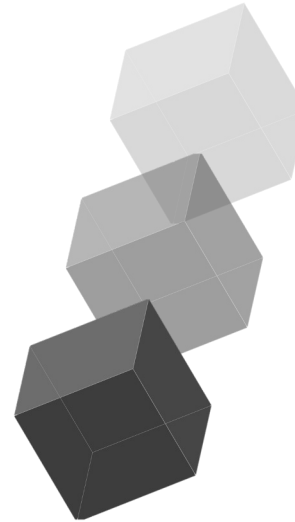
3D  
Volumetric  
Measurement  
Unit



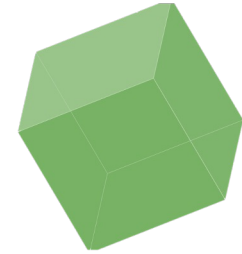
Surface Data  
Layer from  
Cameras  
  
RGB &  
Hyperspectral



3D Semantic  
Segmentation  
Deep  
Learning AI



4D  
Temporal  
Data  
Component  
  
Multiple  
Time  
States



Permanent  
Address  
  
Spatial DB  
  
Intelligent  
Search



# Voxelmap San Francisco – Aerial View

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# Voxelmaps San Francisco – Street-level





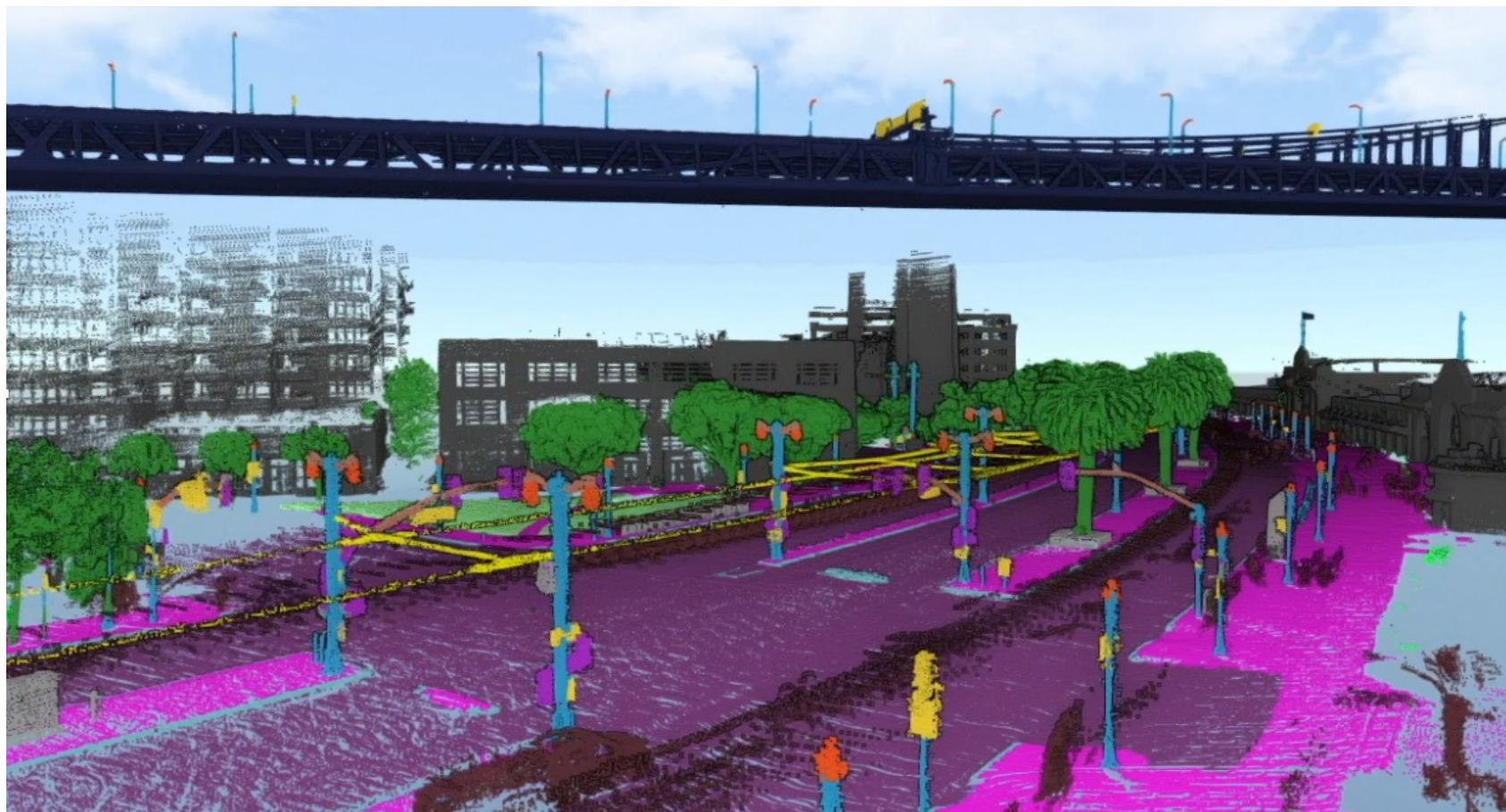




# AI Integrated



# Voxelmap – Digital Twin with 4D ML at the Core



# Not Just for Cities – Muir Woods SF, Ecology, Carbon Accounting, Forest Fires







## Thank You

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