# Open Source Mapping Library Shoot Out

George Owen and Courtney Yatteau

# About this talk

- High-level library comparisons
- Performance comparison
- Conclusions

# About the presenters

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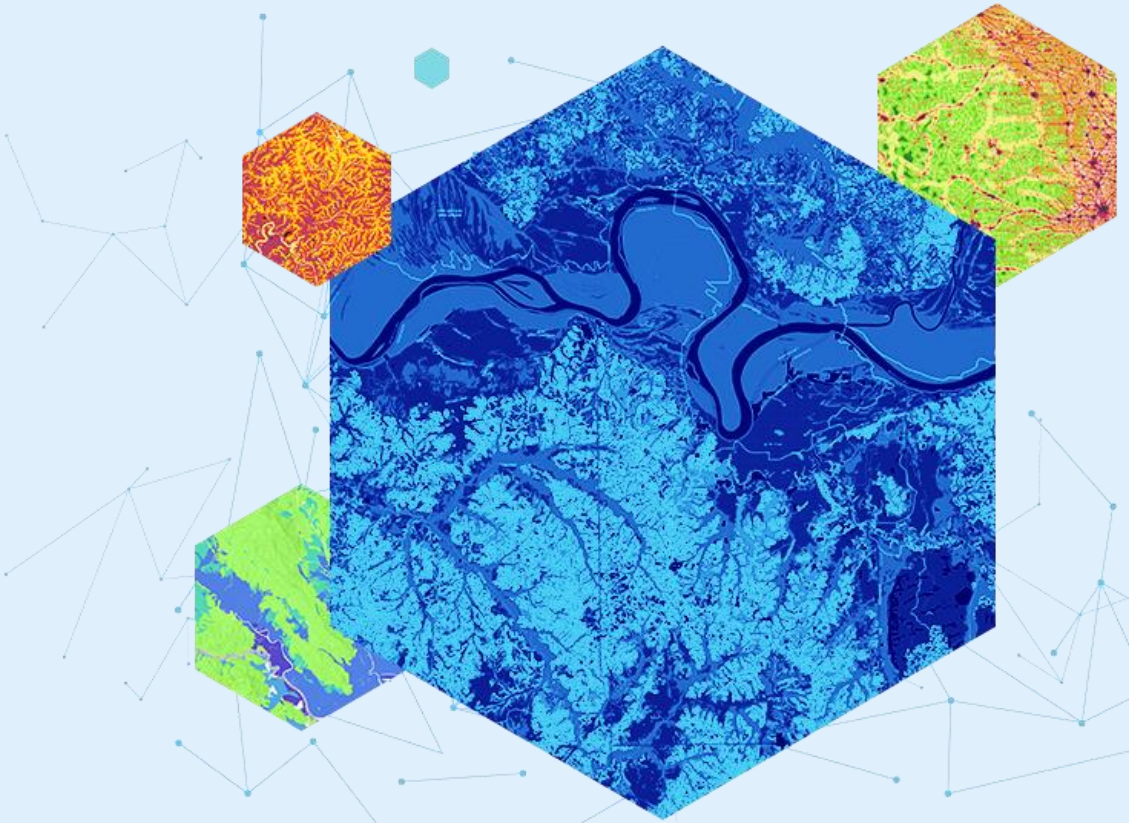
# Why this topic?

- Open source alternatives to Mapbox GL JS, Google Maps SDK, ArcGIS Maps SDK for JS
- Several different options, which library do you choose?
- Consider your specific use case

# Esri’s open vision

## An open platform

- Open standards
- Open data
- Open source libraries
  - https://developers.arcgis.com/



ArcGIS Developers | Documentation | Features | Pricing | Support

CesiumJS | Home

Find page...

- Overview
- Key features
- Get started
- Tutorials
- Authentication
- Scenes
- Data services
- Query
- Visualization
- Geocoding
- Routing
- Places
- Data enrichment

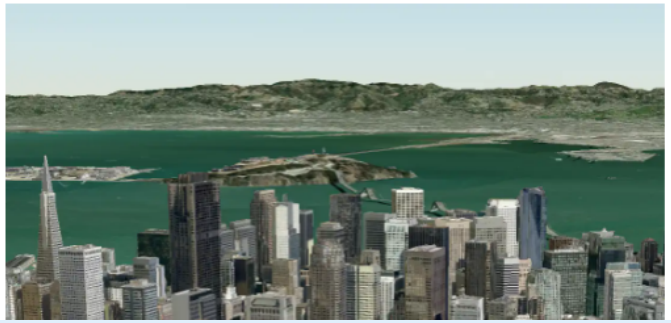
# CesiumJS

Current version: 1.107

CesiumJS is an open source JavaScript library that renders interactive scenes from 3D data and imagery. This guide shows you how to use CesiumJS and ArcGIS location services to display scenes and perform operations such as adding layers, geocoding, routing, data enrichment, and spatial queries.

## Where to start

1. Discover what you can build with CesiumJS and location services.
2. Get an API key and build your first app.
3. Explore the tutorials.



## Open source

Esri Leaflet >

MapLibre GL JS >

OpenLayers >

CesiumJS >

## Esri Leaflet / Sample Code

Find page...

- Featured
- Basemap layers
- Feature layers
- Visualization
- Tile layers
- Dynamic map layers
- Image map layers
- Projection
- Query
- Geocoding
- Authentication
- Services

# Library comparisons

Leaflet (and Esri Leaflet), MapLibre GL JS, OpenLayers, CesiumJS

# Show of hands! ✋

Have you ever used the following open source mapping library?

**Leaflet**

**MapLibre GL JS**

**OpenLayers**

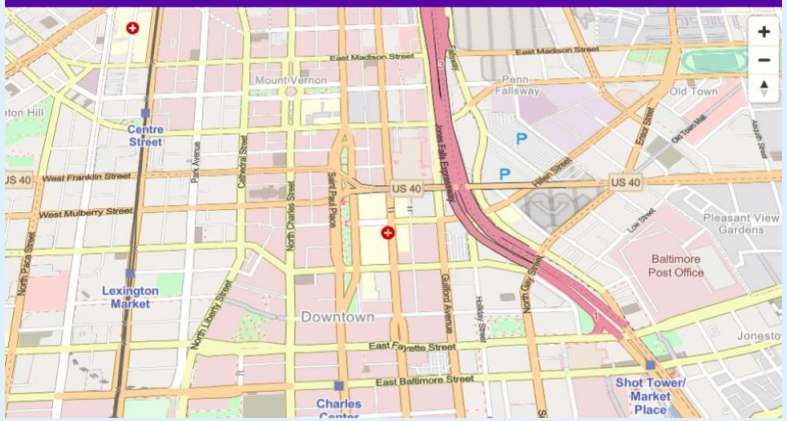
**CesiumJS**

# Maps and scene support

| | 2D | 2.5D | 3D |
|---|---|---|---|
| Leaflet | ✓ | ✗ | ✗ |
| MapLibre GL JS | ✓ | ✓ | ✓ |
| OpenLayers | ✓ | ✗ | ✗ |
| CesiumJS | ✓ | ✓ | ✓ |

✓ Full support ◔ Partial support ✗ No support

MapLibre GL JS: OSM basemap with building heights



# Data and layer support

| | Web GL | GeoJSON features | ArcGIS data services | Vector tiles | Raster tiles | I3S |
|---|---|---|---|---|---|---|
| Leaflet (v. 1.9.4) | ✗ | ✓ | ◔ [1] | ◔ [2] | ✓ | ✗ |
| MapLibre GL JS (v 3.0.1) | ✓ | ✓ | ◔ [3] | ✓ | ✓ | ✗ |
| OpenLayers (7.4.0) | ◔ | ✓ | ◔ [3] | ✓ | ✓ | ✗ |
| CesiumJS (v. 1.106.0) | ✓ | ✓ | ◔ [3] | ✗ | ✓ | ✓ |

✓ *Full support* ◔ *Partial support* ✗ *No support*

1. Esri Leaflet

2. Esri Leaflet, Leaflet.VectorGridLayer, etc.

3. ArcGIS REST JS

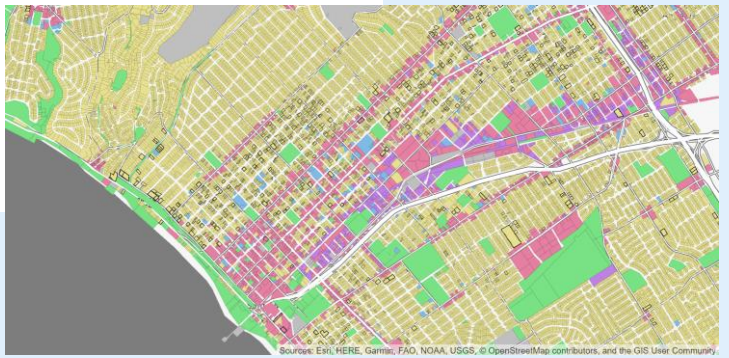
# Styling data

| | Style vector tiles | Style raster (map) tiles | Style GeoJSON |
|---|---|---|---|
| OpenLayers | ◔[1] | ✓ | ✓ |
| Leaflet | ◔[1] | ✗ | ✓ |
| MapLibre GL JS | ✓ | ◔[2] | ✓ |
| CesiumJS | ✗ | ◔[2] | ✓ |

✓ *Full support* ◔ *Partial support* ✗ *No support*

1. Requires use of MapLibre style specification and additional plugins

2. Change global values for hue/brightness/etc



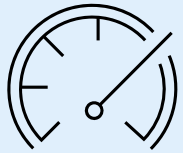
# Library file sizes

| Library or Plugin | Version | Node file size | Packages | CDN JS | CDN CSS |
|---|---|---|---|---|---|
| Leaflet | 1.9.4 | 2.86 MB | 1 | 44.2 KB | 3.7 KB |
| Esri Leaflet | 3.0.10 | 765 KB | 4 | 19.2 KB | *Geocoder plugin: >1 KB |
| MapLibre GL JS | 3.0.1 | 11.2 MB | 55 | 202 KB | 8.6 KB |
| OpenLayers | 7.4.0 | 4.82 MB | 18 | 213 KB | 1.9 KB |
| ol-mapbox-style | 10.6.0 | 6.55 MB | Not applicable | 40.3 KB | Not applicable |
| CesiumJS | 1.106.0 | 17.4 MB | 35 | 917 KB | 6 KB |

# Community involvement

As of October 20th, 2023

| Library | Weekly npm downloads | Github stars | Stack overflow | Questions answered |
|---|---|---|---|---|
| Leaflet | 927,768 | 38.7k | 13.9k | ~60% |
| MapLibre GL JS | 169,556 | 5k | 93 | ~50% |
| OpenLayers | 215,244 | 10.4k | 5.1k | ~80% |
| CesiumJS | 70,283 | 11.1k | 849 | ~75% |

# Performance metrics 

Leaflet (w/ Esri Leaflet), MapLibre GL JS, OpenLayers

# Performance testing goals

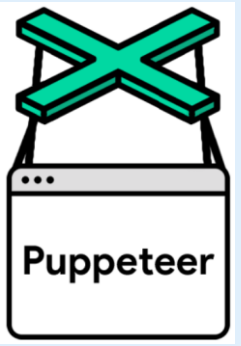
Compare similar 2D mapping libraries:

- OpenLayers
- MapLibre GL JS
- Leaflet

Find the most performant library for:

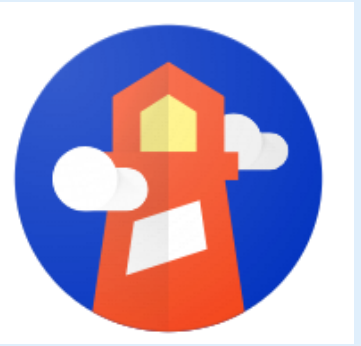
- Library load time
- Basemaps
- Common data types

# Methodology




Performance tools:

- Puppeteer.js – Trace page loading
- Lighthouse report – Performance metrics in report



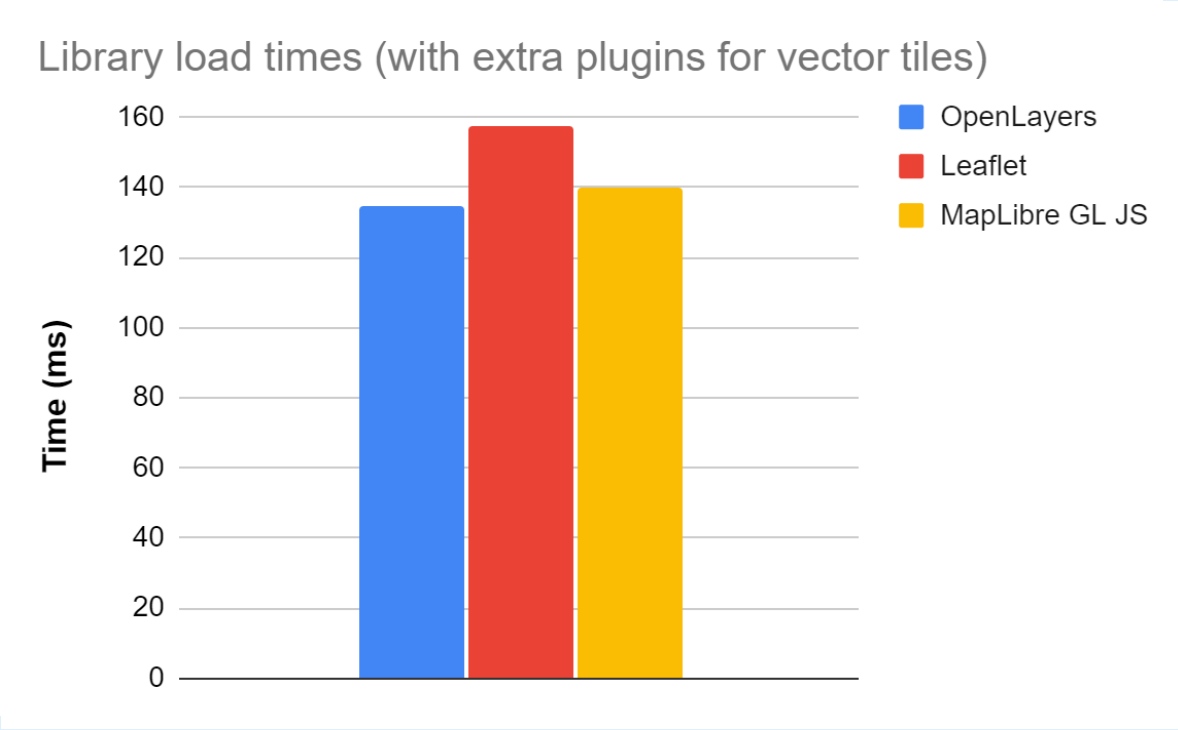
Types of data:

- Basemaps: Vector tile basemap, Map tile basemap
- Vector tile data
- Map tile data
- GeoJSON data

# Methodology continued

- Environment: My laptop
  - Dell Precision 7560
  - Intel i7-11800H, x64-based
  - 32 GB RAM, 16 GB VRAM
  - Windows 10 Enterprise
- Node.js script to automate testing (see GitHub)
- 20 iterations of each test, all results are averaged
- *DISCLAIMER: we are not web performance SMEs*

# Library load times


* Leaflet using Esri Leaflet & Esri Leaflet Vector, OpenLayers using OpenLayers Mapbox Style (OLMS)

# Terminology

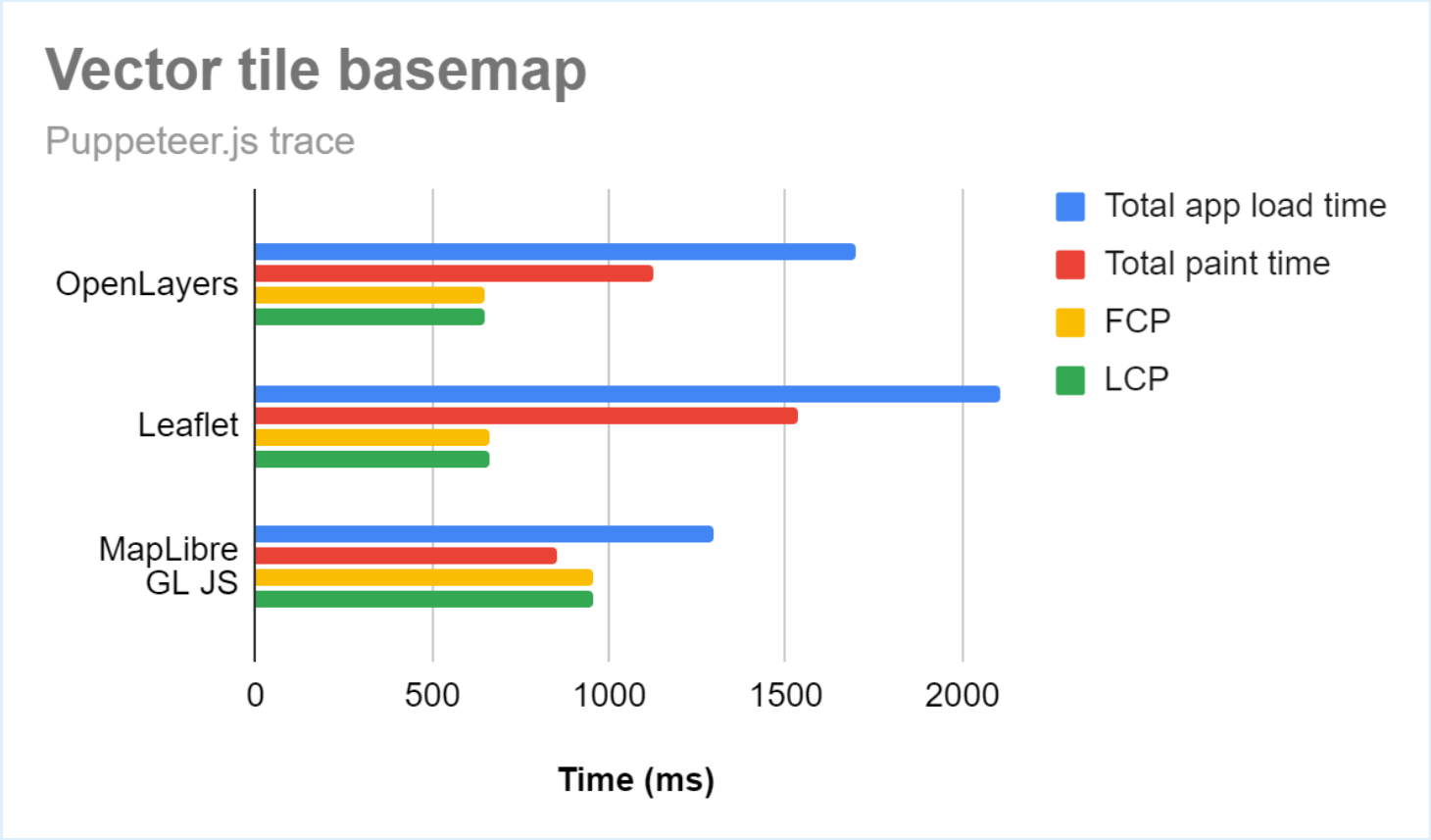
- **Paint Event –** Tracks pixels rendered on display
- **First contentful paint (FCP) –** First visible content
- **Largest contentful paint (LCP) –** Largest visual update
- **Total blocking time –** Duration during which the user can see content but not interact with it (FCP -> Interactive)

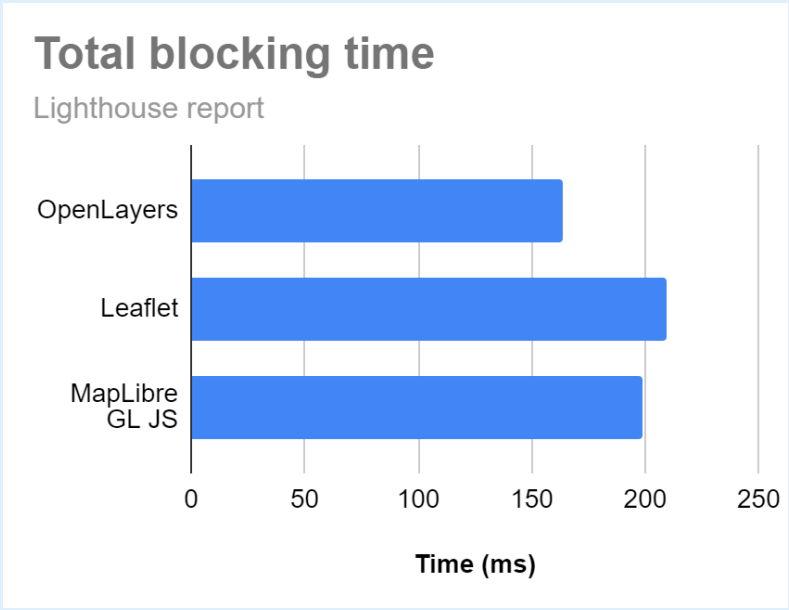
# Vector tile basemap

- ArcGIS Light Gray basemap

# Vector basemap results

*Leaflet using Esri Leaflet Vector, OpenLayers using OLMS



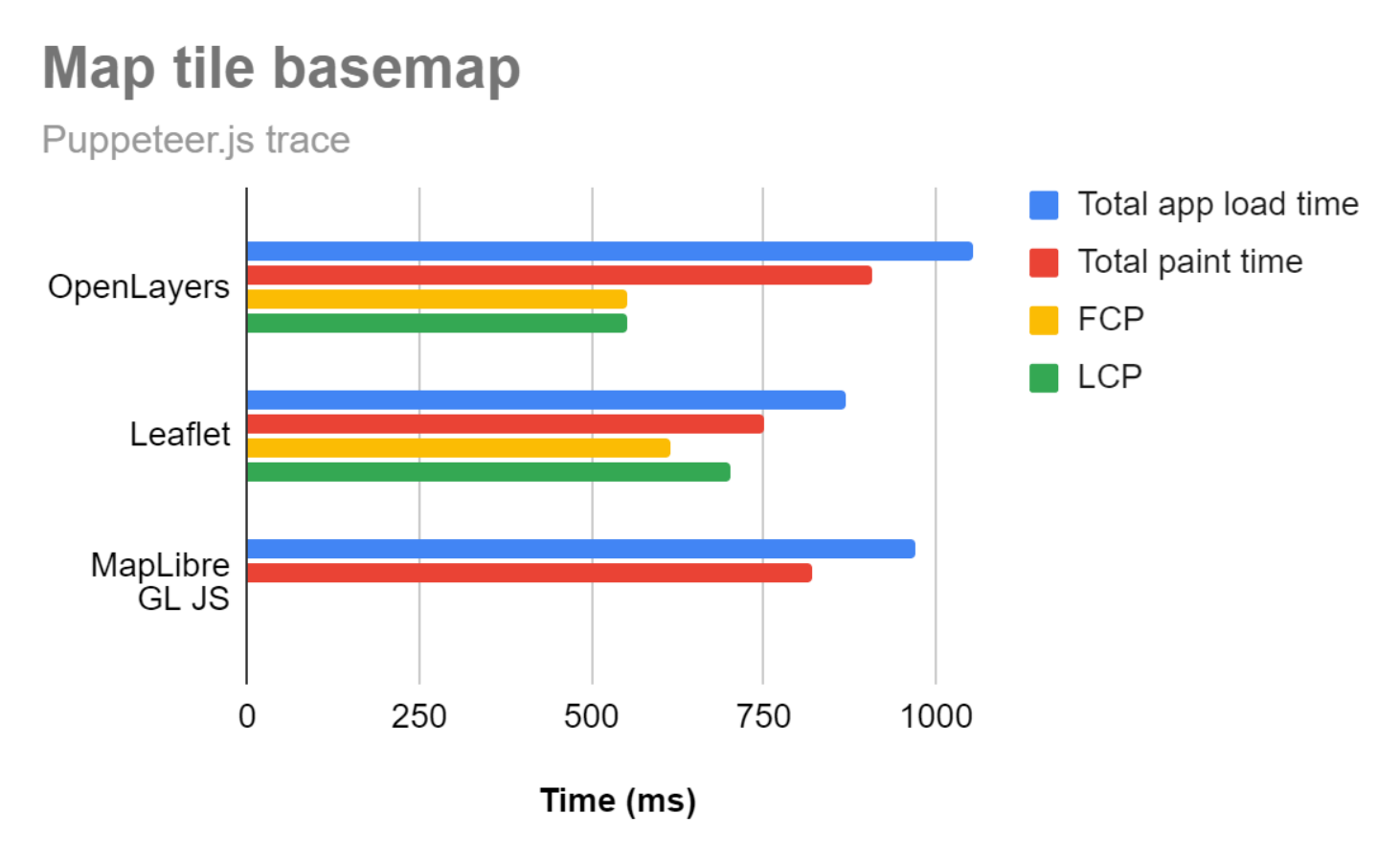



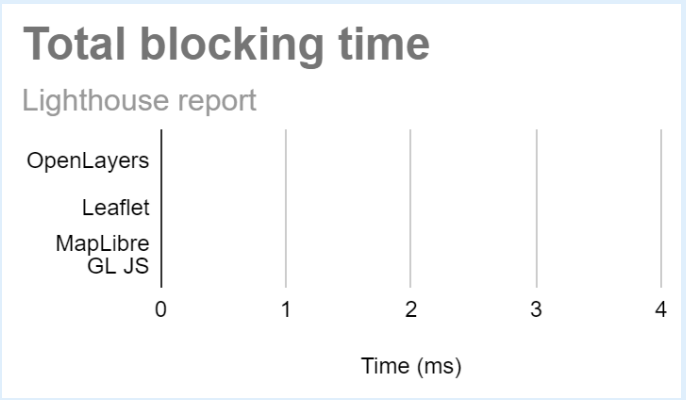

Winner: MapLibre GL JS

# Map tile basemap

- ArcGIS World Imagery basemap

# Map tile basemap results

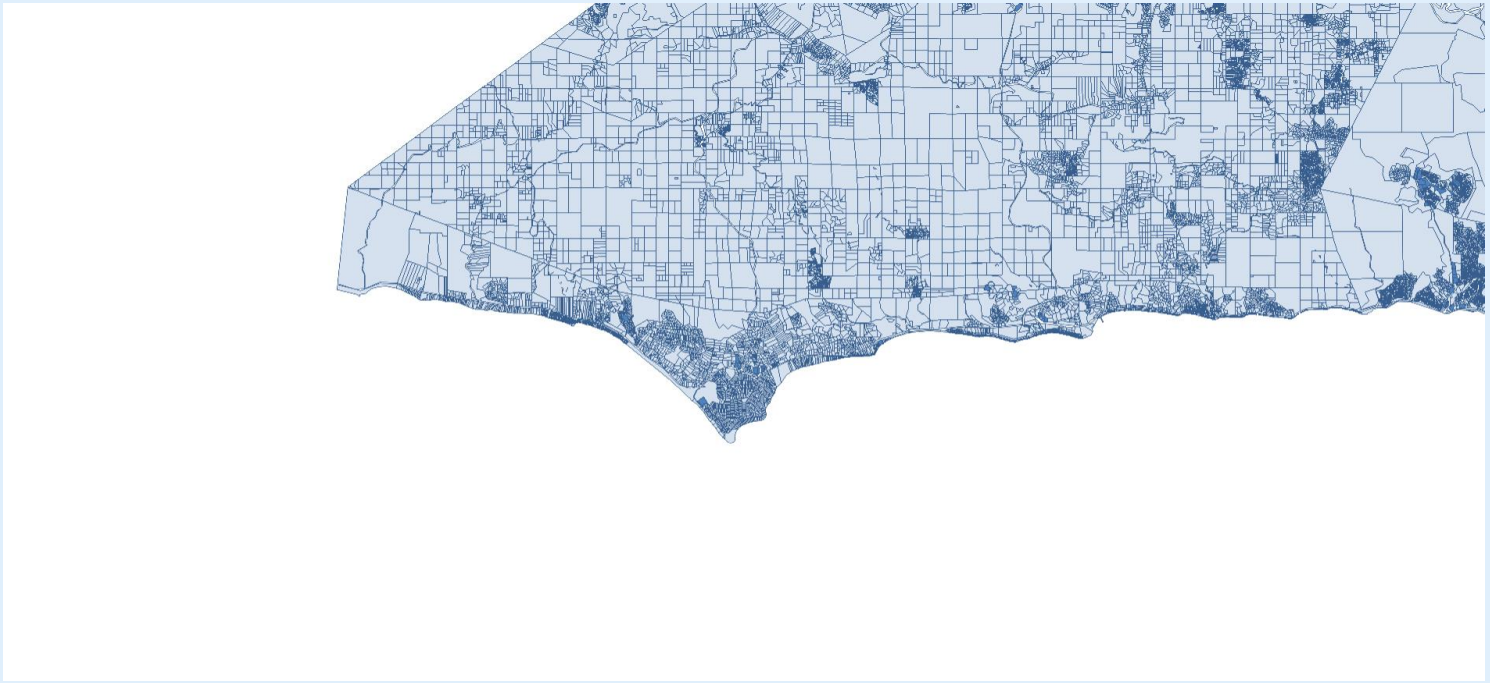



Winner: Leaflet

# Vector tile data

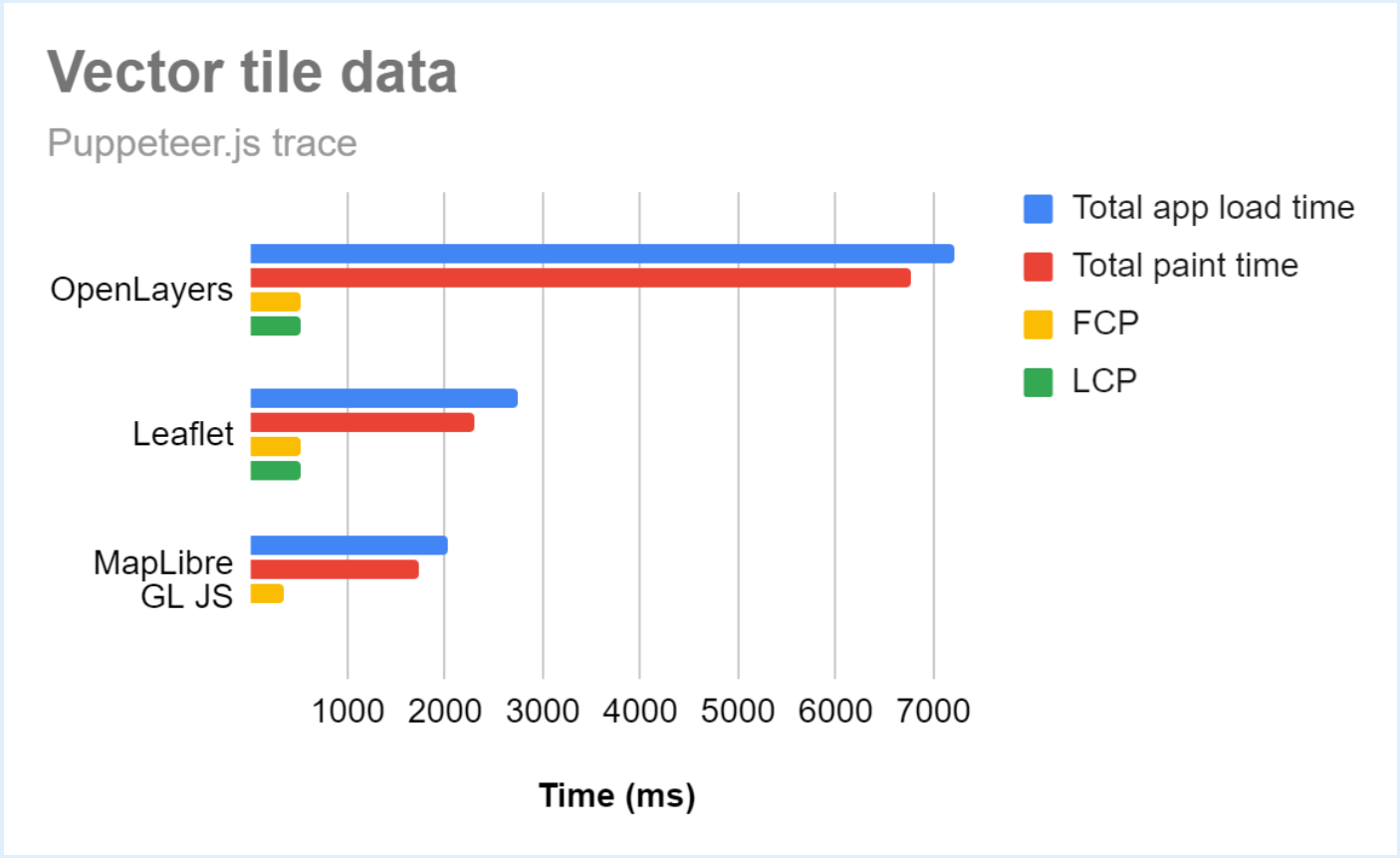
- Vector tile layer hosted in ArcGIS
- Land parcels in Malibu and Santa Monica

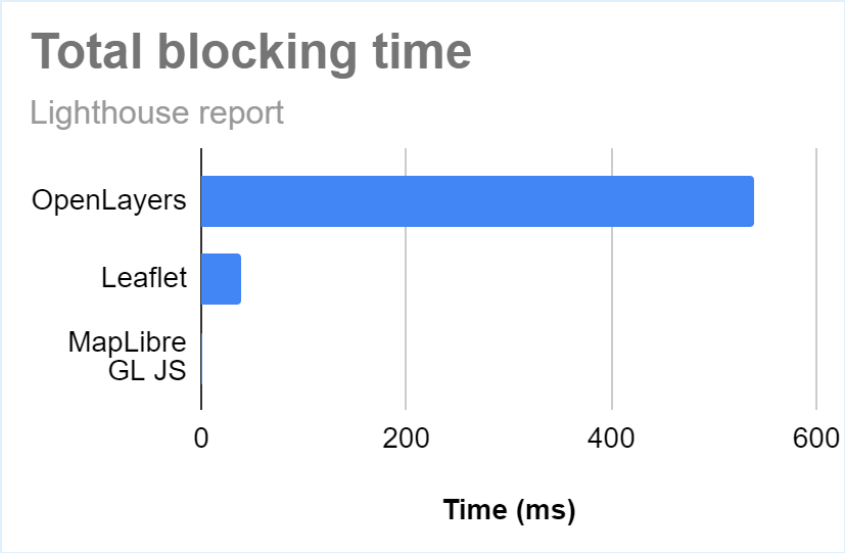


https://www.arcgis.com/home/item.html?id=f0298e881b5b4743bbdf2c7d378acc84

# Vector tile data results

*Leaflet using Esri Leaflet Vector

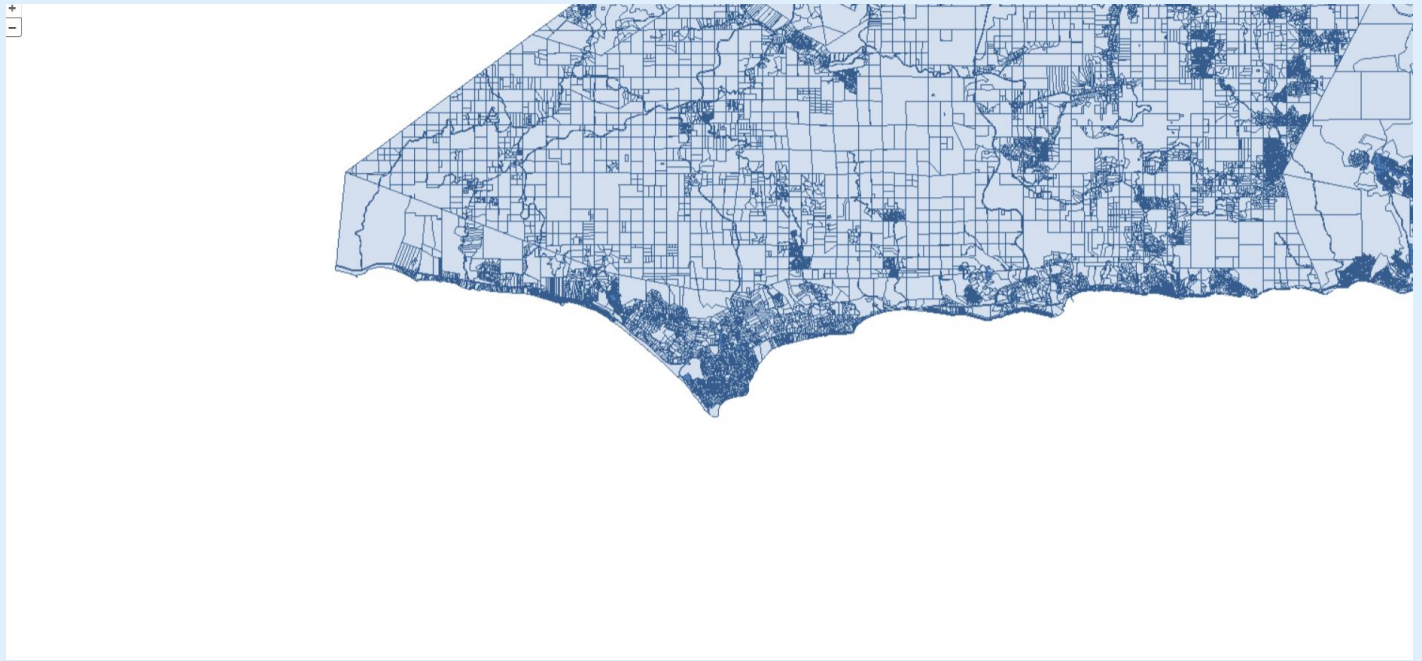



Winner: MapLibre GL JS

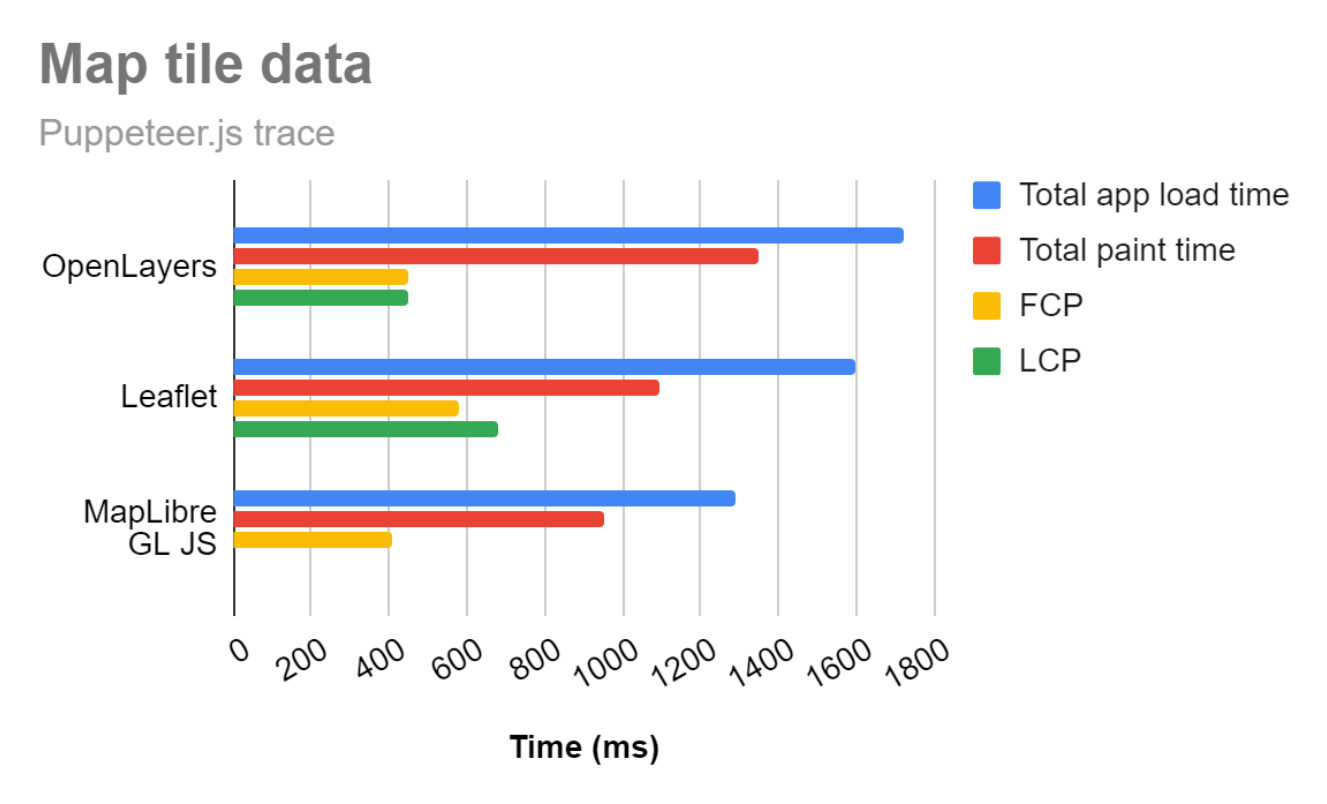
# Map tile data source

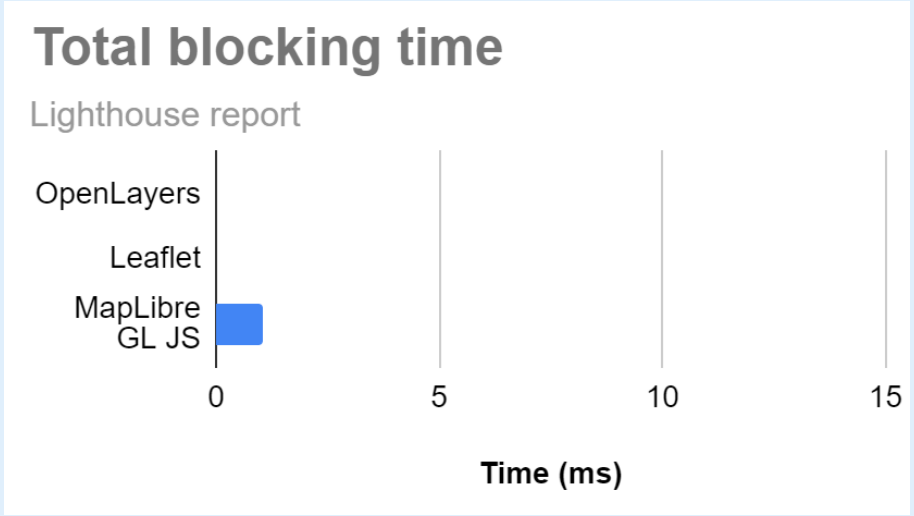
- Map tile layer hosted in ArcGIS
- Land parcels in Malibu and Santa Monica



https://services3.arcgis.com/GVgbJbqm8hXASVYi/ArcGIS/rest/services/Santa_Monica_Mountains_Parcels/MapServer

# Map tile data results



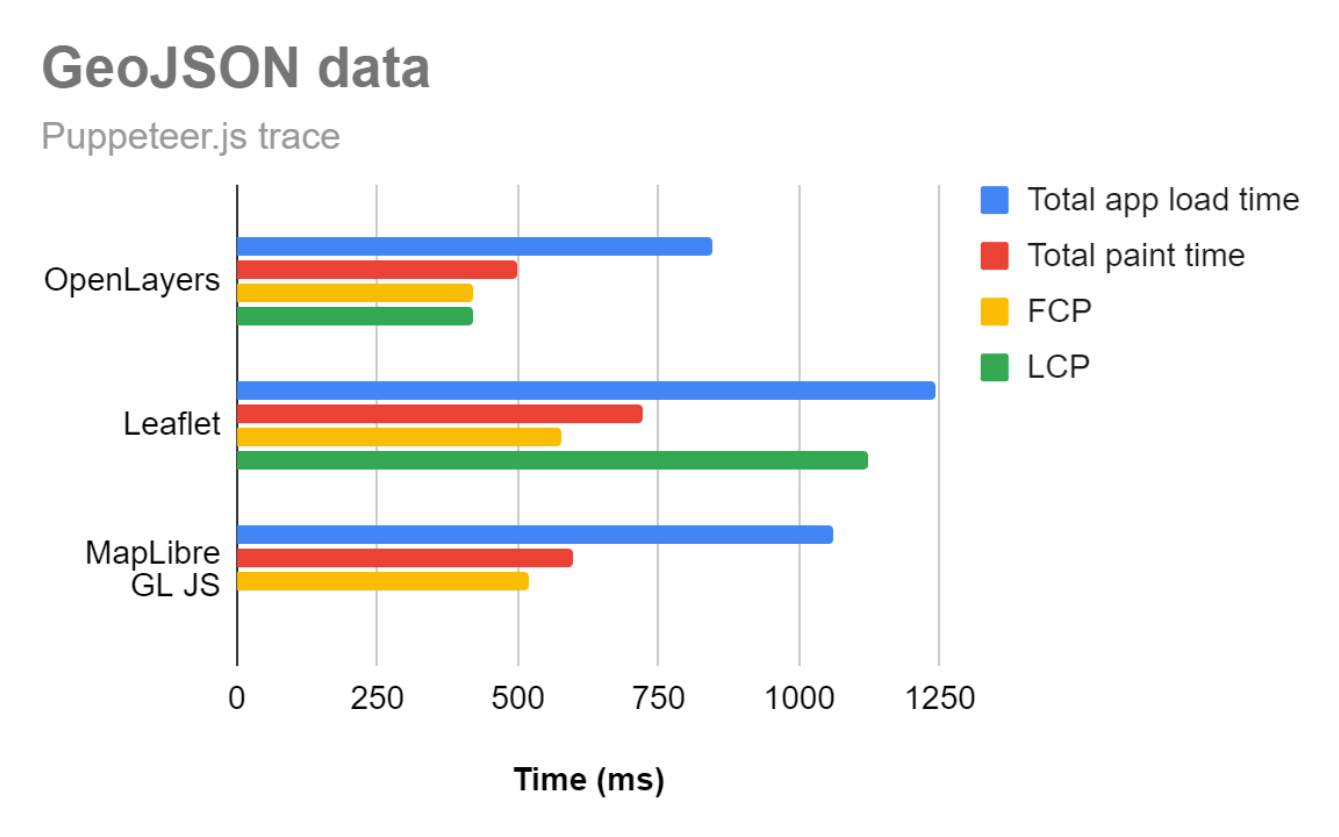

Winner: MapLibre GL JS

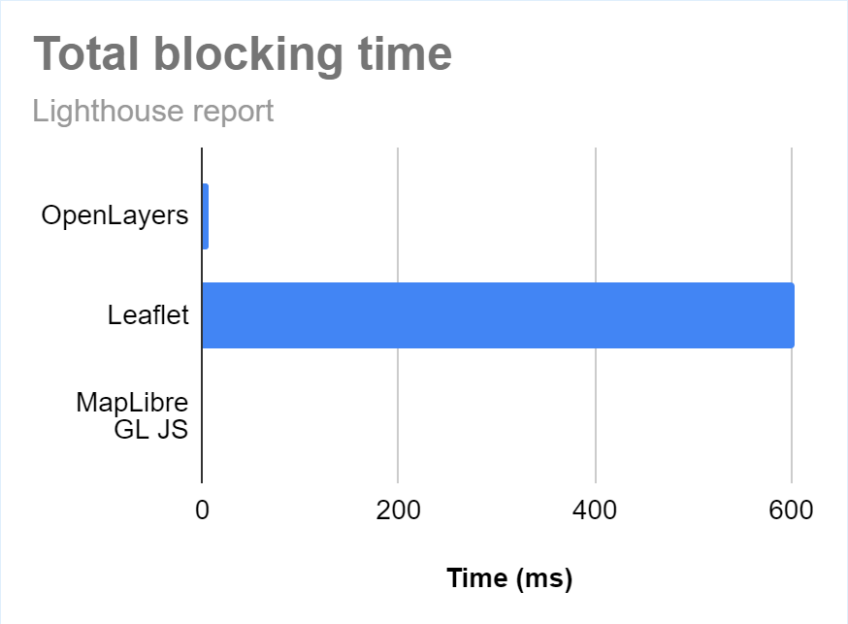
# GeoJSON data source

- Feature layer hosted in ArcGIS, query features as GeoJSON
- ~1700 features in extent

https://www.arcgis.com/home/item.html?id=66c5bd3cde384c448216bd7ed9f4061f

# GeoJSON data results




Winner: OpenLayers

# Conclusions

## The pros and cons

# OpenLayers

## Pros ✅:

- Best library for GIS operations
- Longest lifespan existence
- Performance: GeoJSON

## Cons ❌:

- Limited WebGL support
- Not performant for vector tile data
- Steep learning curve

# Leaflet

## Pros ☑:

- Small library size
- Esri Leaflet: built-in integration with ArcGIS hosted data
- Very active community
- Lots of plugins
- Performance: Middle of the pack

## Cons ✕:

- No WebGL support

# MapLibre GL JS

## Pros ☑:

- WebGL support
- Vector tile layer customization
- Performance: All around most performant

## Cons ✕:

- Small community *(partly due to being the newest)*
- Limited plugins (reliant on outdated Mapbox plugins)

# CesiumJS

## Pros ✅:

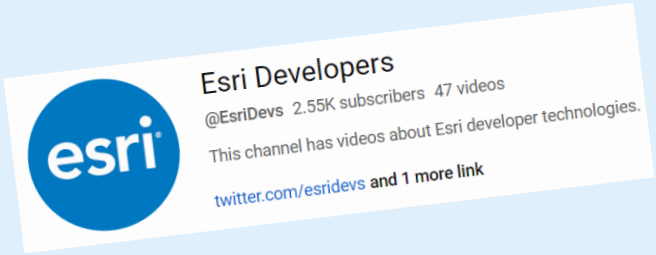
- 3D scene support
- Advanced 3D modeling, time-dynamic visualization
- Different use cases (for more advanced apps)

## Cons ❌:

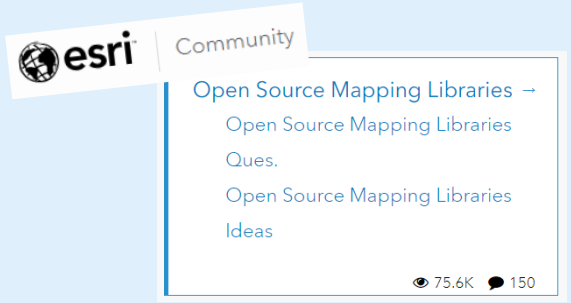
- Large library size
- GPU intensive
- No vector tile layer support

# Resources

- Github repo (slides+code)
- EsriDevs YouTube (@esridevs)
- EsriDevs X (Twitter) (@esridevs)
- MediaSpace videos (links.esri.com/devvideos)
- Esri Community (links.esri.com/esridevcommunity)
- Esri developer site (developers.arcgis.com)





# Q & A

# References 


- https://github.com/addyosmani/puppeteer-webperf#devtools-interaction
- https://developers.arcgis.com
- https://developer.chrome.com/docs/lighthouse/performance/
- *Zunino, Velazquez, Celemin, Mateos, Hirsch, Rodriguez (2020). Evaluating the Performance of Three Popular Web Mapping Libraries: A Case Study Using Argentina's Life Quality Index.*