MARS 2020 MISSION TRACKER

Visualizing Perseverance Rover's Journey in Jezero Crater

Presented by:
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A Spatial Studies Lab project, led by
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Who we are

Bruno Sousa and **Uilvim Franco**

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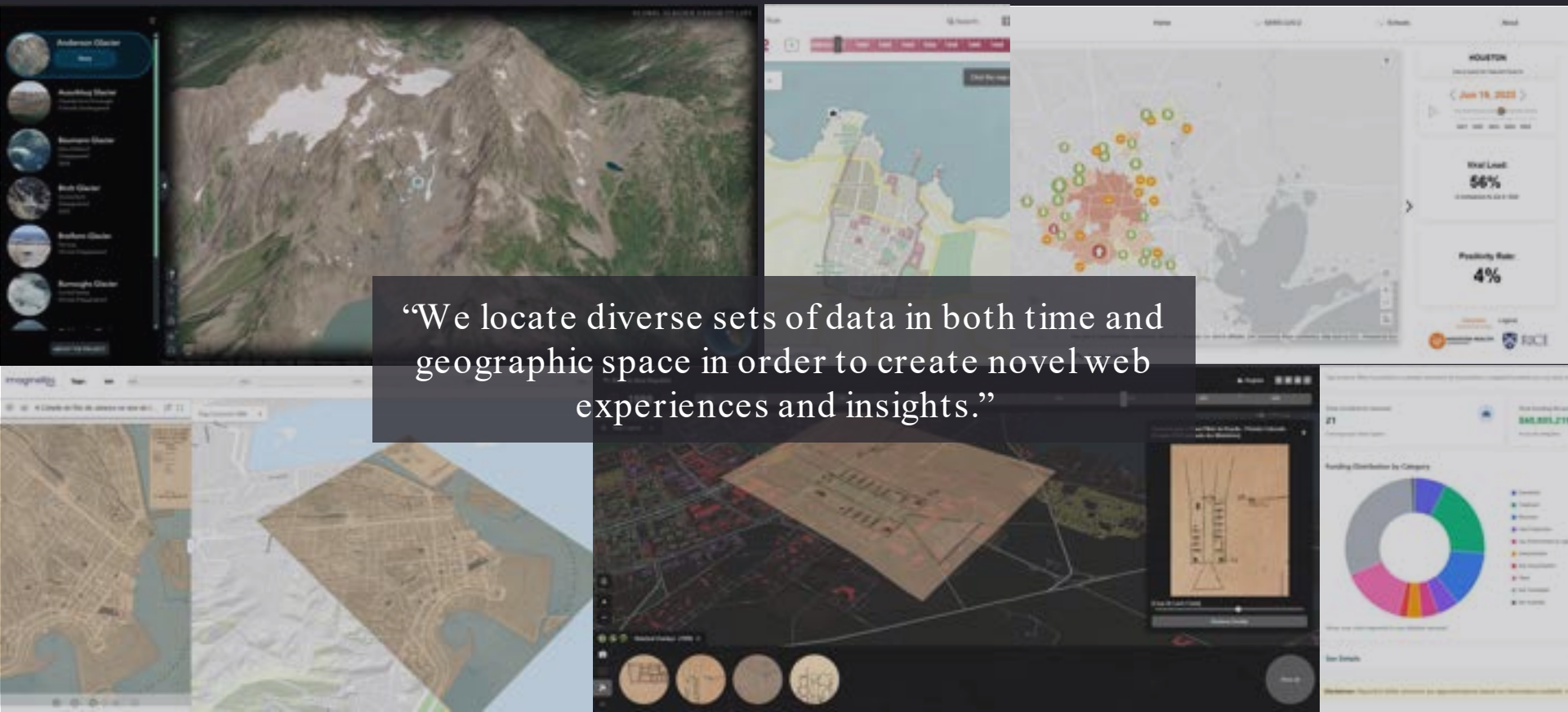
RICE UNIVERSITY

Our Journey



"We locate diverse sets of data in both time and geographic space in order to create novel web experiences and insights."

The long road to returning first-ever samples from Mars

By Ashley Strickland, CNN

7 min read · Updated 6:56 PM EDT, Sat August 1, 2020

(CNN) — When NASA's Perseverance rover touches down on Mars in February 2021, the mission will spend the next two years exploring one of the oldest and most intriguing sites on the red planet: Jezero Crater. The mission launched to Mars this week.

Original Location Map by NASA

The Opportunity: Beyond 2D Maps and Static Images

The Challenge

Mars 2020 Mission location data from NASA is **rich**, but it's often displayed in **2D maps**, which can make it difficult for the public to interpret and understand the **scale**, **distances**, and **environment** .

Our Goal

To create a new visualization that can facilitate public understanding. We wanted to answer the question:
How does Jezero Crater really look like?

Our Solution

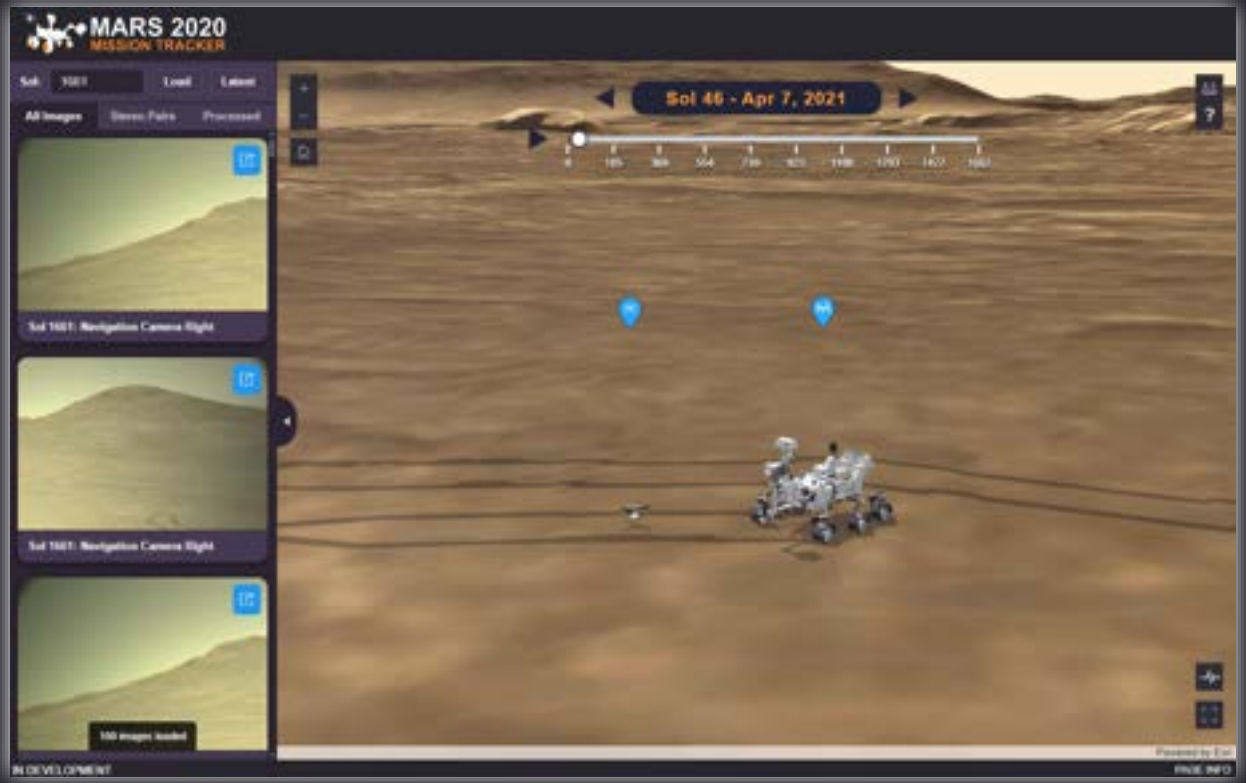
Our Solution: The Mars 2020 Mission Tracker

We developed a web application to show **live data** about NASA's Perseverance Rover and Ingenuity Helicopter.

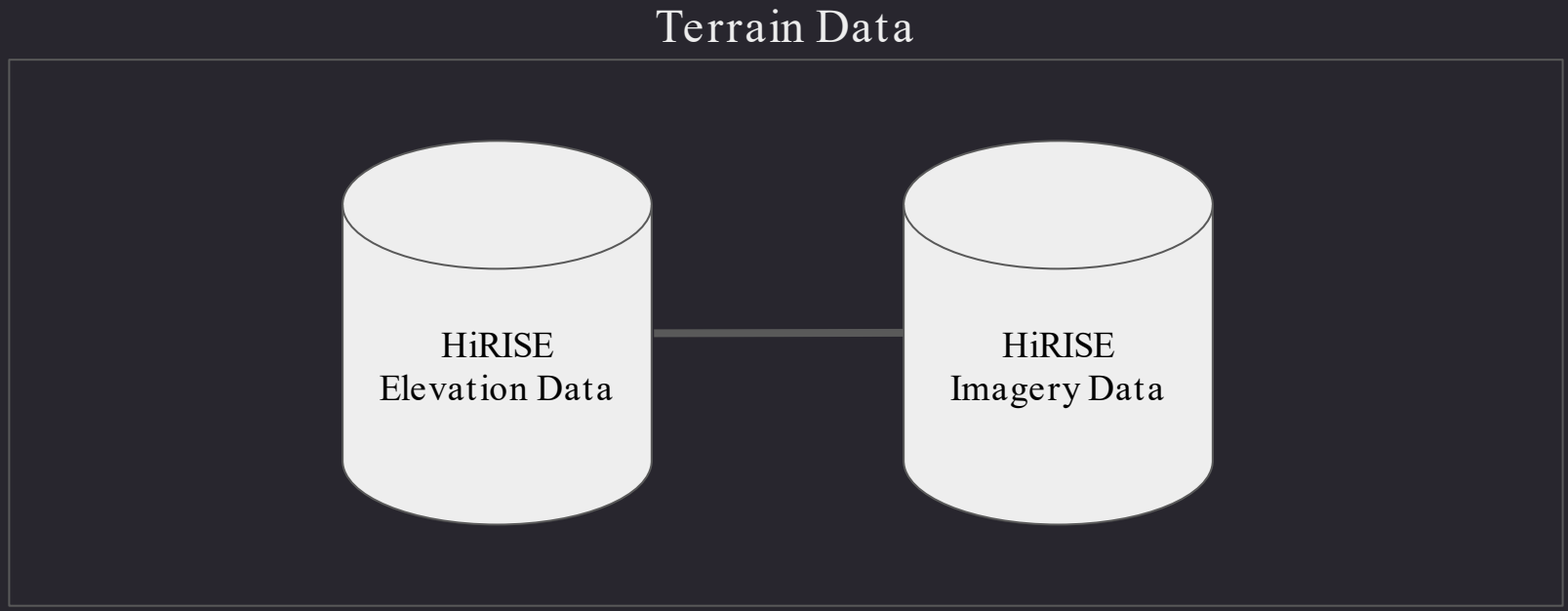
Launched just days after the February 2021 landing, the tracker provides an **immersive, interactive experience** of the Jezero Crater.

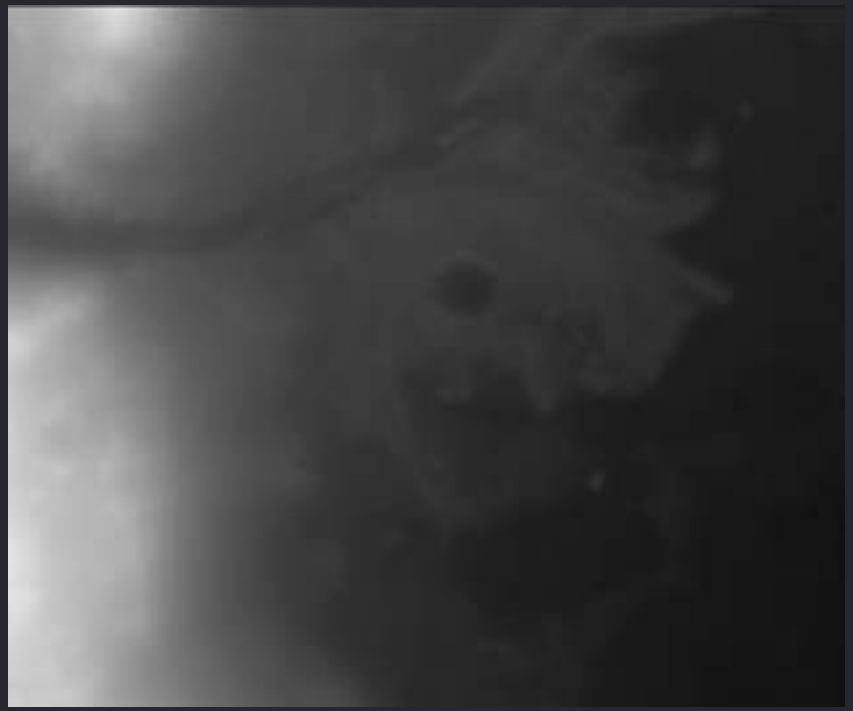
Key Objectives:

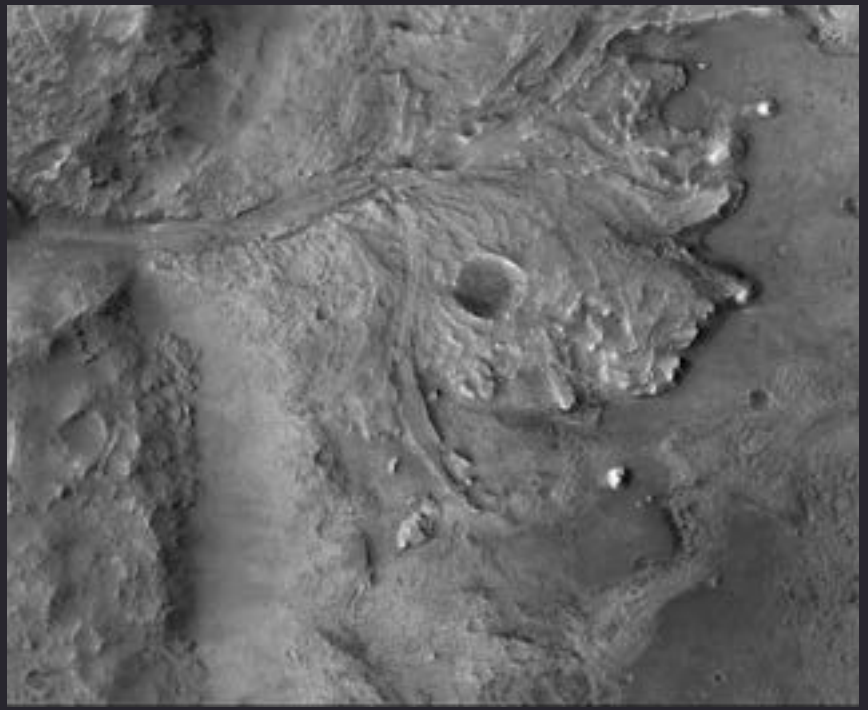
- **Engage:** Present data in a visually compelling way.
- **Educate:** Offer a deeper sense of the Martian environment and mission scale.
- **Empower:** Allow users to explore the Crater on their own terms.



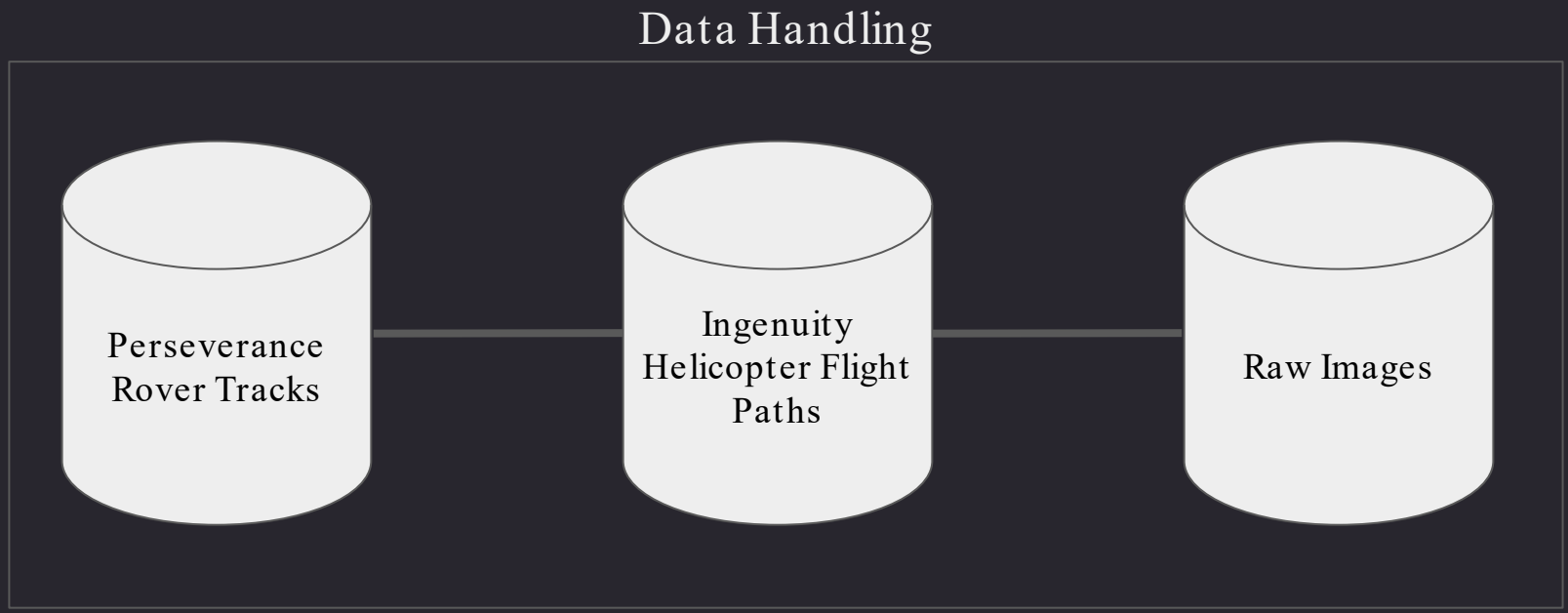
How It Works: The Technology Stack







How It Works: The Technology Stack



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Perseverance Rover Tracks

NASA to ArcGIS Online	Polyline Simplification	Offset Center Lines	Polygons Buffer	Graphic Layer
NASA GeoJSON with **Traverse Data** is added to an ArcGIS Online Scene as a layer. Polyline features are queried from the Traverse layer by **Javascript code**.	**Geometry is validated** to ensure it has at least 2 points. If the path has more than 2 points, Ramer–Douglas–Peucker (RDP) with an epsilon of 0.1 is applied to **simplify the path and reduce vertices**.	Two offset polylines are built from the **simplified centerline**: offsetLine1 is created at +1.1 meters. offsetLine2 is created at -1.1 meters. Offsets are computed per-vertex by averaging neighbor directions and applying a normal vector.	For each offset polyline, each segment is buffered by computing a rectangular quad around it. Both polygon buffers are merged into a single **multipart geometry**	A Graphic with the combined polygon buffers is added to "**tracksLayer**", its symbol is set (fill black), attributes are copied, and a popup template is attached. The graphics layer is added to the map.

Ingenuity Helicopter Flight Paths

Data Ingestion and Querying	Path Validation and Densification	Altitude Assignment (Z Values)	Graphic Layer	3D View Configuration
NASA GeoJSON flight path data is added to ArcGIS Online and queried for "**Ingenuity Flight Paths**".	Flight paths are validated by **flight number**, and their vertex count is increased for smoother lines.	**Altitudes are assigned to vertices**: 0.5 for the first, 1 for the last, and maximum flight altitude for middle vertices.	A new graphic polyline is constructed from the densified, altitude-assigned path, styled, and added to a **GraphicsLayer** on the map.	The "**GraphicsLayer's**" elevation is configured in the 3D view to display points at a **specific distance from the ground**, using the assigned Z values to create a floating flight path effect.

Image Gallery

NASA API → Identify image pairs → Generate anaglyphs → Display

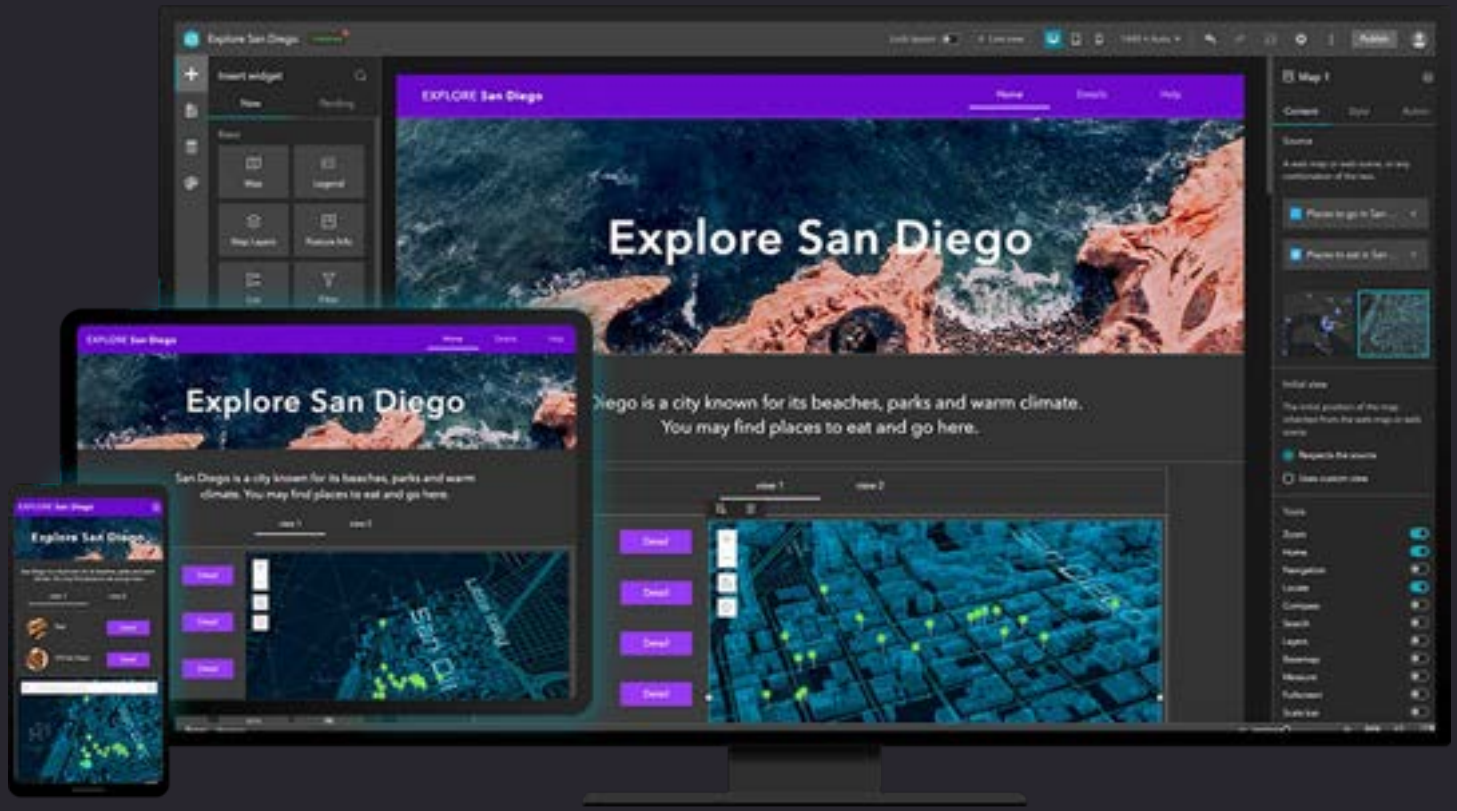
The widget sends requests to the NASA API to retrieve lists of Mars rover images. These images include metadata such as **camera type, mission day (sol), and image URLs**

The widget then analyzes the retrieved images to find **stereo pairs**. It specifically looks for images taken by the rover's left and right cameras (e.g., NAVCAM_LEFT and NAVCAM_RIGHT). Images are matched by mission day, time, and camera type to **ensure accurate pairing**.

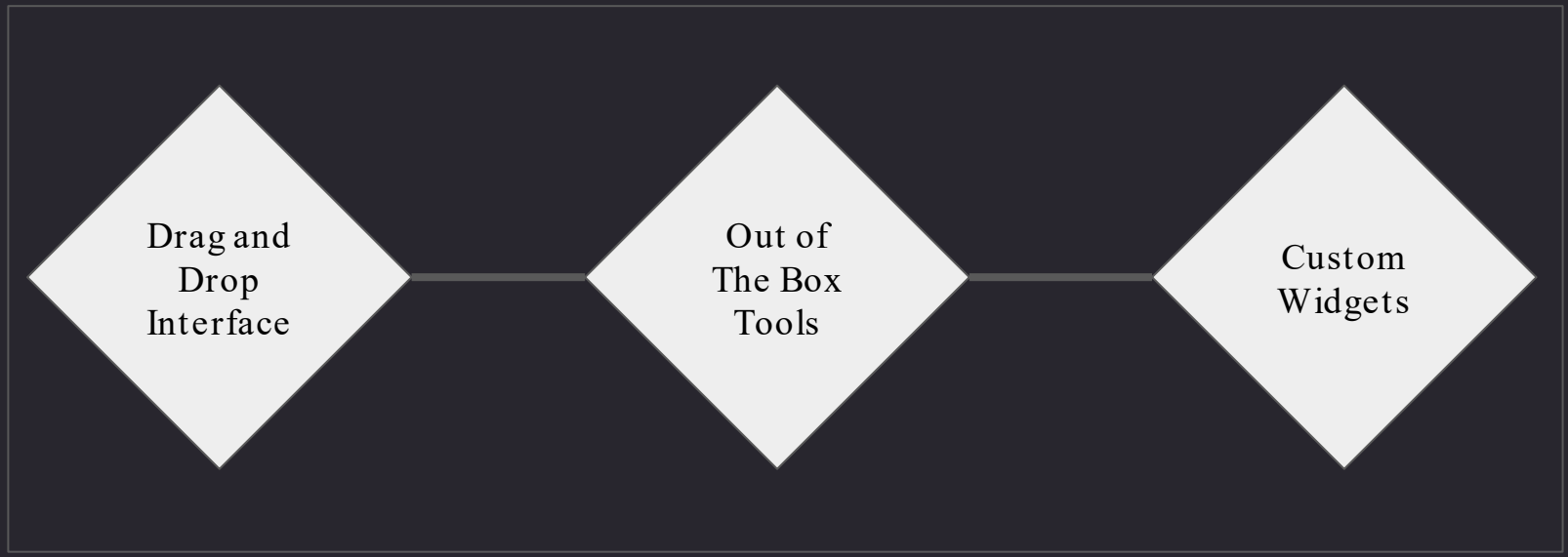
For each identified left/right image pair, the widget combines them to **create an anaglyph**. An anaglyph is a single image designed for red/cyan 3D viewing.

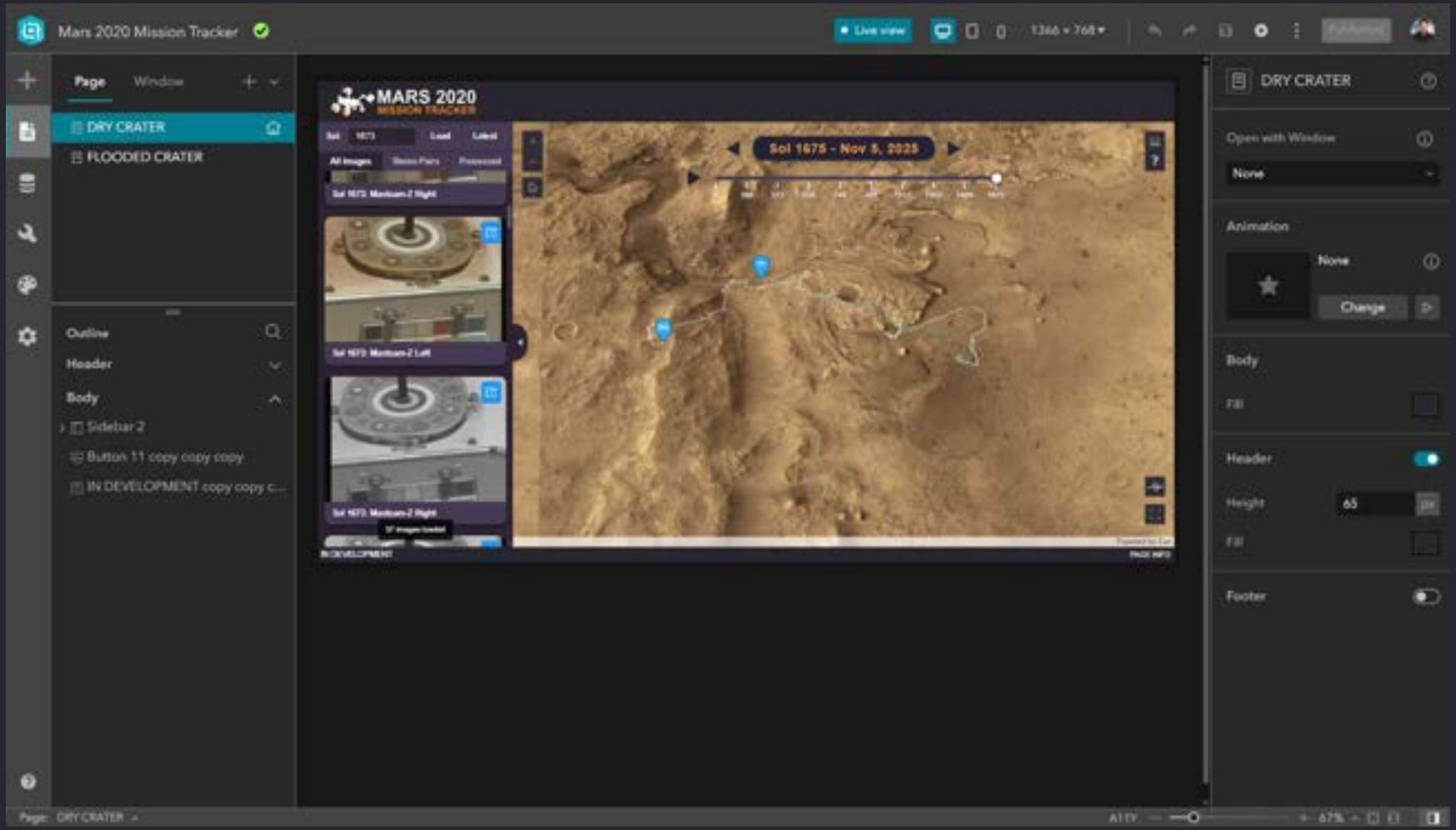
Finally, the widget displays the original images, the identified pairs, and the generated **anaglyphs in a gallery** for users to view.

How It Works: The Technology Stack


EXPLORE San Diego
Explore San Diego
Explore San Diego
Explore San Diego

ArcGIS Experience Builder Dev.




Mars 2020 Mission Tracker
Live view
1366 × 768
Page
Window
DRY CRATER
FLOODED CRATER
Outline
Header
Body
Sidebar 2
Button 11 copy copy copy
IN DEVELOPMENT copy copy c...
MARS 2020
MISSION TRACKER
Sol 1675 - Nov 5, 2025
DRY CRATER
Open with Window
None
Animation
None
Change
Body
Fill
Header
Height
65
px
Fill
Footer
Page: DRY CRATER
67%

```tsx
export default function GalleryModal(props: GalleryModalProps) {
  function handleNext(e?: React.MouseEvent) {
  }

  // Build mars.nasa.gov raw image page URL from the provided image src
  function buildSourceUrl(photo: Photo | null) {
    if (!photo || !photo.img_src) return null
    // take filename without query
    const filename = (photo.img_src.split('/').pop() || '').split('?')[0]
    if (!filename) return null
    // remove extension
    let name = filename.replace(/\.\w+$/i, '')
    const parts = name.split('_')
    // if last part is a pure digit size marker (eg 1200, 320) remove it
    if (parts.length > 1 && /^\d{2,4}$/.test(parts[parts.length - 1])) parts.pop()
    // remove trailing numeric suffix from the final segment if present (eg 105301 -> 1051)
    parts[parts.length - 1] = parts[parts.length - 1].replace(/(.+?)\d+$/, '$1')
    const id = parts.join('_')
    return `https://mars.nasa.gov/mars2020/multimedia/raw-images/${id}`
  }

  const modalJsx = (
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      background: 'rgba(0,0,0,0.9)', zIndex: 99999, display: modalOpen ? 'flex' : 'none',
      alignItems: 'stretch', justifyContent: 'stretch'
    }}
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        position: 'relative',
        margin: 0,
        minHeight: '100vh',
        width: '100vw',
        maxWidth: '100vw',
        maxHeight: '100vh',
        borderRadius: 0,
        boxShadow: 'none',
        overflow: 'hidden',
        display: 'flex',
        flexDirection: 'column',
        background: '#0b1116'
      }}>
        {svgFilters}
        {/* <button className="modal-close-btn" style={{ position: 'absolute', top: 16, right: 16
          onClick={closeModal}
        >
          <span>×</span>
        </button> */}
```
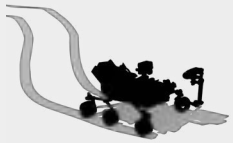

```tsx
// --- Perseverance wheel tracks GraphicsLayer integration ---
(function setupTracksLayer() {
  const pathLayer = JimuMapView.view.map.layers.find(l => l.title === "Perseverance Path");
  if (!pathLayer) {
    console.error("Perseverance Path layer not found in the scene.");
    return;
  }
  JimuMapView.view.whenLayerView(pathLayer).then(async (layerView) => {
    const query = layerView.layer.createQuery();
    query.returnGeometry = true;
    query.outSpatialReference = MARS_SR;
    query.where = "1=1";
    query.num = 10000;
    let allFeatures = [];
    let start = 0;
    let pageSize = 1000;
    let hasMore = true;
    while (hasMore) {
      query.start = start;
      query.num = pageSize;
      const result = await layerView.layer.queryFeatures(query);
      if (result.features.length > 0) {
        allFeatures = allFeatures.concat(result.features);
        start += result.features.length;
        hasMore = result.features.length === pageSize;
      } else {
        hasMore = false;
      }
    }
    const tracksLayer = new GraphicsLayer({ title: "Wheel Tracks" });
    JimuMapView.view.map.add(tracksLayer);
    window.tracksLayer = tracksLayer;

    function rdpSimplify(path, epsilon) {
      function getPerpendicularDistance(pt, lineStart, lineEnd) {
        const dx = lineEnd[0] - lineStart[0];
        const dy = lineEnd[1] - lineStart[1];
        if (dx === 0 && dy === 0) return Math.hypot(pt[0] - lineStart[0], pt[1] - lineStart[1]);
        const t = ((pt[0] - lineStart[0]) * dx + (pt[1] - lineStart[1]) * dy) / (dx * dx + dy * dy);
        const proj = [lineStart[0] + t * dx, lineStart[1] + t * dy];
        return Math.hypot(pt[0] - proj[0], pt[1] - proj[1]);
      }
      function rdp(points, epsilon) {
        let dmax = 0, index = 0;
        for (let i = 1; i < points.length - 1; i++) {
          const d = getPerpendicularDistance(points[i], points[0], points[points.length - 1]);
          if (d > dmax) {
            index = i;
            dmax = d;
          }
        }
```

Key Features

Live Rover & Helicopter Tracking

View the latest location and full traverse path on a **high-resolution 3D map**.

Access **key mission stats** like current mission Sol (Martian day) and total distance driven



Interactive 3D Environment

Explore the true scale of the Jezero Crater, from the landing site to the ancient river delta.

Pan, zoom, and tilt the map to **understand** the challenging terrain Perseverance navigates.

Raw Imagery

See the **latest photos** sent back from Mars, displayed in a gallery filtered by sol.

Use image pairs for **cross-eye 3D** and **Anaglyph 3D**.

Ingenuity Flight Log

Visualize the **3D path** of every historic Ingenuity flight, from takeoff to landing.

Live Demo

https://www.perseverancerover.spatialstudieslab.org/

Points to Showcase:

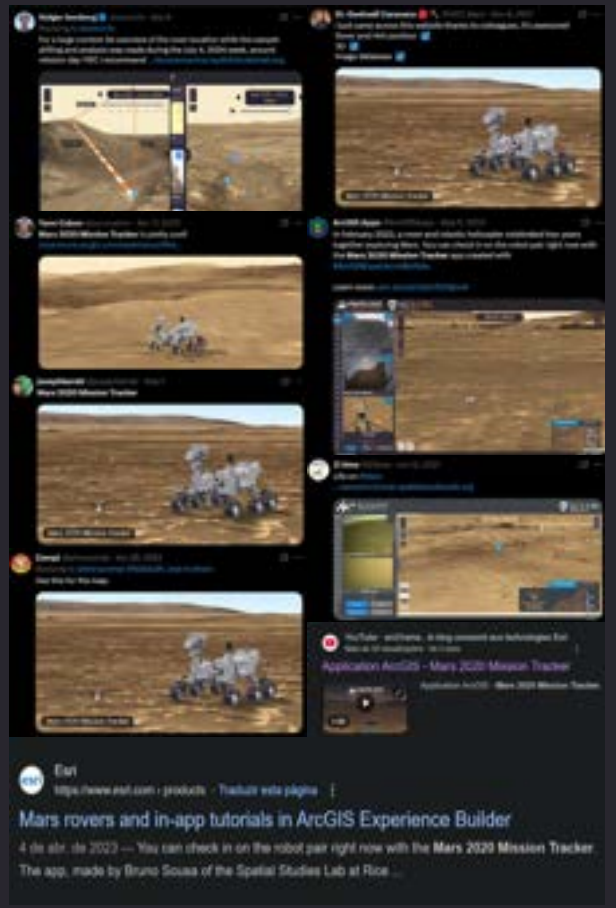
1. The **current location** of the Perseverance Rover.
2. Following its path from the **landing site**.
3. Demonstrating the **3D tilt and zoom functionality** on a geological feature.
4. Gallery showing images taken on each sol


MARS 2020
MISSION TRACKER
Sol: 1661
Load
Latest
All Images
Stereo Pairs
Processed
Sol 1661: Navigation Camera Right
Sol 1661: Navigation Camera Right
100 images loaded
Sol 1662 - Oct 22, 2025
IN DEVELOPMENT
PAGE INFO

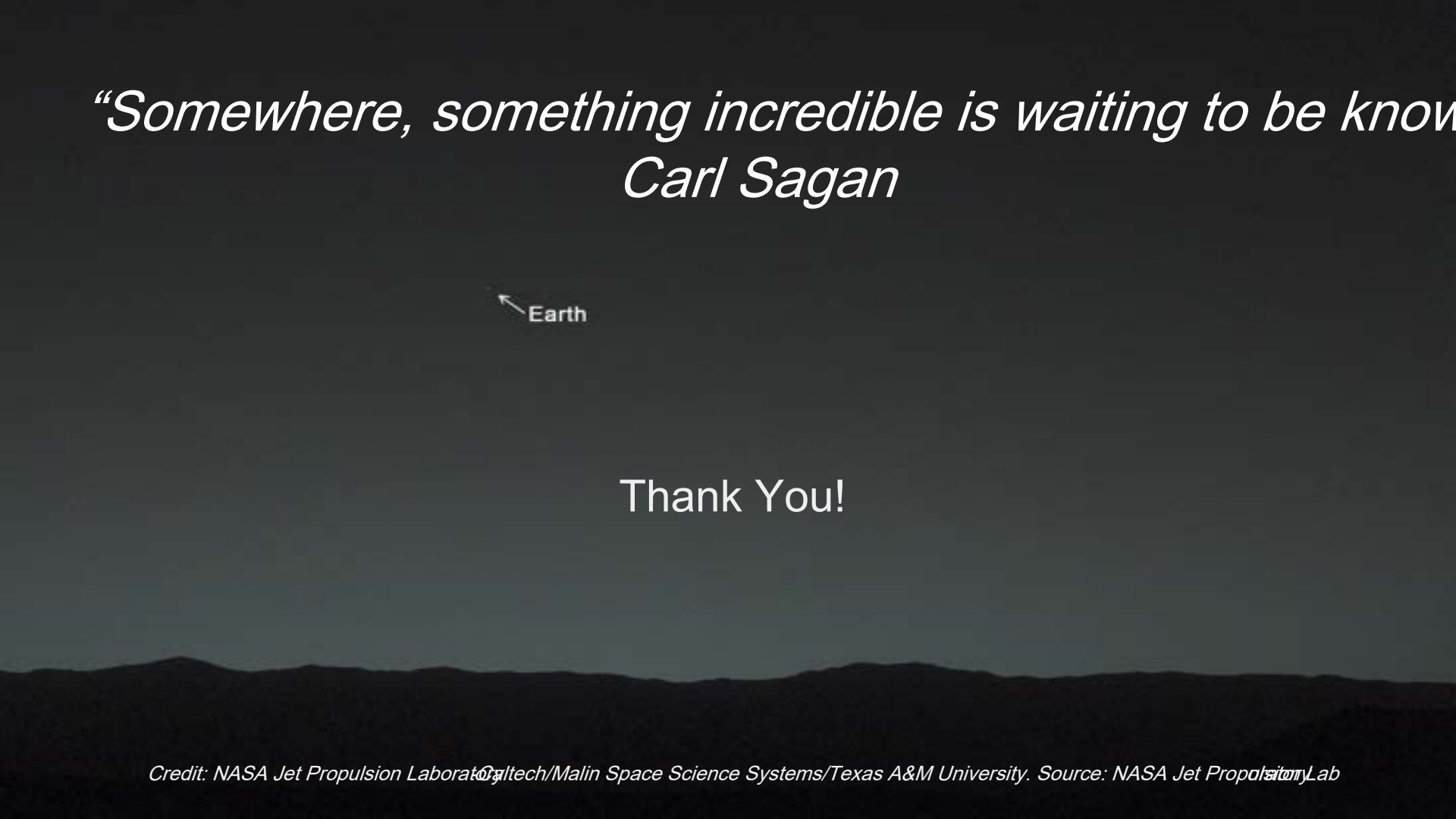
Impact & Future Work

- 60k Users world wide
- Mentions in Published Papers
- Used as a teaching tool in classrooms
- Social Media Reactions

MARS 2020
MISSION TRACKER



“Somewhere, something incredible is waiting to be know
Carl Sagan



Thank You!

Credit: NASA Jet Propulsion Laboratory-Caltech/Malin Space Science Systems/Texas A&M University. Source: NASA Jet Propulsion Laboratory