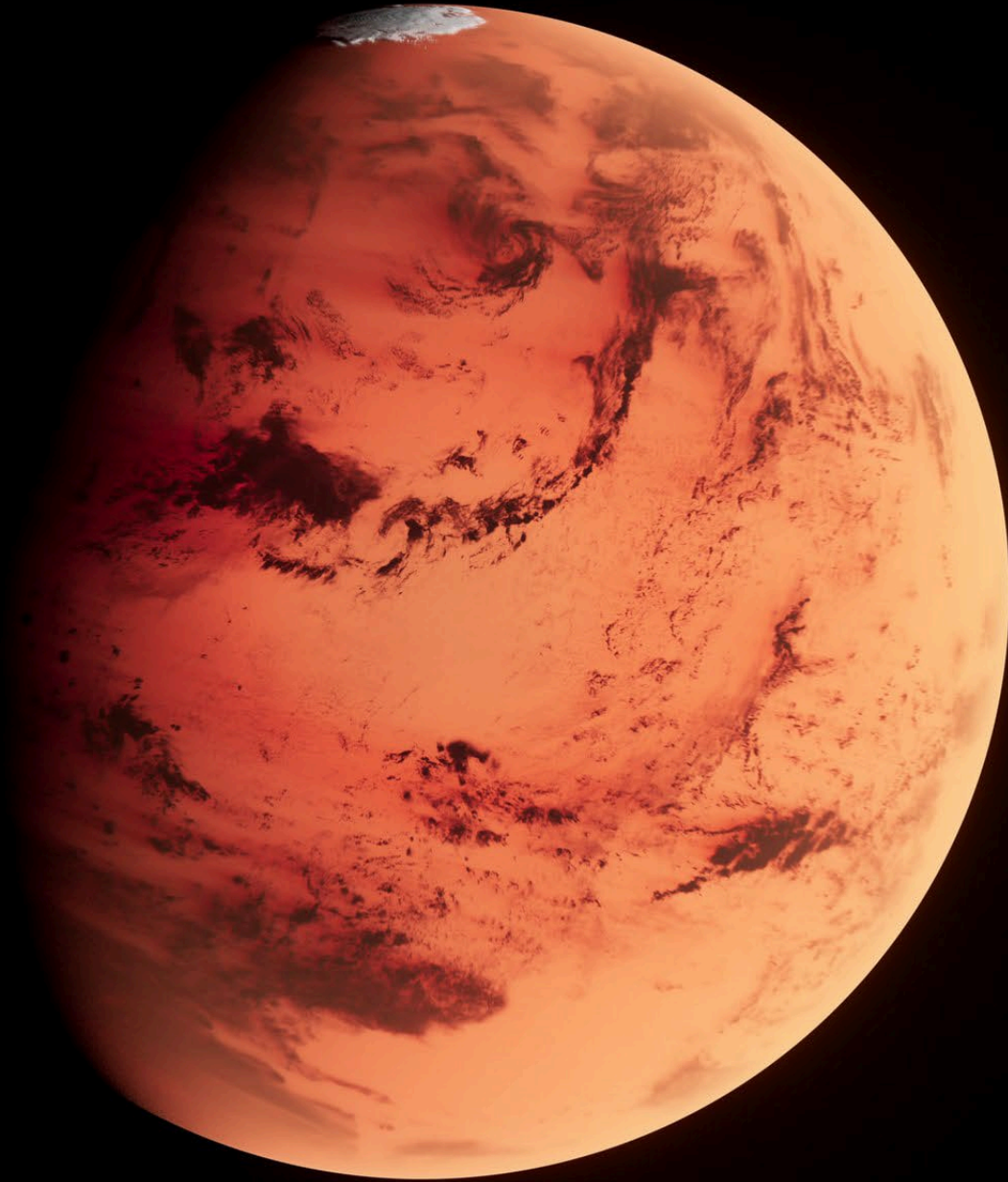




# UNLOCKING THE ROVERS OF MARS

Phillip Purvis

Advisor: Ryan Baxter



# Overview

Perseverance

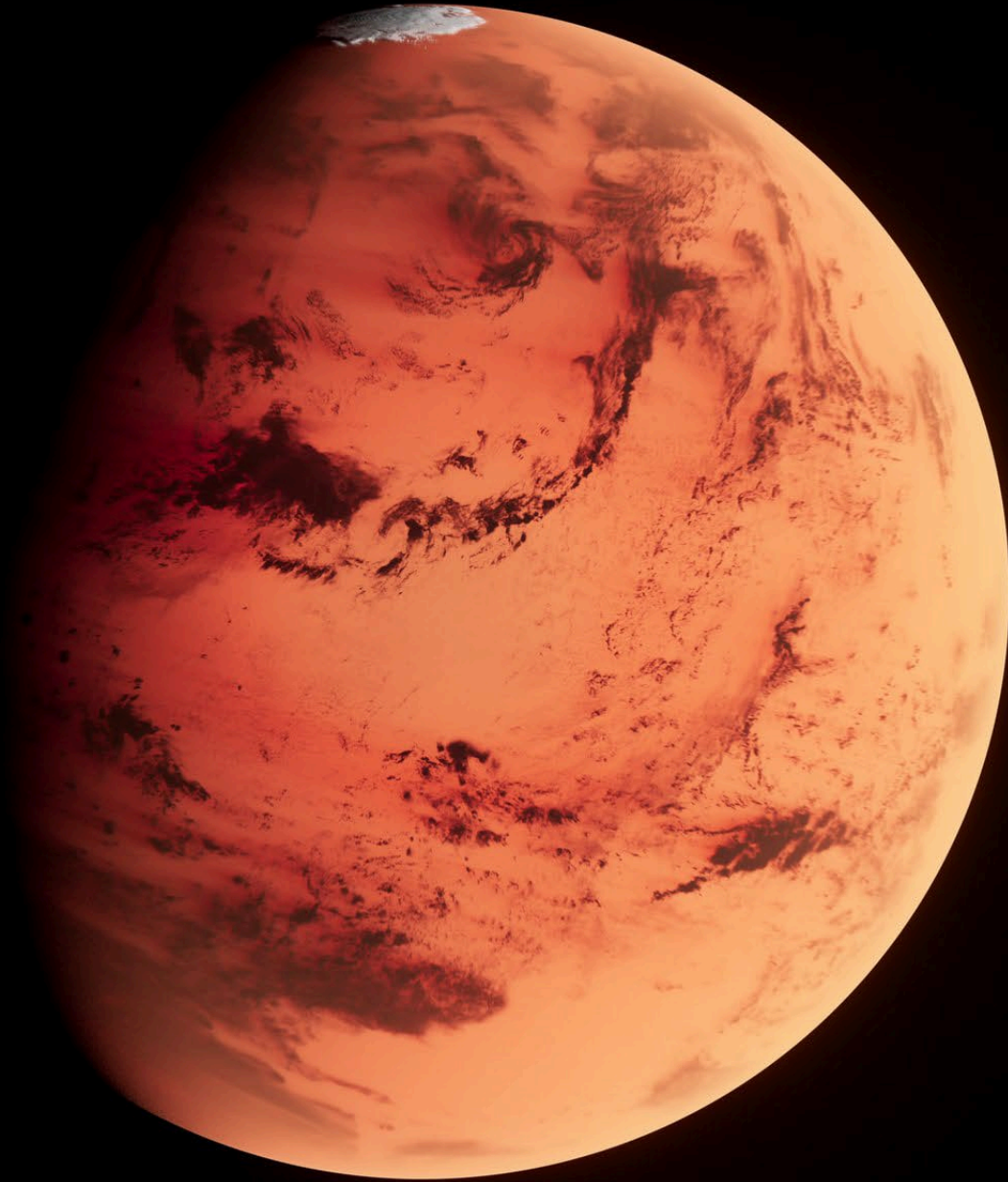
Mars Coordinate Systems

Previous Apps

Web App APIs

Rover Data

Anticipated Results



# Project Goals

## Web App of Mars

- Uses Mars Rover (Perseverance) Location and Imagery Data
- Utilizing a Web App API
- Supporting Multiple Basemaps
- Accessible and Clear for Multiple Audiences
  - Focusing on Scientists, Mars Enthusiasts, and Students
- Adds additional functionality beyond what is currently found in Mars maps



Web Map designed as a part of the Penn State Graduate Program GEOG 863 Final Project.



# Starship

Launches from Orbital Launch Mount A located at [SpaceX Space Launch Facility, TX, USA](#)

Mission is known as **Orbital Flight Test** which is Maiden flight of the two-stage Starship launch vehicle. The booster will separate 170 seconds into flight and return to land approximately 32 km off the shore in the Gulf of Mexico. The second stage will achieve orbit until performing a powered, targeted splashdown approximately 100 km off the northwest coast of Kauai (Hawaii).

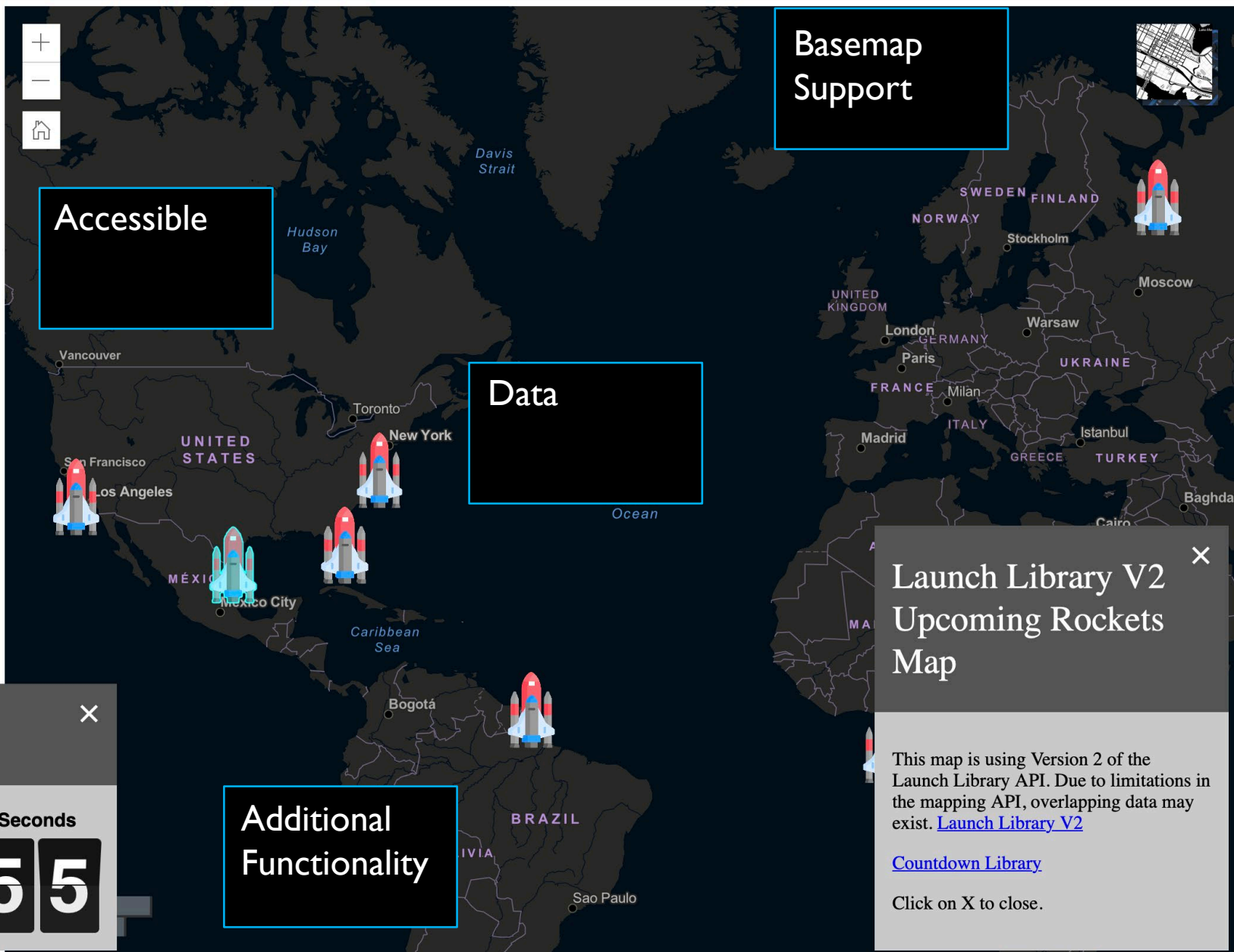
Please see [SpaceX](#) for more information.



## Countdown to Launch

Icon

Days	Hours	Minutes	Seconds
61	11	06	55





ROVERS

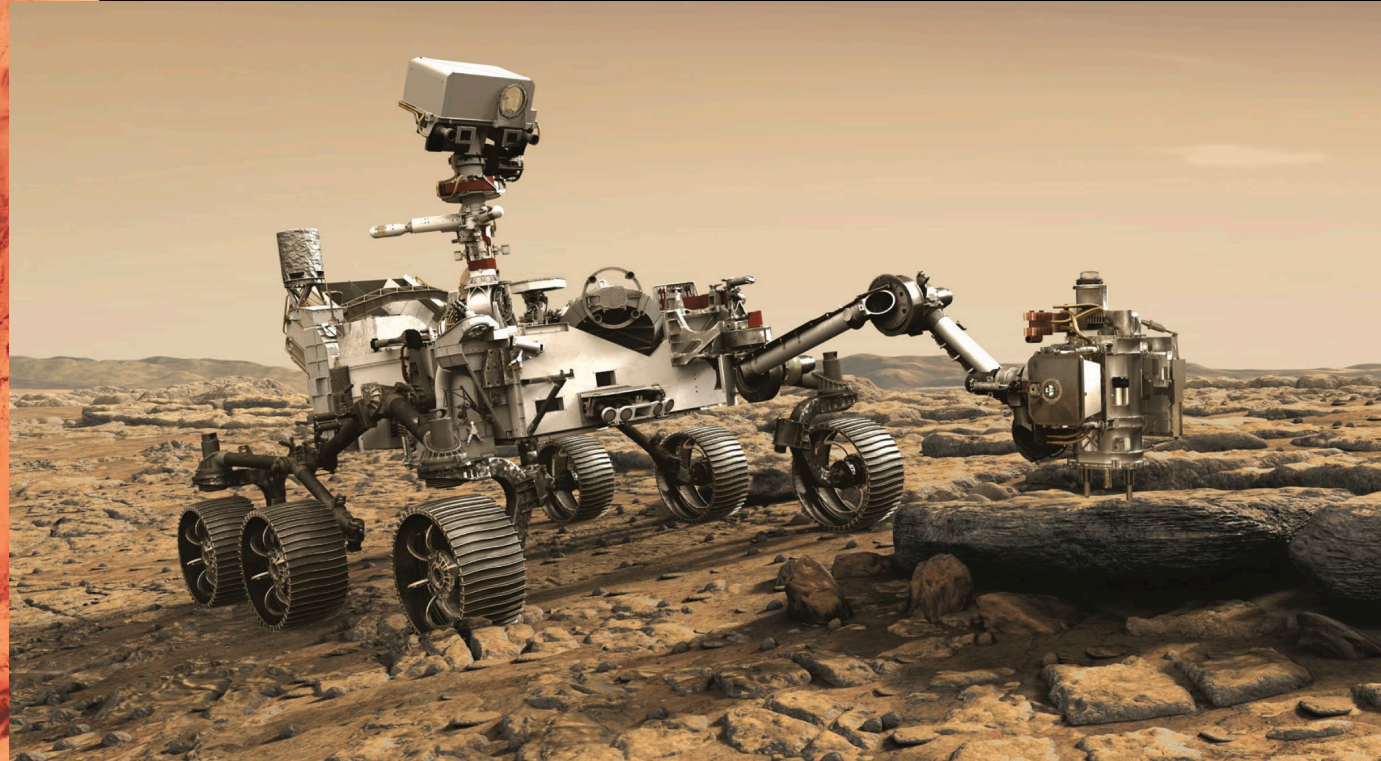


# What are Rovers?

- Unmanned Aerial Vehicles deployed to planets for research (often due to inhospitable conditions)
- First Rover to Mars was in 1997 called Sojourner (followed by Spirit, Opportunity, Curiosity, and finally Perseverance in 2021)

## What are they used for?

- Mars rovers explore for evidence of current or previous extraterrestrial life



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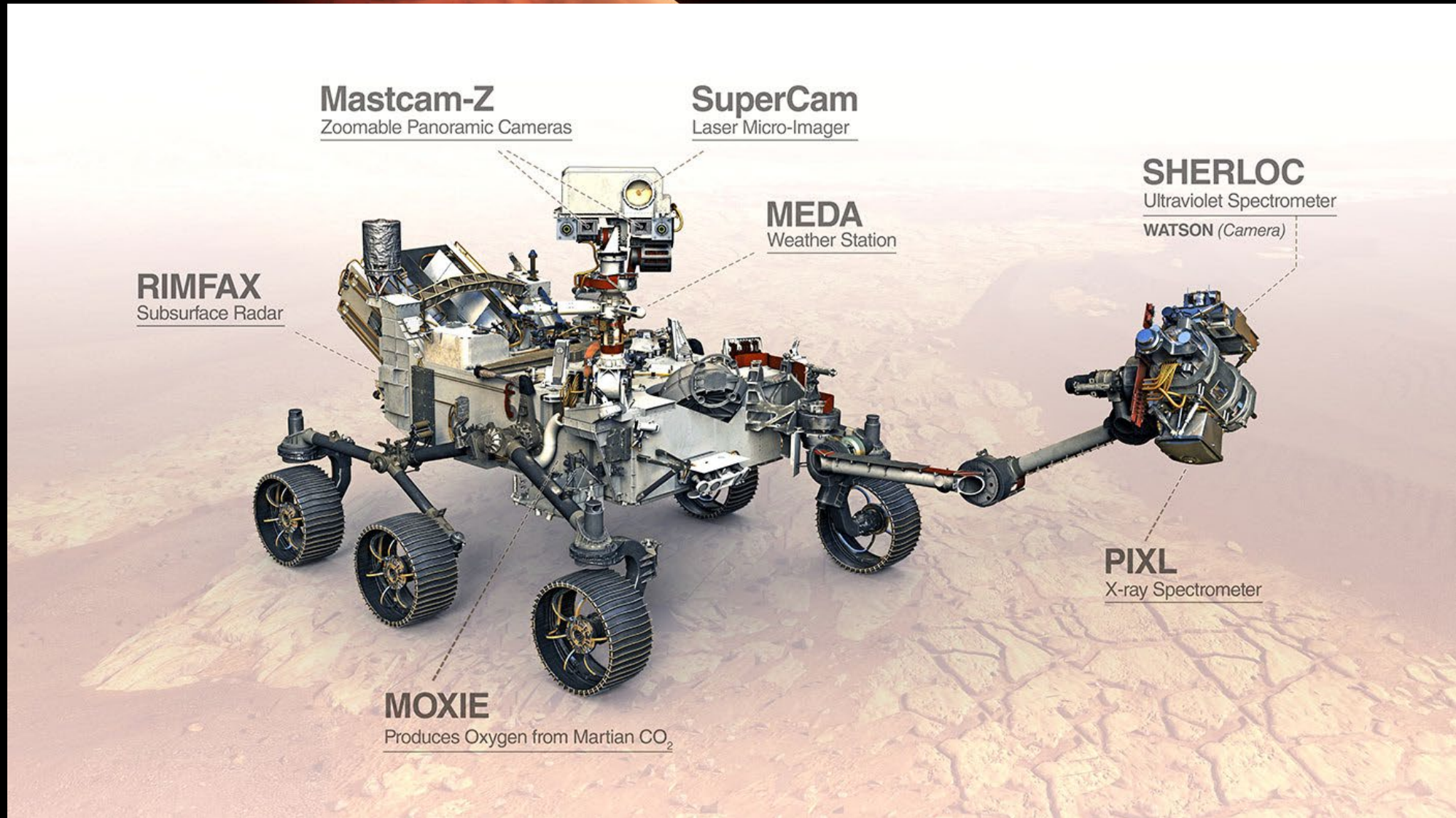
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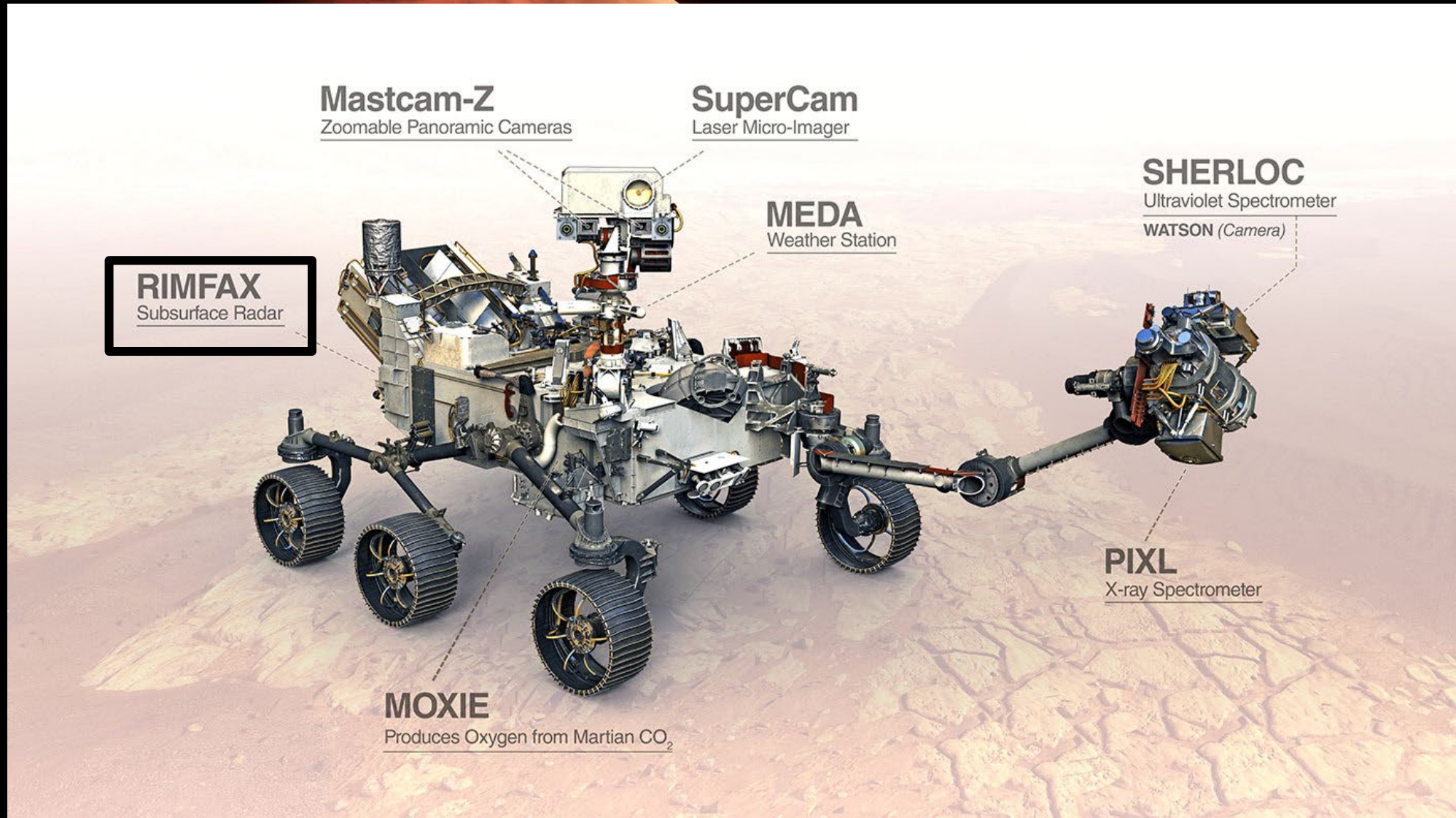


# What is Perseverance?



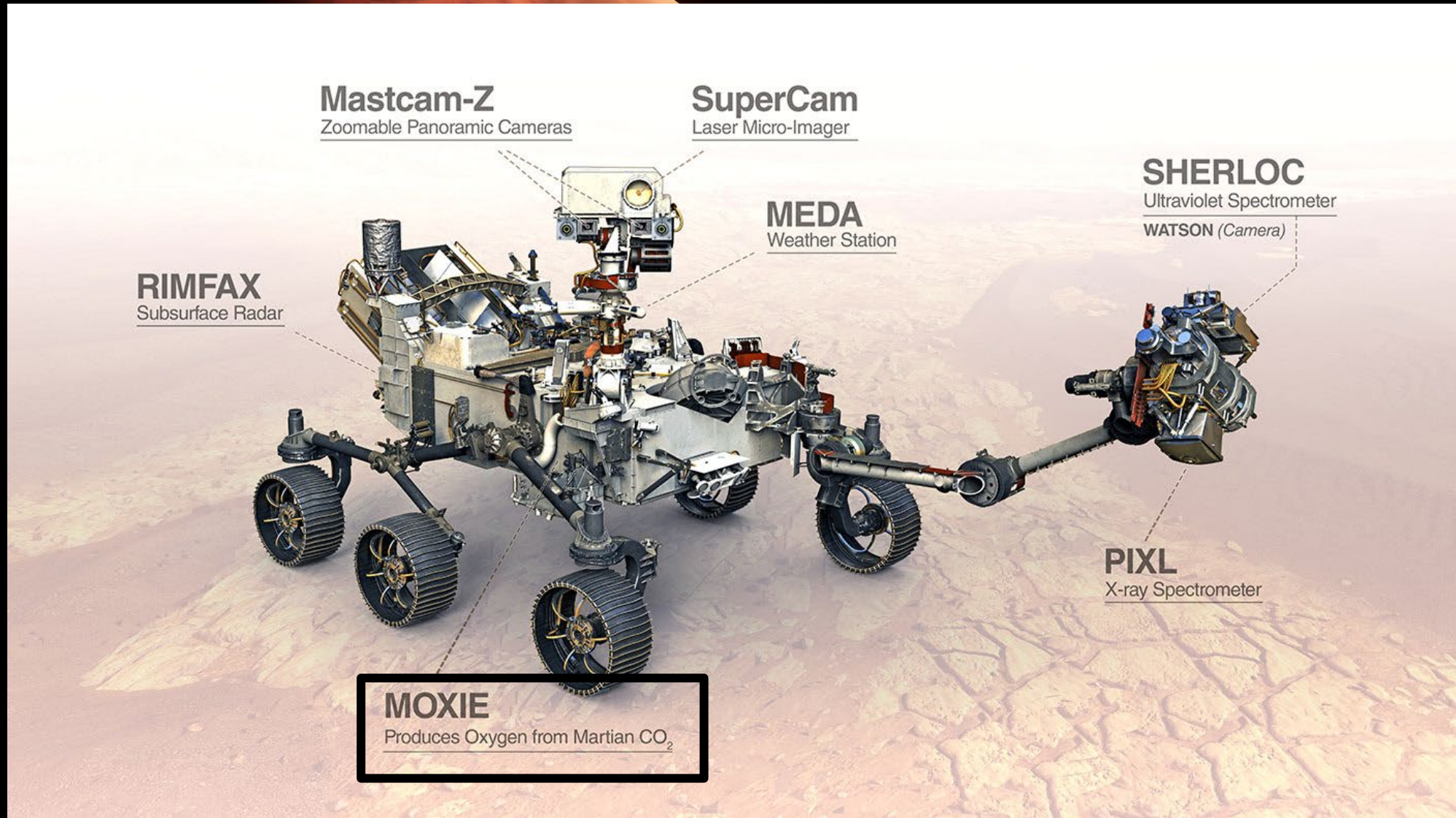


# What is Perseverance?



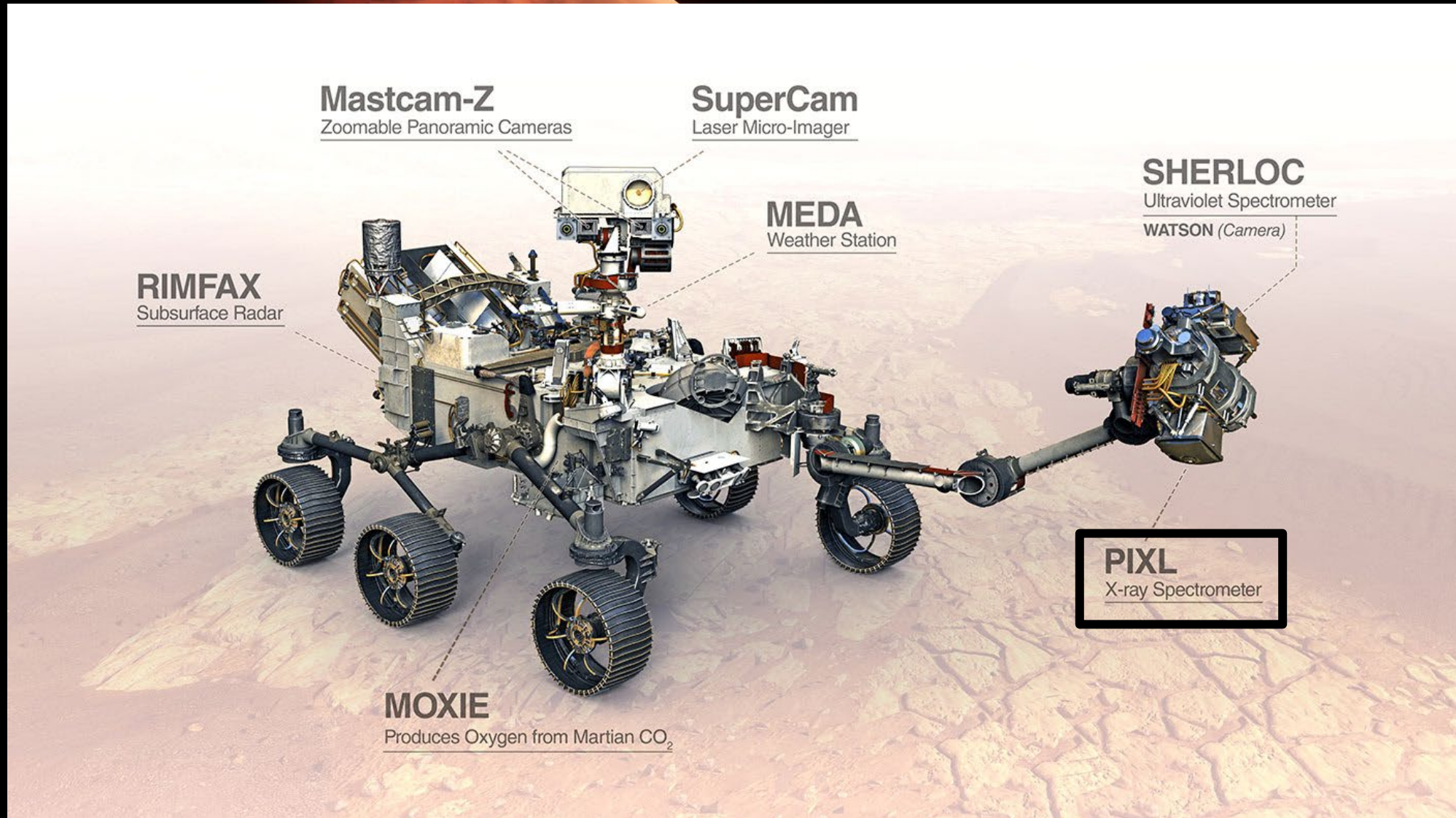


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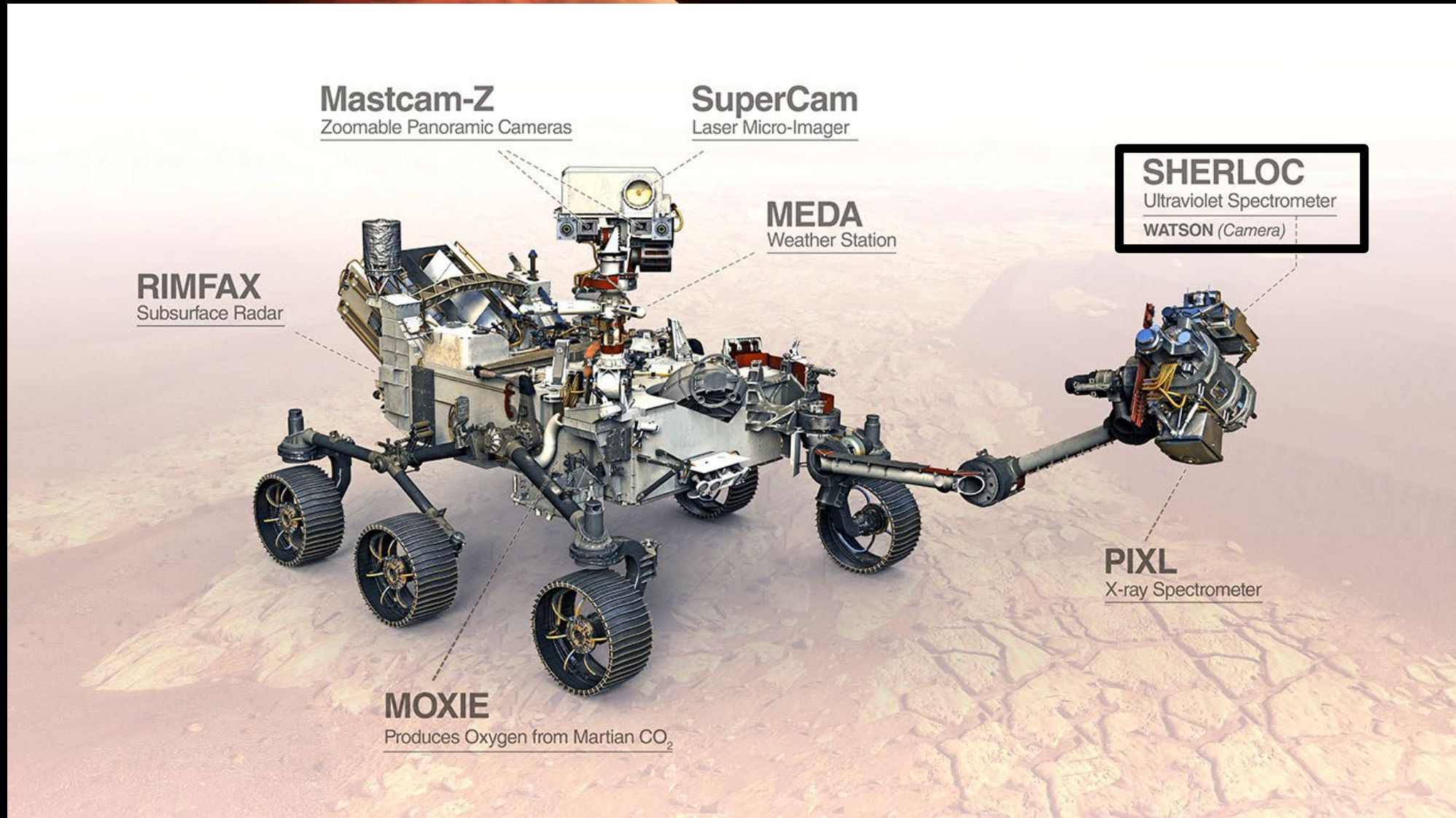


# What is Perseverance?



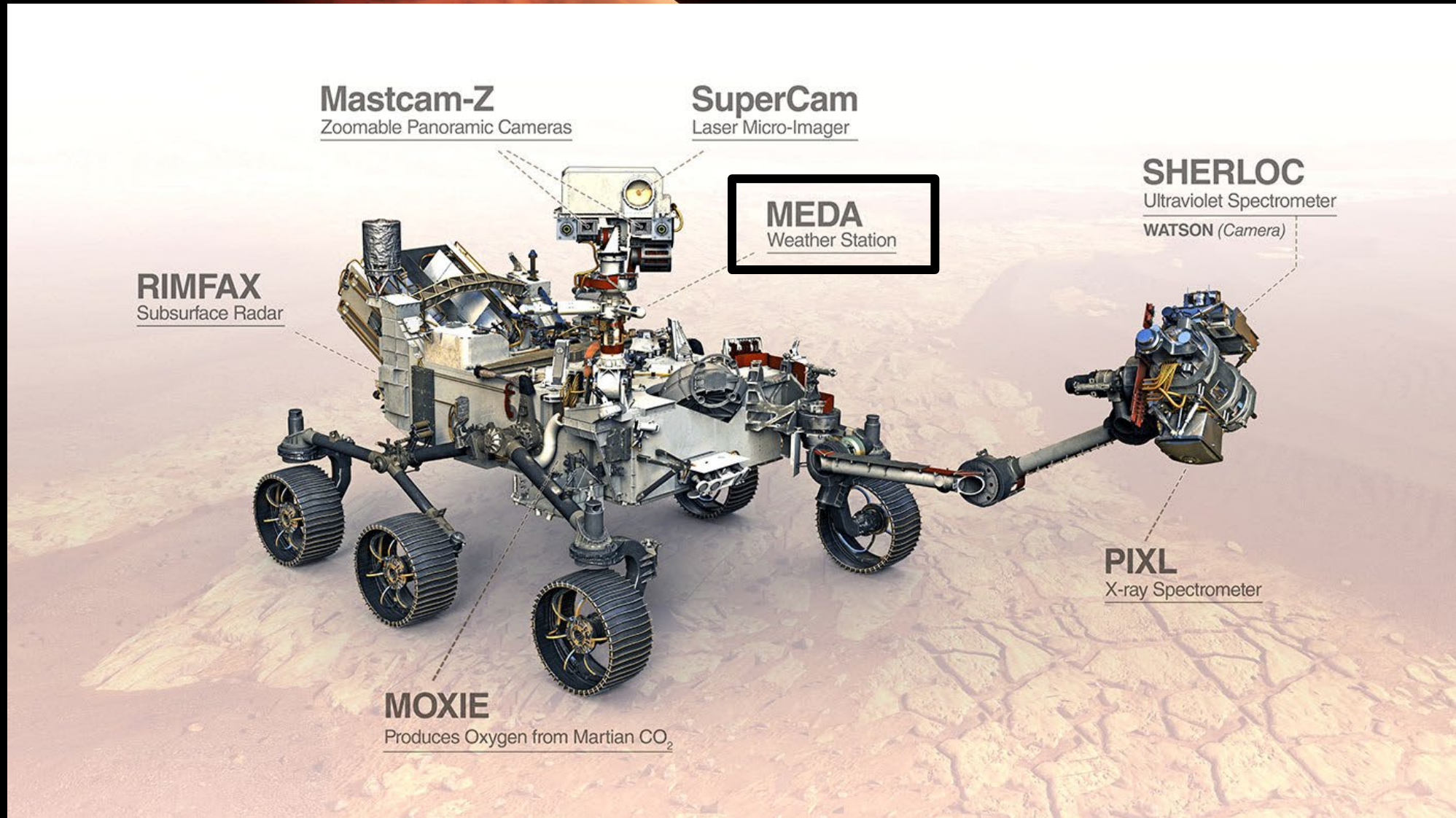


# What is Perseverance?



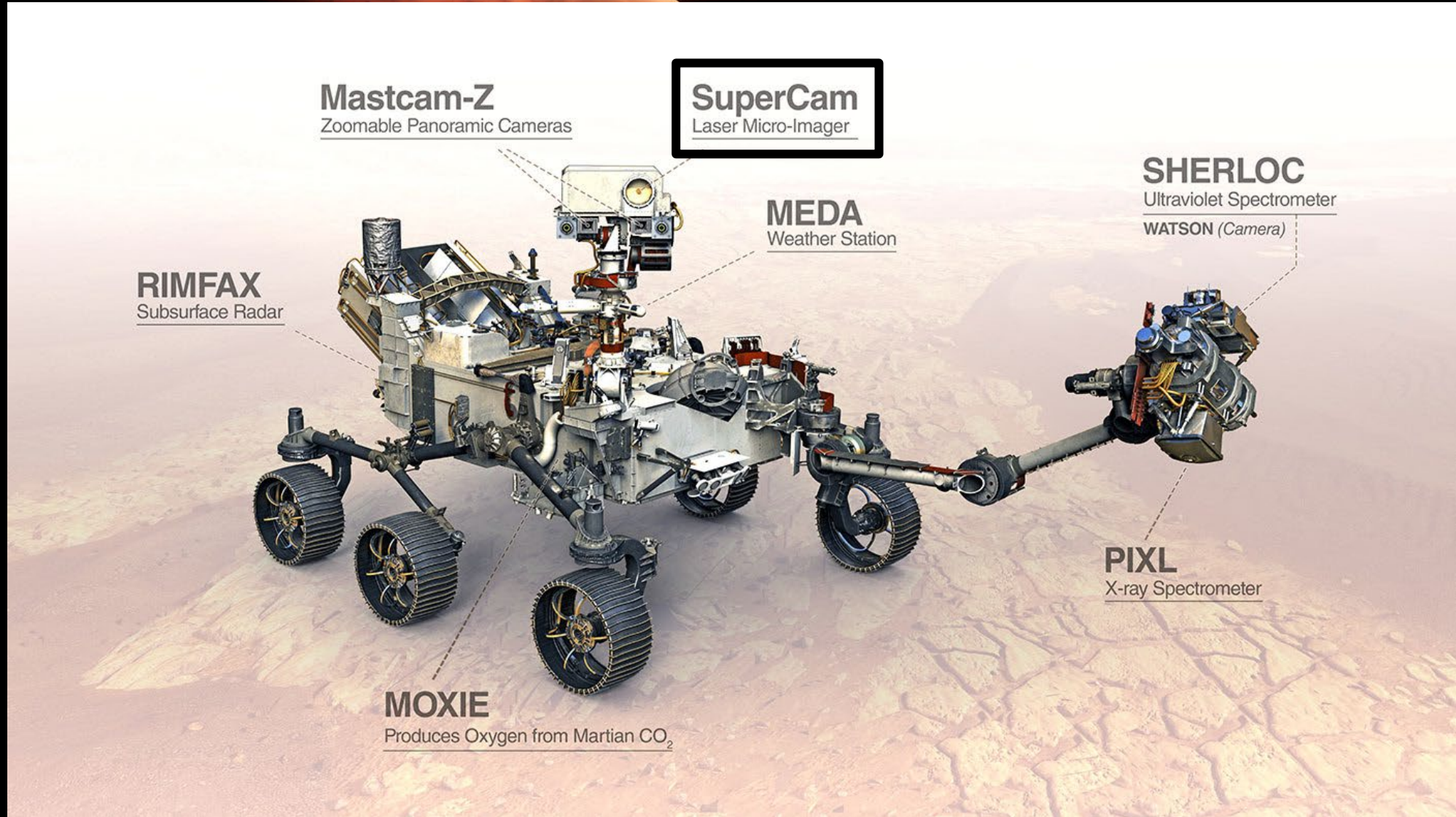


# What is Perseverance?



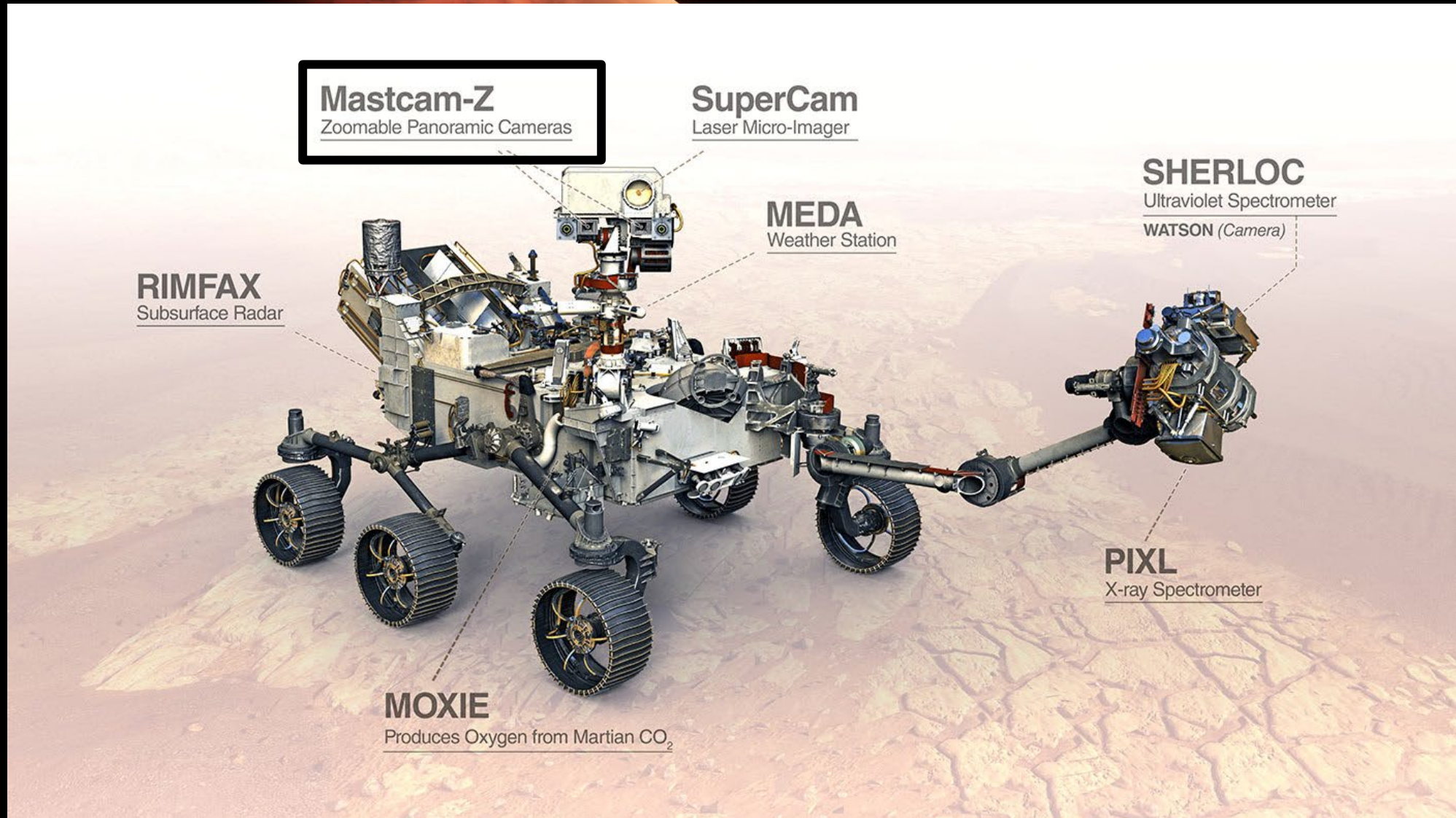


# What is Perseverance?

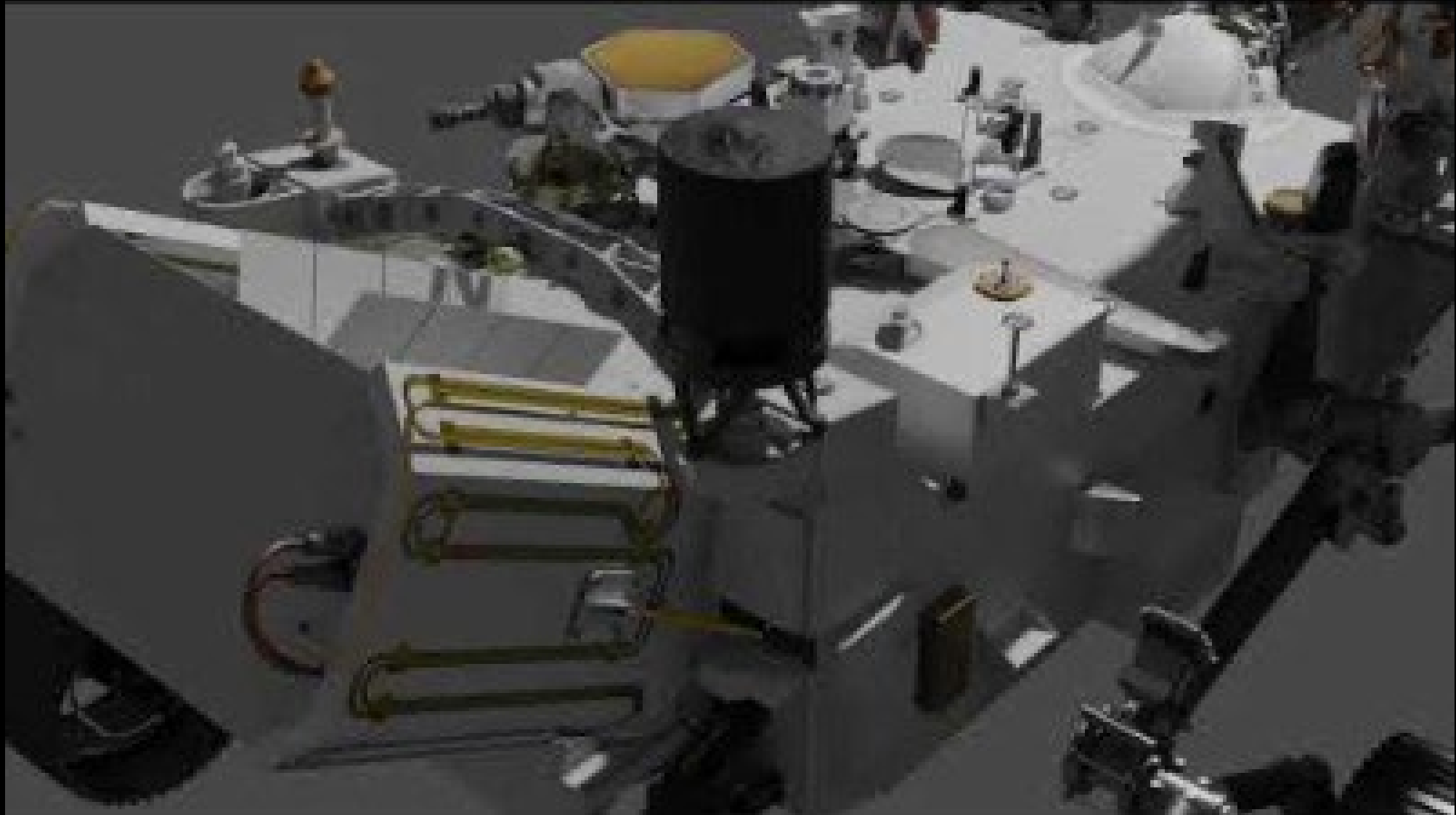




# What is Perseverance?



# What is MastCam-Z?

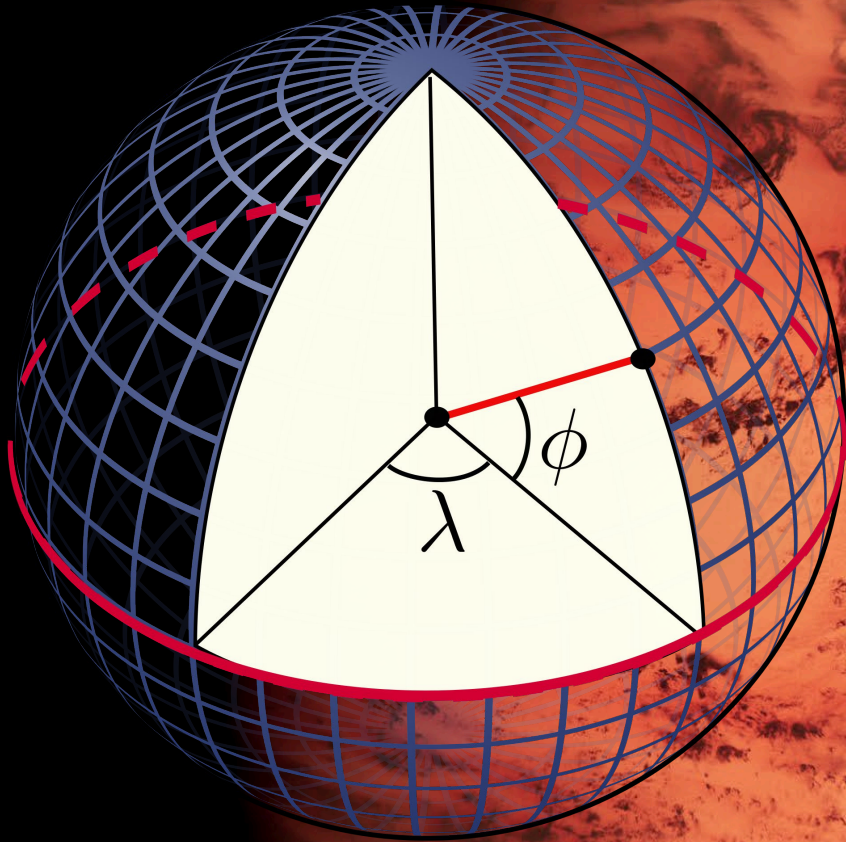




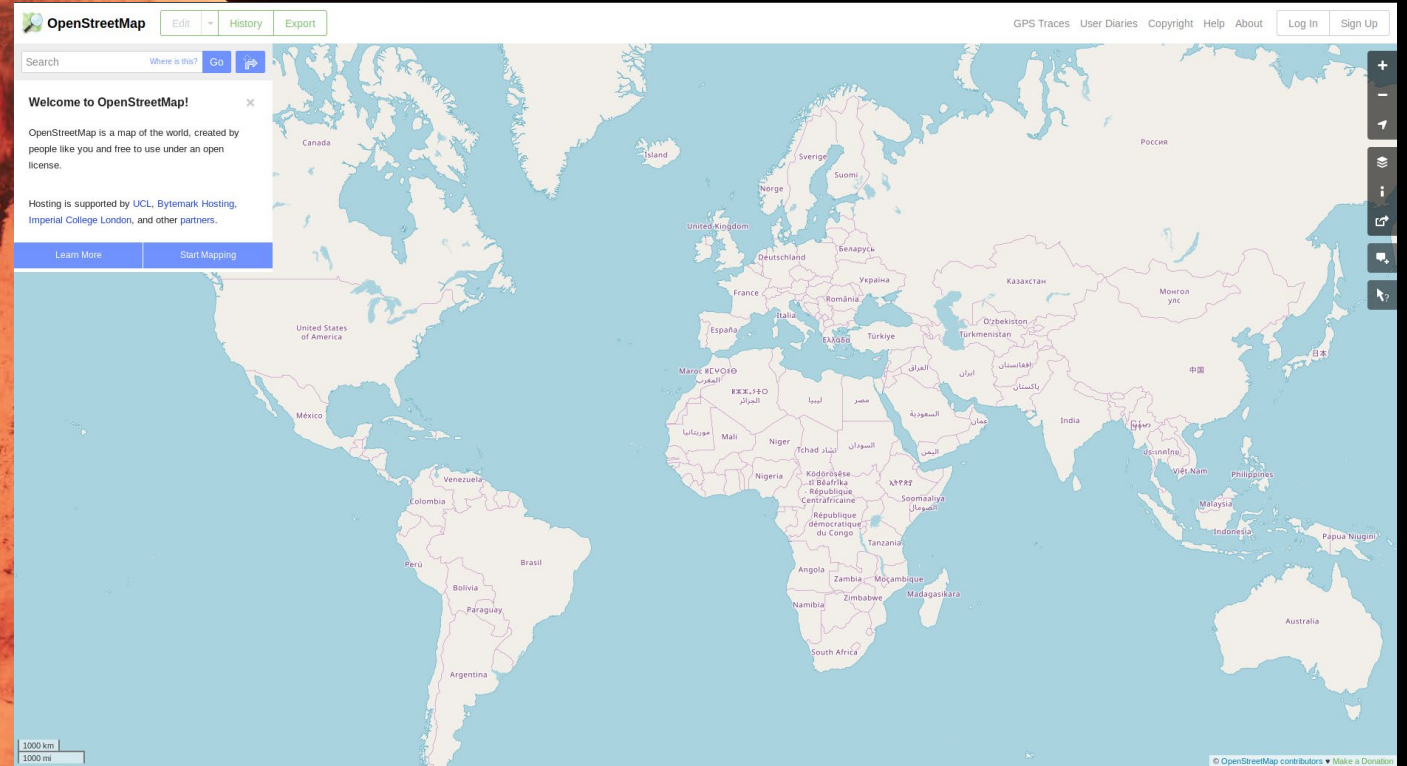


# MARS COORDINATE SYSTEMS

# What are Coordinate Systems?



Geographic Coordinate Systems

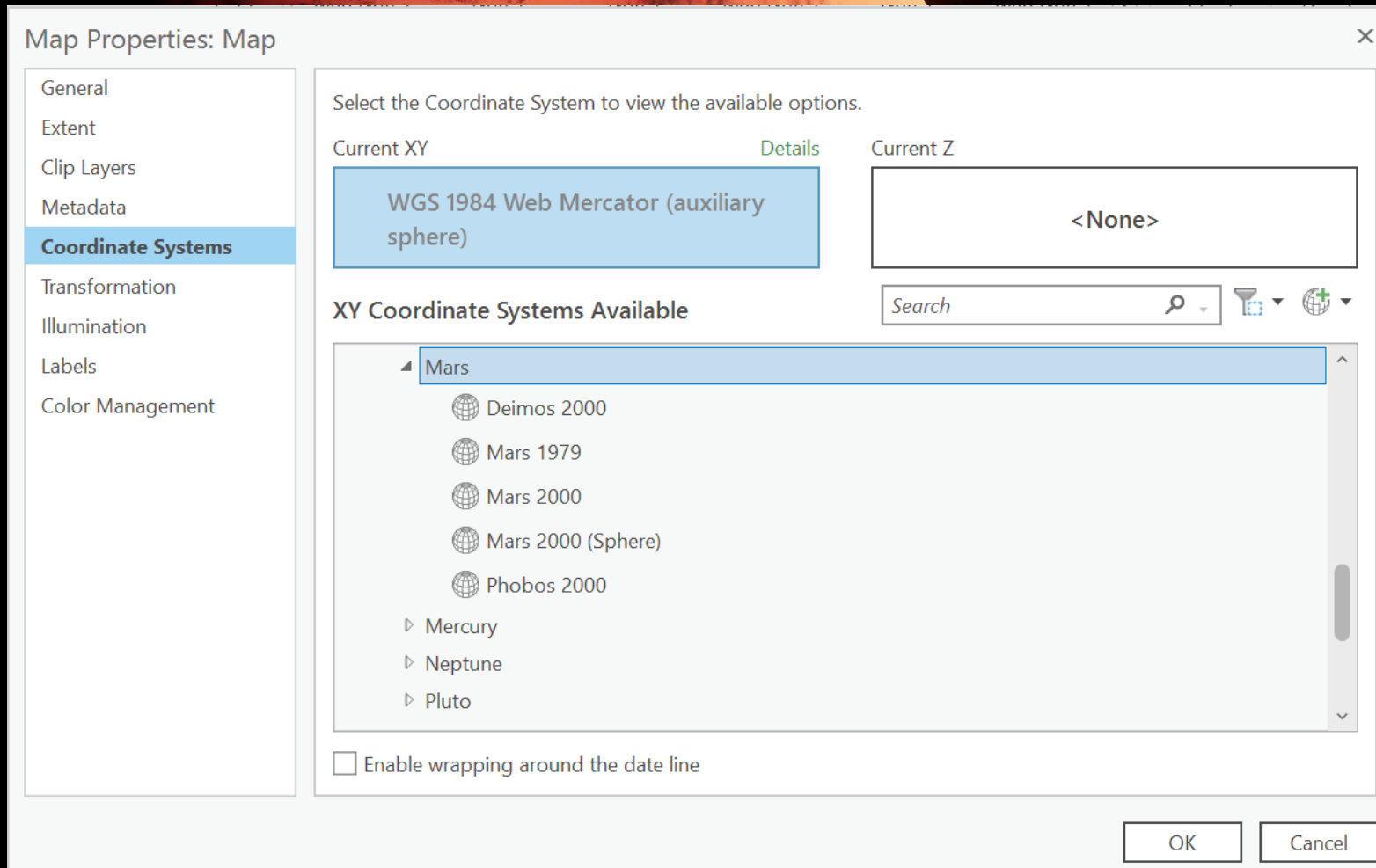


Projected Coordinate Systems



# What are Mars' Coordinate Systems?

- Mars 1979, Mars 2000, and Mars 2000 [Sphere]



# What are Mars' Coordinate Systems?

- Mars 1979, Mars 2000, and Mars 2000 [Sphere]

Coordinate System Details		Coordinate System Details		Coordinate System Details	
Geographic Coordinate System	Mars 1979	Geographic Coordinate System	Mars 2000	Geographic Coordinate System	Mars 2000 (Sphere)
WKID	104904	WKID	104905	WKID	104971
Authority	Esri	Authority	Esri	Authority	Esri
Angular Unit	Degree (0.0174532925199433)	Angular Unit	Degree (0.0174532925199433)	Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Reference Meridian (0.0)	Prime Meridian	Reference Meridian (0.0)	Prime Meridian	Reference Meridian (0.0)
Datum	D Mars 1979	Datum	D Mars 2000	Datum	Mars 2000 (Sphere)
Spheroid	Mars 1979 IAU IAG	Spheroid	Mars 2000 IAU IAG	Spheroid	Mars 2000 (Sphere)
Semimajor Axis	3393400.0	Semimajor Axis	3396190.0	Semimajor Axis	3396190.0
Semiminor Axis	3375730.0	Semiminor Axis	3376200.0	Semiminor Axis	3396190.0
Inverse Flattening	192.0430107526882	Inverse Flattening	169.8944472236118	Inverse Flattening	0.0



# What are Mars' Coordinate Systems?

- Mars 1979, Mars 2000, and Mars 2000 [Sphere]

Coordinate System Details ×		Coordinate System Details ×		Coordinate System Details ×	
Geographic Coordinate System	Mars 1979	Geographic Coordinate System	Mars 2000	Geographic Coordinate System	Mars 2000 (Sphere)
WKID	104904	WKID	104905	WKID	104971
Authority	Esri	Authority	Esri	Authority	Esri
Angular Unit	Degree (0.0174532925199433)	Angular Unit	Degree (0.0174532925199433)	Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Reference Meridian (0.0)	Prime Meridian	Reference Meridian (0.0)	Prime Meridian	Reference Meridian (0.0)
Datum	D Mars 1979	Datum	D Mars 2000	Datum	Mars 2000 (Sphere)
Spheroid	Mars 1979 IAU IAG	Spheroid	Mars 2000 IAU IAG	Spheroid	Mars 2000 (Sphere)
Semimajor Axis	3393400.0	Semimajor Axis	3396190.0	Semimajor Axis	3396190.0
Semiminor Axis	3375730.0	Semiminor Axis	3376200.0	Semiminor Axis	3396190.0
Inverse Flattening	192.0430107526882	Inverse Flattening	169.8944472236118	Inverse Flattening	0.0

# What are Mars' Coordinate Systems?

- Mars 1979, Mars 2000, and Mars 2000 [Sphere]

Geographic Coordinate System	Mars 2000 (Sphere)
WKID	104971
Authority	Esri
Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Reference Meridian (0.0)
Datum	Mars 2000 (Sphere)
Spheroid	Mars 2000 (Sphere)
Semimajor Axis	3396190.0
Semiminor Axis	3396190.0
Inverse Flattening	0.0

Geographic Coordinate System	WGS 1984
WKID	4326
Authority	EPSG
Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Greenwich (0.0)
Datum	D WGS 1984
Spheroid	WGS 1984
Semimajor Axis	6378137.0
Semiminor Axis	6356752.314245179
Inverse Flattening	298.257223563





PREVIOUS APPS

# Google



- Regions
- Spacecraft
- Stories
- Mountains
- Canyons
- Dunes
- Plains
- Ridges
- Craters

plains

Search

[Link this view](#)

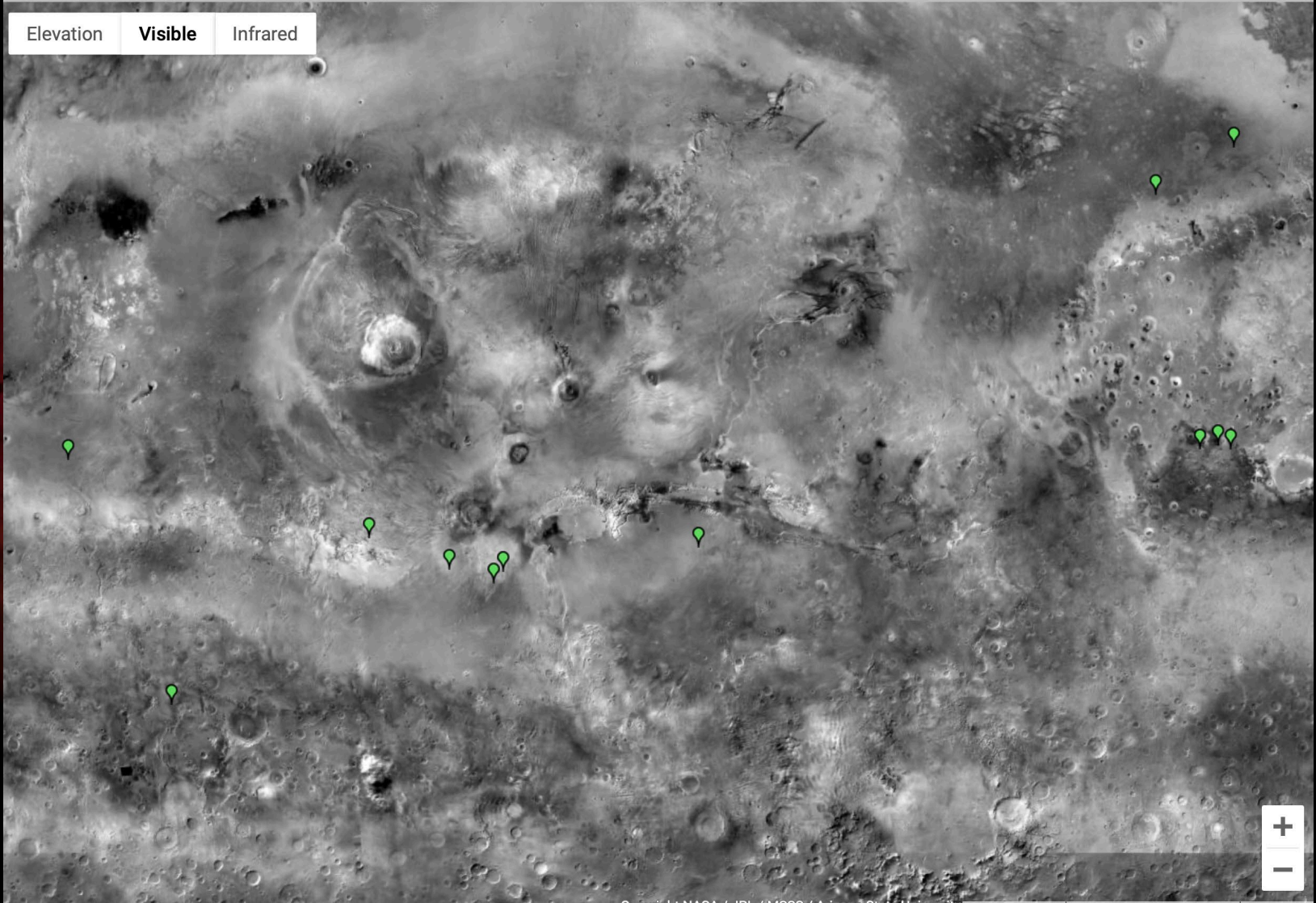
[View Mars with Google Earth](#)

[About](#)

Elevation

**Visible**

Infrared





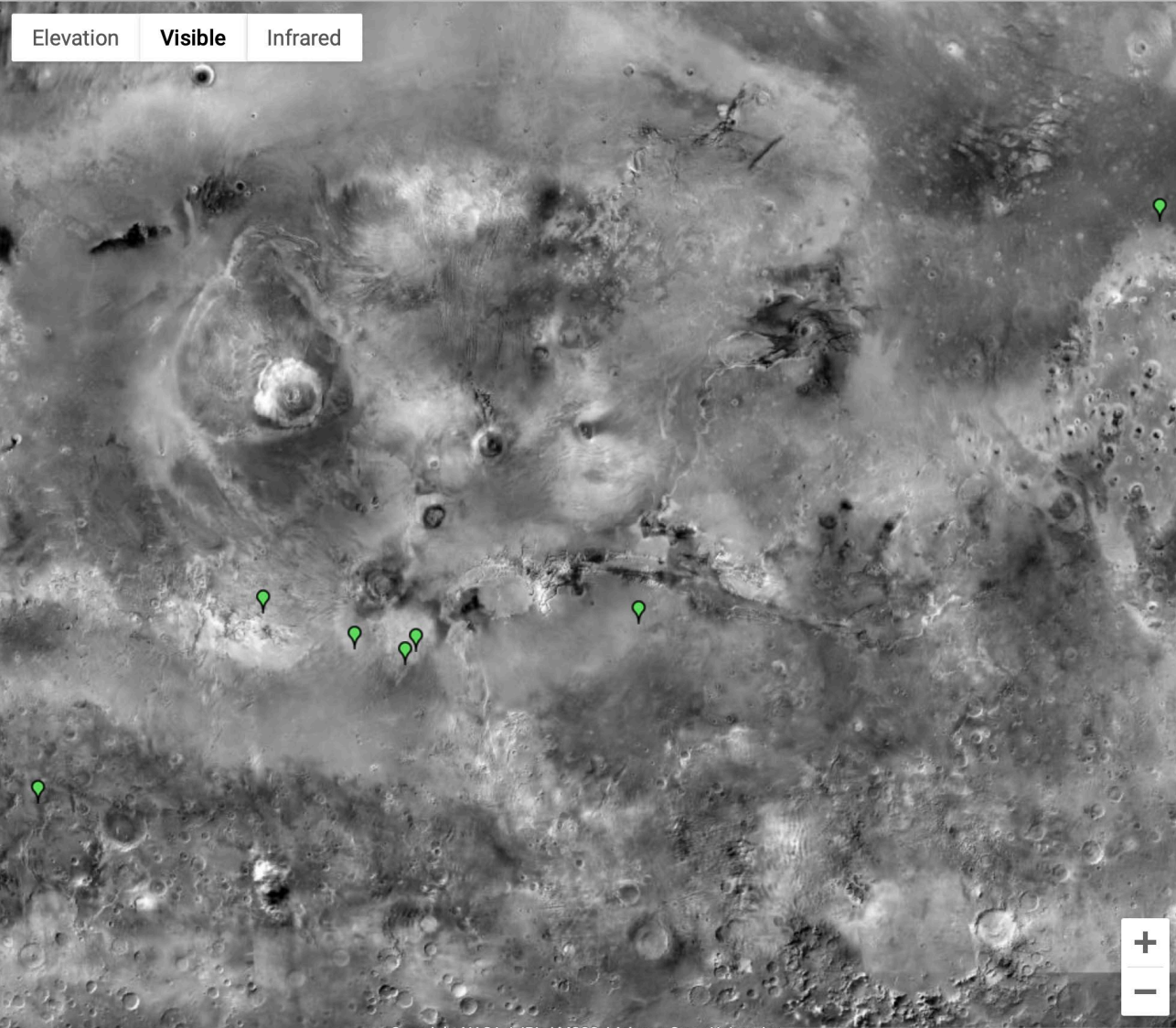
### Search results for plains

Found 177 matches  
[Limit results to current region](#)

[glossary](#)

- [Windstreaks in Daedalia](#)  
NASA Mars Odyssey / THEMIS article
- [Odd Crater](#)  
NASA Mars Odyssey / THEMIS article
- [Filled Crater](#)  
NASA Mars Odyssey / THEMIS article
- [Terra Meridiani](#)  
NASA Mars Odyssey / THEMIS article
- [Northeastern Meridiani](#)  
NASA Mars Odyssey / THEMIS article
- [Meridiani](#)  
NASA Mars Odyssey / THEMIS article
- [Acidalia Planitia Crater](#)  
NASA Mars Odyssey / THEMIS article
- [Acidalia Plainitia](#)  
NASA Mars Odyssey / THEMIS article
- [Elysium Planitia](#)  
NASA Mars Odyssey / THEMIS article
- [Lava Flows](#)  
NASA Mars Odyssey / THEMIS article
- [Arsia Mons Overlapping Flows](#)  
NASA Mars Odyssey / THEMIS article
- [Terra Cimmeria Highlands](#)  
NASA Mars Odyssey / THEMIS article
- [Aeolis](#)  
Named for: Floating island where winds were kept in a cave.
- [Aeria](#)  
Named for: Greek name for Egypt; "far land of mist".
- [Aetheria](#)  
Named for: Upper world; land of living.














Elevation Visible Infrared

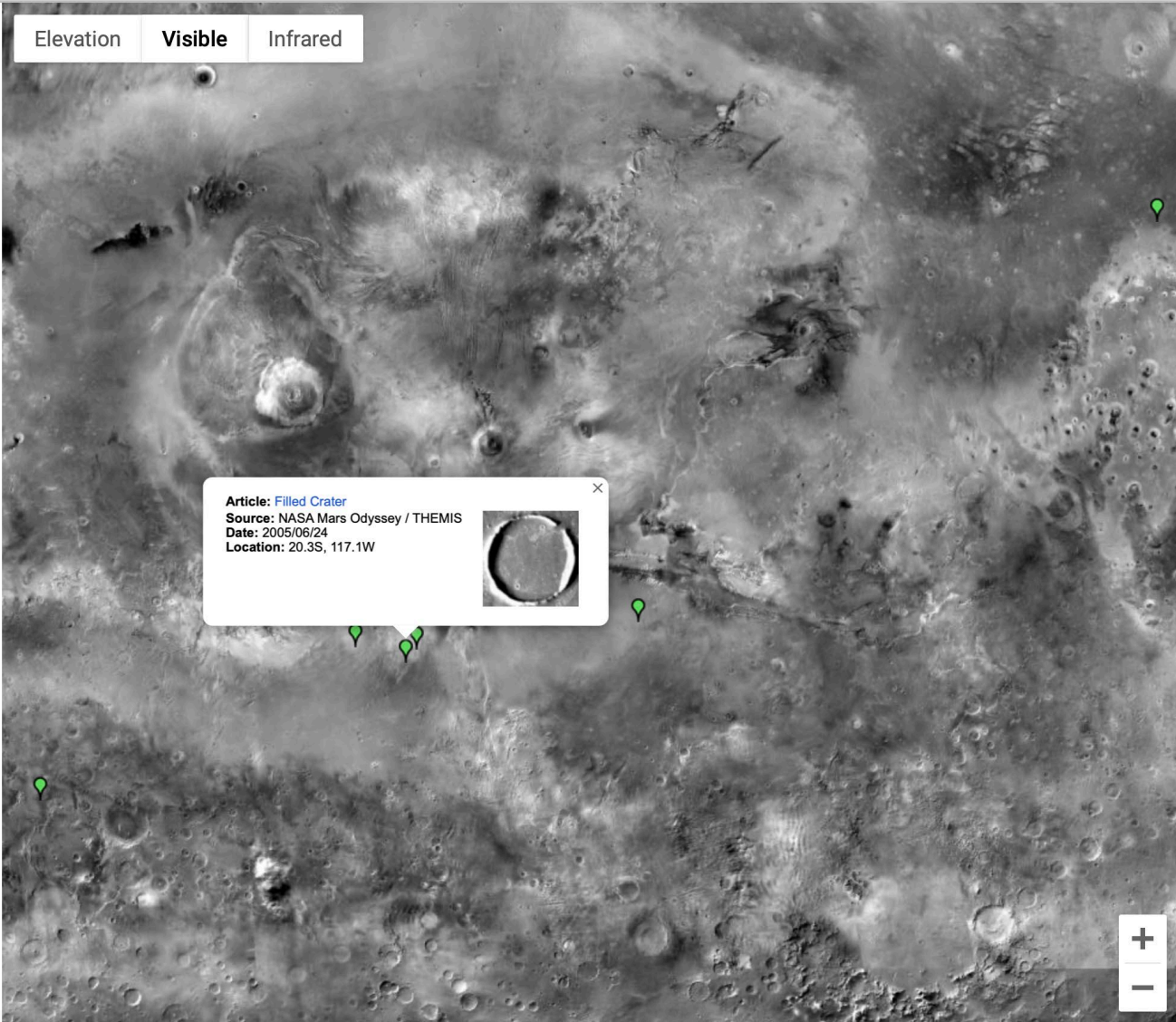


### Search results for plains

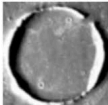
Found 177 matches  
[Limit results to current region](#)

[glossary](#)

-  [Windstreaks in Daedalia](#)  
NASA Mars Odyssey / THEMIS article
-  [Odd Crater](#)  
NASA Mars Odyssey / THEMIS article
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NASA Mars Odyssey / THEMIS article
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NASA Mars Odyssey / THEMIS article
-  [Meridiani](#)  
NASA Mars Odyssey / THEMIS article
-  [Acidalia Planitia Crater](#)  
NASA Mars Odyssey / THEMIS article
-  [Acidalia Planitia](#)  
NASA Mars Odyssey / THEMIS article
-  [Elysium Planitia](#)  
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-  [Aetheria](#)  
Named for: Upper world; land of living.



**Article:** [Filled Crater](#)  
**Source:** NASA Mars Odyssey / THEMIS  
**Date:** 2005/06/24  
**Location:** 20.3S, 117.1W






# NASA

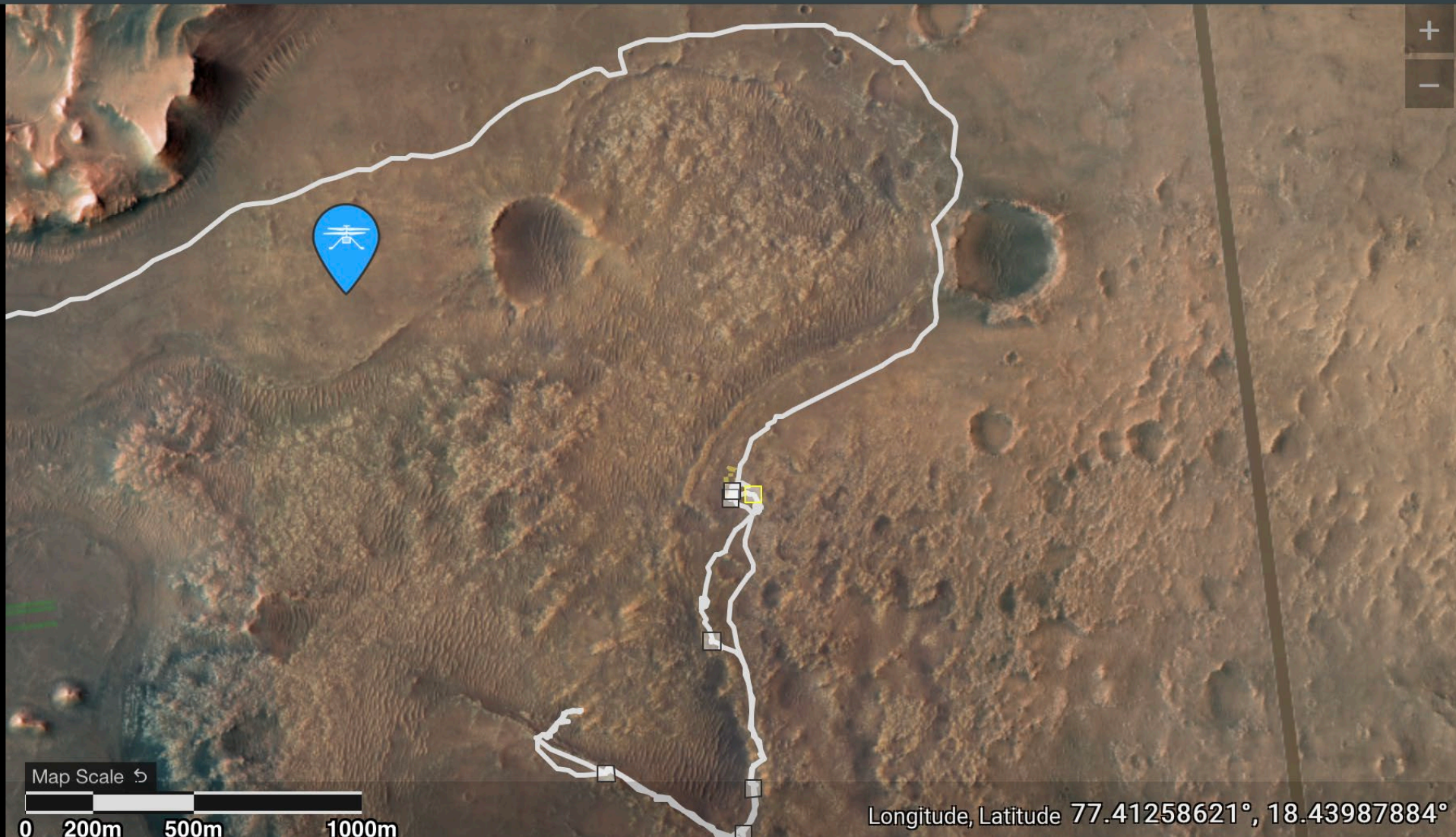


Perseverance's Location

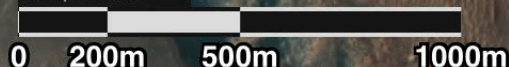
Latest Drive: Sol 409 | Total Distance 5.82 miles / 9.36 km

Surface View: Van Zyl Overlook (Name)

[Surface](#)



Map Scale ↺



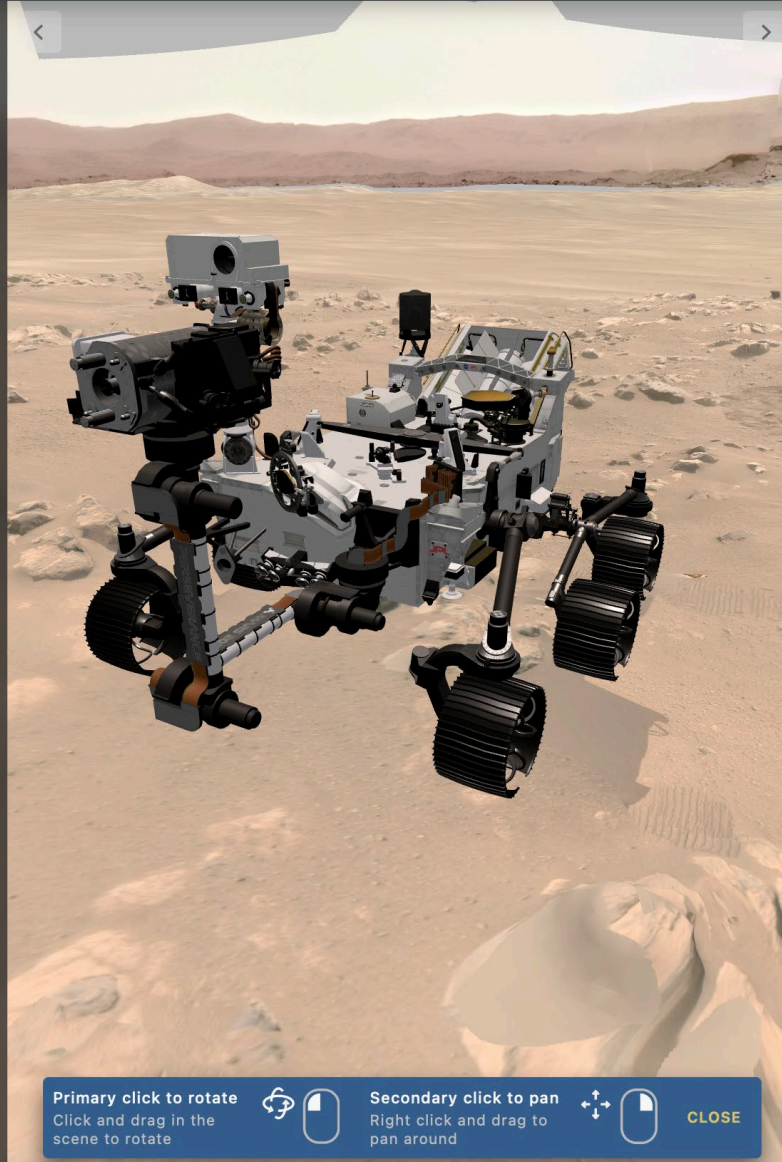
Longitude, Latitude 77.41258621°, 18.43987884°



# NASA

Images 0

Click anywhere in the scene to see images that contain that point. ✕



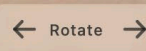
Primary click to rotate  
Click and drag in the scene to rotate



Secondary click to pan  
Right click and drag to pan around



CLOSE



## Van Zyl Overlook



Open map view ↗

### Points of interest

- Mars Helicopter Deployment Site

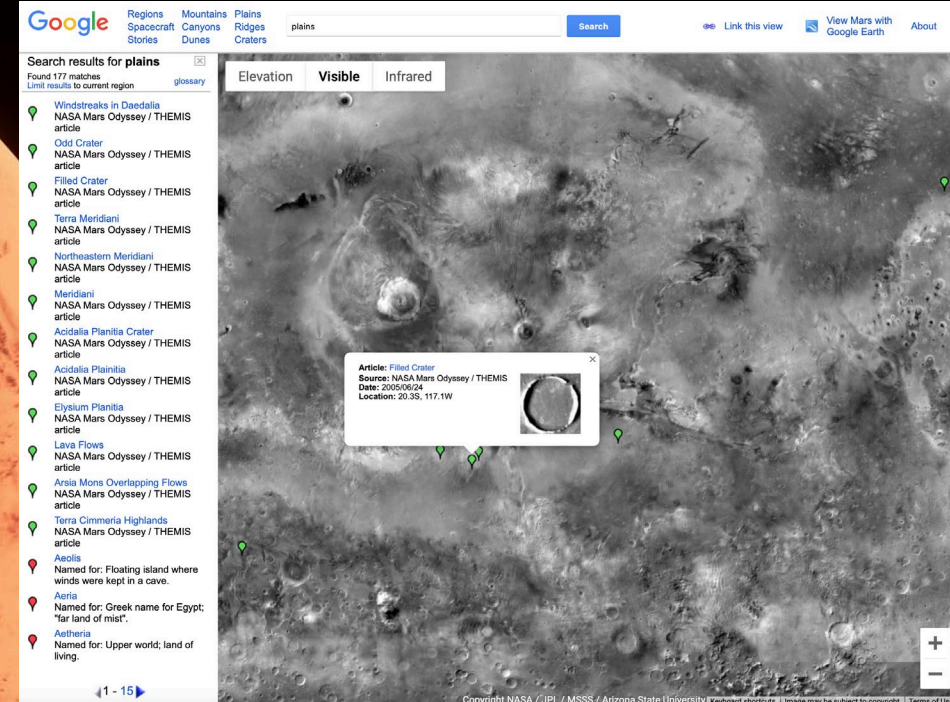
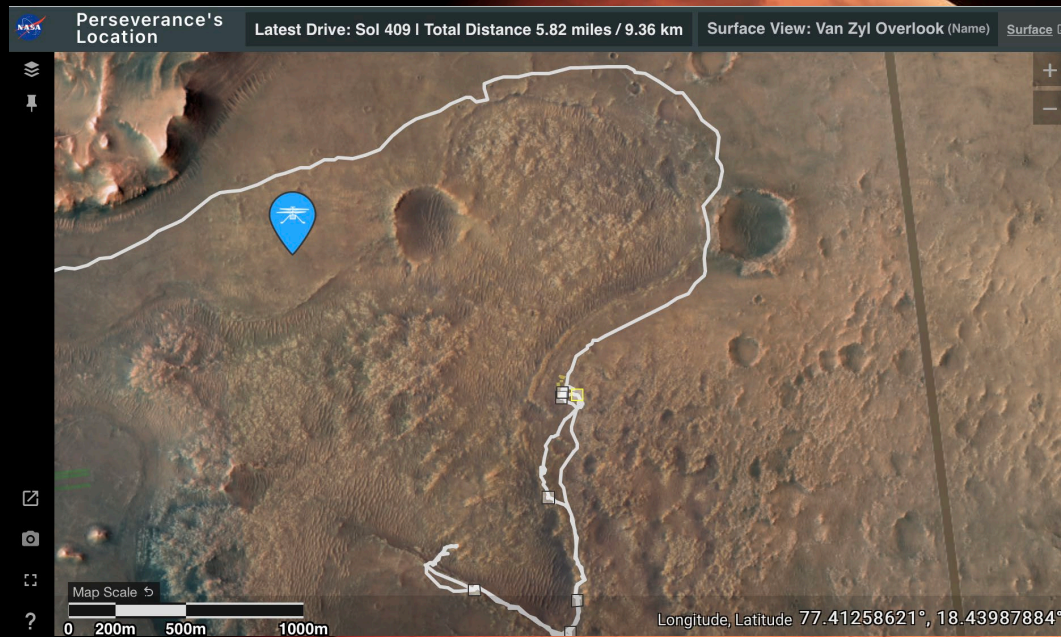
### About

Perseverance parked at this location during the Mars Helicopter's initial campaign of test flights. From here, the rover trained its cameras and microphones on Ingenuity, documenting the sights and sounds of the rotorcraft's historic first flights on Mars.

The site was informally named after Jakob van Zyl, the helicopter team's longtime colleague, mentor, and leader at NASA's Jet Propulsion Laboratory in Southern California. He passed away unexpectedly in August 2020, about a month after the launch of Perseverance.



# NASA vs. Google



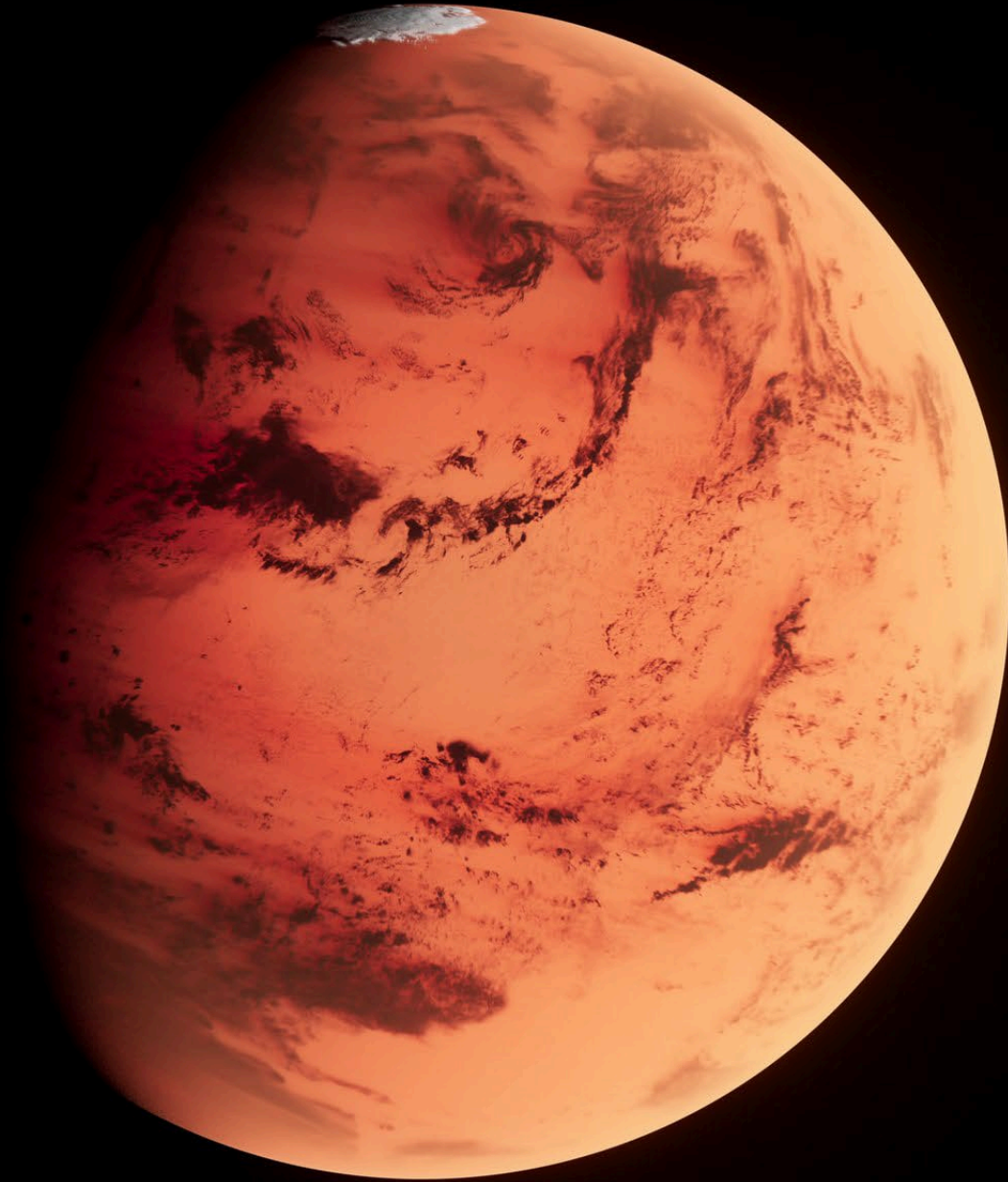
- Shows all Perseverance Locations
- Limited Basemap Functionality
- Features Surface 3-D Mosaics (Limited on locations).
- Photos are only available on key locations
- Reference layer available

- Multiple functional basemaps
- UI is lacking in accessibility and is dated
- Popups are disorganized
- No reference layer with labels



DATA





# Data

## Datasets Utilized

- Point data for Perseverance day to day
- Line Data for Rover Path (?)
- Rover Imagery tied to popups from point data
- Possible additional data affixed to Perseverance's location
- Basemaps (Satellite, Infrared, DEM)



# The Data Itself

- 414 Waypoints which covered 6.3 miles so far
- All in Sol Units





# How do we extract the data?



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- Monthly News



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[Latest news updates >](#)  
[Latest images >](#)



275  
SHARES



Privacy - Terms

# How do we extract the data?

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  "name": "M20_waypoints",
  "features": [
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```

- Point data for Perseverance day to day







WEB APP APIS



# What are Web App APIs?


- Web App Application Programming Interface or Web App APIs are “complex” coding libraries allowing for creation of web map content
- Split between Open Source and Proprietary (mainly the latter)

## ArcGIS API for JavaScript / Sample Code

```
1 <html>
2 <head>
3   <meta charset="utf-8" />
4   <meta
5     name="viewport"
6     content="initial-scale=1,maximum
7       -scale=1,user-scalable=no"
8   />
9   <title>
10    Custom ElevationLayer -
11    Exaggerating elevation | Sample |
12    ArcGIS API for
13    JavaScript 4.23
14  </title>
15
16  <link
17    rel="stylesheet"
18    href="https://js.arcgis.com/4.23
19      /esri/themes/light/main.css"
20  />
21
22  <script src="https://js.arcgis.com/4
23    .23/"></script>
24
25  <script>
26    require([
27      "esri/Map",
28      "esri/views/SceneView",
29      "esri/layers/ElevationLayer",
30      "esri/layers/BaseElevationLayer",
31      "esri/Basemap",
32      "esri/layers/TileLayer"
33    ], (
34      Map,
35      SceneView,
36      ElevationLayer,
37      BaseElevationLayer,
38      Basemap,
39      TileLayer
40    ) => {
41      //////////////////////////////////
42      //////////////////////////////////
```



# Common Web App APIs

 [mapbox](#) | [Docs](#)

[Maps](#) [Navigation](#) [Search](#) [Vision](#) [Data](#) [Help](#) [Sign in](#)

**Mapbox GL JS**

Search

**GUIDES**

- Installation
- Migrate to Mapbox GL JS v2
- Browsers and testing
- Adaptive projections
- Pricing

**API REFERENCE**

**EXAMPLES**

**PLUGINS AND FRAMEWORKS**

**STYLE SPECIFICATION**

**TUTORIALS**

**TROUBLESHOOTING**

[All docs](#) > [Mapbox GL JS](#) > [Guides](#)

## Mapbox GL JS

Current version: v2.8.2 [View changelog](#)

- ✓ Custom map styles
- ✓ Fast vector maps
- ✓ Compatible with other Mapbox tools

[Install](#) [Contribute on GitHub](#)


**On this page**

- Use cases
- Key concepts
- Use Mapbox GL JS with other tools
- Attribution

# Leaflet

an open-source JavaScript library for mobile-friendly interactive maps


[Overview](#) [Tutorials](#) [Docs](#) [Download](#) [Plugins](#) [Blog](#)

 **ArcGIS Developer**

ArcGIS API for JavaScript

## OpenLayers

[Docs](#) [Examples](#) [API](#) [Code](#)



*A high-performance, feature-packed library for all your mapping needs.*



# ESRI JS vs. Leaflet.js

☰ </> ArcGIS Developer

ArcGIS API for JavaScript

Leaflet 

an open-source JavaScript library  
for mobile-friendly interactive maps

[Overview](#) [Tutorials](#) [Docs](#) [Download](#) [Plugins](#) [Blog](#)

- Proprietary
- Limited functionality -> “Out of the Box”
- Extensive Documentation
- Open Source
- Expandable Functionality
- Limited Documentation (Rely on other users)



ANTICIPATED RESULTS



# DEVELOPMENT PROCESS

Finalizing Proposal  
Feedback and Data  
Extraction

Custom Popups

Bug Fixing and  
Finalizing

June

July

August

September

October

Data Processing and  
Prepare a Working Web  
Map

Web Design





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QUESTIONS?