OreCzml

a 3D visualisation library for Orekit

4th Orekit talk

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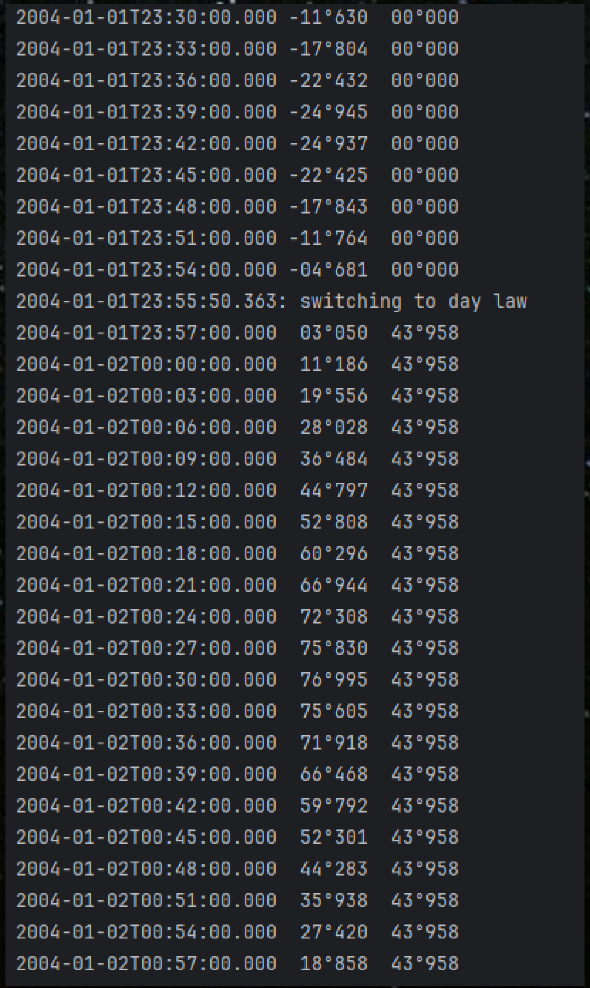
A need for 3D visualisation

Orekit : A robust computation tool with a lack in visualisation

Why 3D display is essential:

- Visual verifications on the fly
- Improved communication
- Simplifies complex output datas
- Educational demonstrations



```
2004-01-01T23:30:00.000 -11°630  00°000
2004-01-01T23:33:00.000 -17°804  00°000
2004-01-01T23:36:00.000 -22°432  00°000
2004-01-01T23:39:00.000 -24°945  00°000
2004-01-01T23:42:00.000 -24°937  00°000
2004-01-01T23:45:00.000 -22°425  00°000
2004-01-01T23:48:00.000 -17°843  00°000
2004-01-01T23:51:00.000 -11°764  00°000
2004-01-01T23:54:00.000 -04°681  00°000
2004-01-01T23:55:50.363: switching to day law
2004-01-01T23:57:00.000  03°050  43°958
2004-01-02T00:00:00.000  11°186  43°958
2004-01-02T00:03:00.000  19°556  43°958
2004-01-02T00:06:00.000  28°028  43°958
2004-01-02T00:09:00.000  36°484  43°958
2004-01-02T00:12:00.000  44°797  43°958
2004-01-02T00:15:00.000  52°808  43°958
2004-01-02T00:18:00.000  60°296  43°958
2004-01-02T00:21:00.000  66°944  43°958
2004-01-02T00:24:00.000  72°308  43°958
2004-01-02T00:27:00.000  75°830  43°958
2004-01-02T00:30:00.000  76°995  43°958
2004-01-02T00:33:00.000  75°605  43°958
2004-01-02T00:36:00.000  71°918  43°958
2004-01-02T00:39:00.000  66°468  43°958
2004-01-02T00:42:00.000  59°792  43°958
2004-01-02T00:45:00.000  52°301  43°958
2004-01-02T00:48:00.000  44°283  43°958
2004-01-02T00:51:00.000  35°938  43°958
2004-01-02T00:54:00.000  27°420  43°958
2004-01-02T00:57:00.000  18°858  43°958
```

Example of result from orekit-tutorials (from the console after a run)

A solution

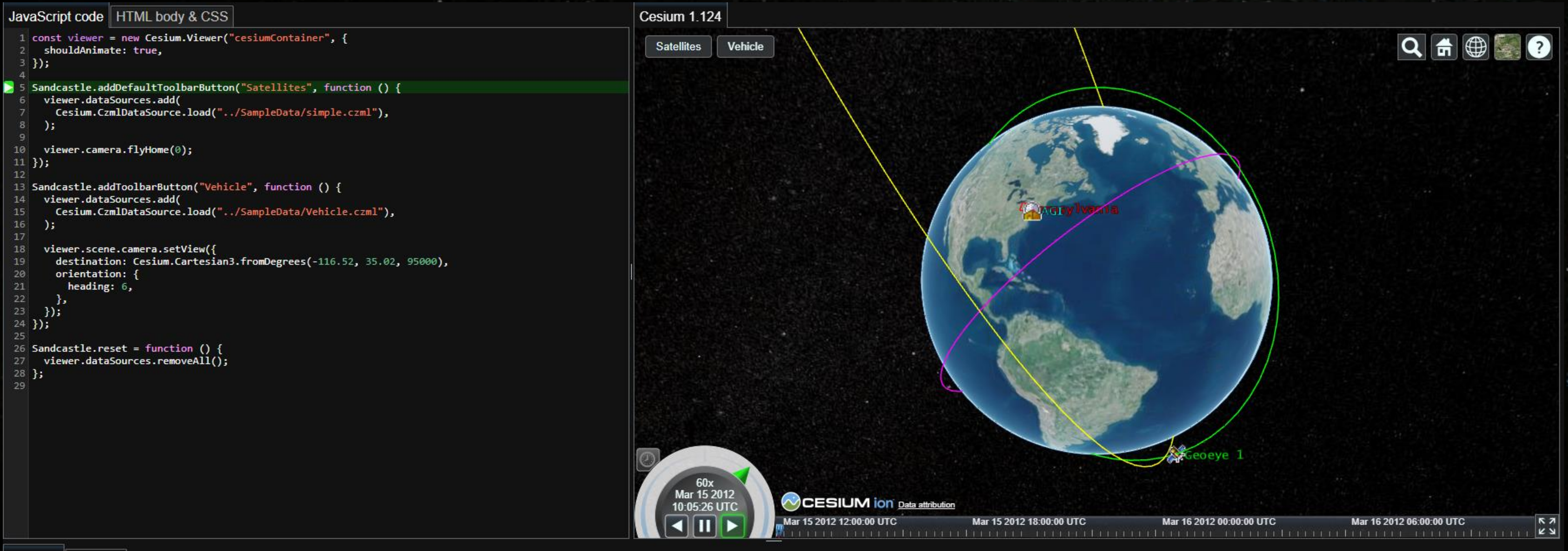
CesiumJS

- Javascript library
- Display Interface
- Possibility to use it offline/online

Logo of CesiumJS

Example of usage of CesiumJs

- Usage online : Sandcastle (https://sandcastle.cesium.com)
  - Resources imported from Cesium Ion

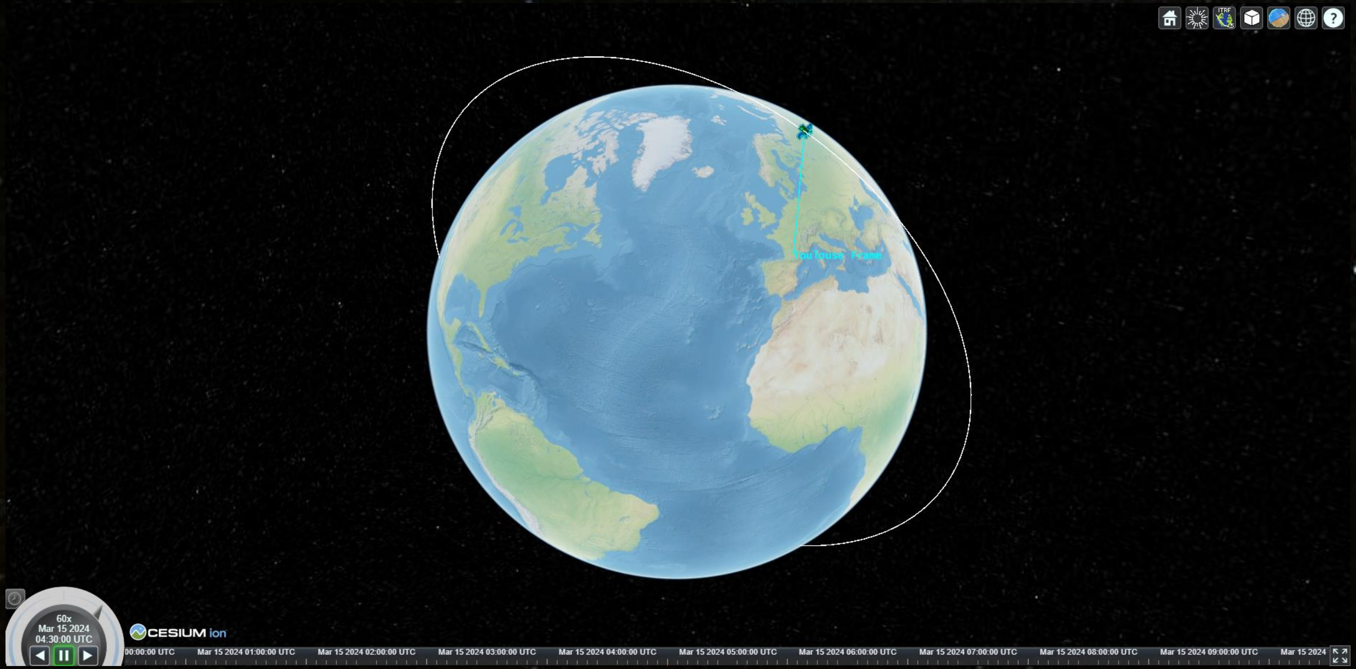


```javascript
const viewer = new Cesium.Viewer("cesiumContainer", {
  shouldAnimate: true,
});

Sandcastle.addDefaultToolbarButton("Satellites", function () {
  viewer.dataSources.add(
    Cesium.CzmlDataSource.load("../SampleData/simple.czml"),
  );

  viewer.camera.flyHome(0);
});

Sandcastle.addToolbarButton("Vehicle", function () {
  viewer.dataSources.add(
    Cesium.CzmlDataSource.load("../SampleData/Vehicle.czml"),
  );

  viewer.scene.camera.setView({
    destination: Cesium.Cartesian3.fromDegrees(-116.52, 35.02, 95000),
    orientation: {
      heading: 6,
    },
  });
});

Sandcastle.reset = function () {
  viewer.dataSources.removeAll();
};
```

Cesium sandcastle interfaces with the javascript interpreter and the run window

Example of usage of CesiumJS

- Usage offline – A GitLab repository (https://gitlab.orekit.org/Zudo/oreczml-js-interface)
  - Resources imported locally
  - Javascript local server – adapted to bigger simulations



Local javascript server with CesiumJS window launched

What is OreCzml ?

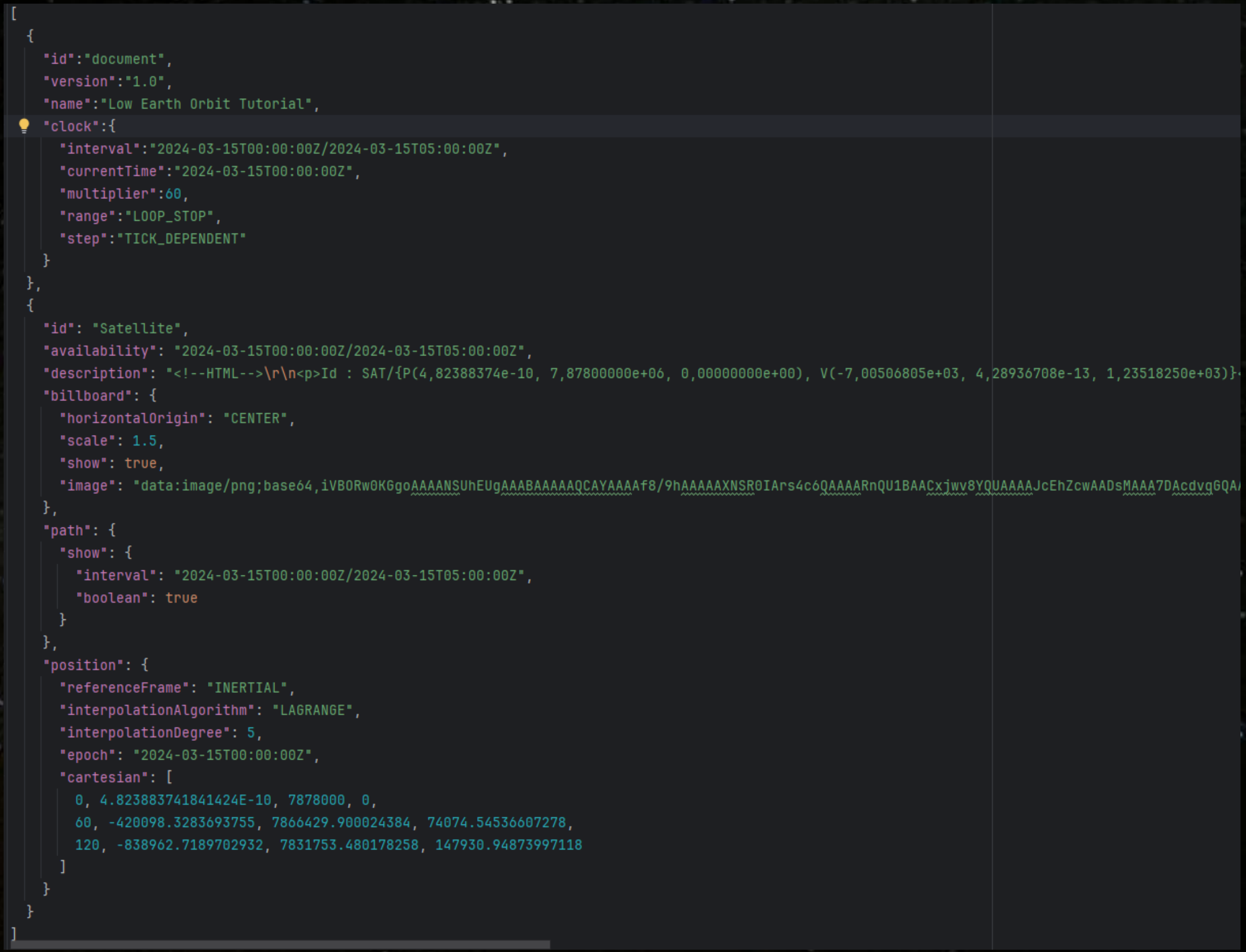
Developed to create an interface between Orekit and CesiumJs.

- Java library
- Uses Orekit and Cesium language writer as dependencies
- Converts Orekit objects into understandable objects for CesiumJS (Czml)
- First release : V1.0

What is Czml ?

"Cesium Language"

- JSON Format with only one element
- Describes objects in the simulation
- Skeleton of the simulation
- File that Cesium understands and reads

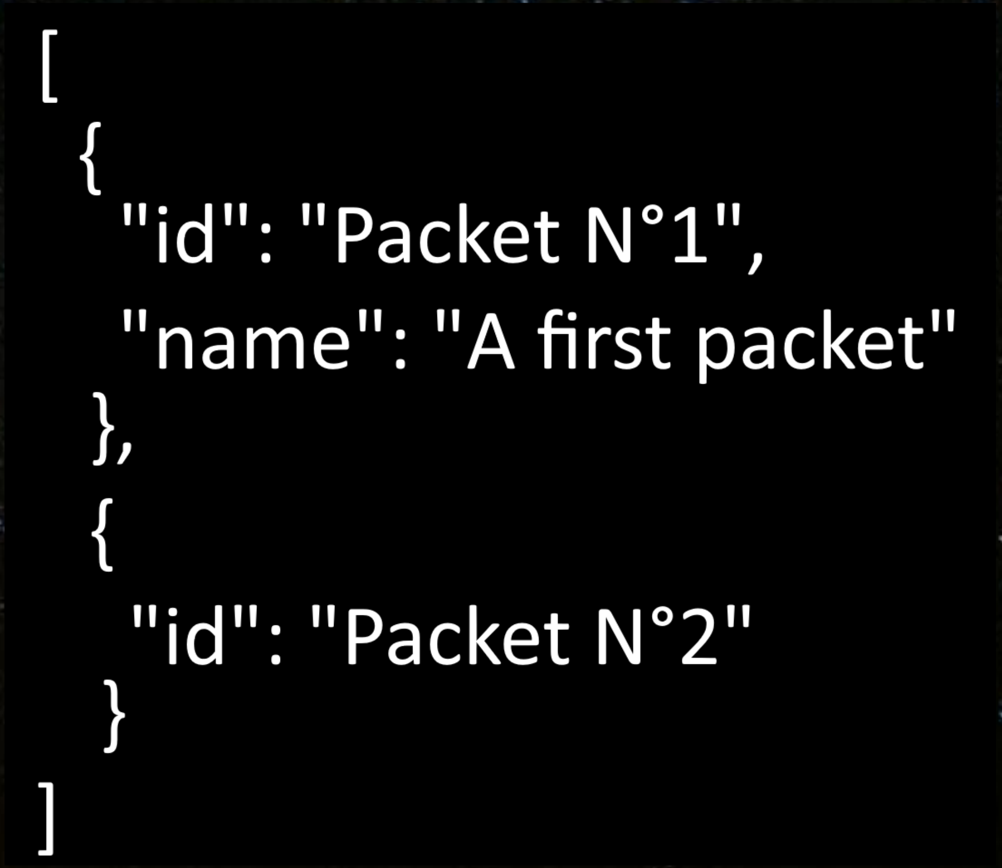


```
[
  {
    "id":"document",
    "version":"1.0",
    "name":"Low Earth Orbit Tutorial",
    "clock":{
      "interval":"2024-03-15T00:00:00Z/2024-03-15T05:00:00Z",
      "currentTime":"2024-03-15T00:00:00Z",
      "multiplier":60,
      "range":"LOOP_STOP",
      "step":"TICK_DEPENDENT"
    }
  },
  {
    "id": "Satellite",
    "availability": "2024-03-15T00:00:00Z/2024-03-15T05:00:00Z",
    "description": "<!--HTML-->\r\n<p>Id : SAT/{P(4,82388374e-10, 7,87800000e+06, 0,00000000e+00), V(-7,00506805e+03, 4,28936708e-13, 1,23518250e+03)}
    "billboard": {
      "horizontalOrigin": "CENTER",
      "scale": 1.5,
      "show": true,
      "image": "data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAABAAAAAQCAYAAAAf8/9hAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAJcEhZcwAADsMAAA7DAcdvqGQA
    },
    "path": {
      "show": {
        "interval": "2024-03-15T00:00:00Z/2024-03-15T05:00:00Z",
        "boolean": true
      }
    },
    "position": {
      "referenceFrame": "INERTIAL",
      "interpolationAlgorithm": "LAGRANGE",
      "interpolationDegree": 5,
      "epoch": "2024-03-15T00:00:00Z",
      "cartesian": [
        0, 4.823883741841424E-10, 7878000, 0,
        60, -420098.3283693755, 7866429.900024384, 74074.54536607278,
        120, -838962.7189702932, 7831753.480178258, 147930.94873997118
      ]
    }
  }
]
```

Example of a simple Czml file with a satellite

Czml architecture

- File start with "[" and ends with "]"
- Objects = Packets
- Packets starts with "{" and ends with "}"
- Properties inside packets with quotations marks
- Values after ":"



```
[
 {
  "id": "Packet N°1",
  "name": "A first packet"
 },
 {
  "id": "Packet N°2"
 }
]
```

Architecture of a Czml file

Usage of the Cesium Language Writer

- Developed by Ansys Government initiatives (AGI). They developed System Tool Kit (STK) which is well-known now.
- The Cesium Language Writer (Czml writer) is used as a dependency on OreCzml.
- This library aims at writing and formatting the String outputted to generate a Czml file with the right architecture.

Functionalities of OreCzml

Creates objects in the file from Orekit objects

Possibility to create (V1.0):

- Satellites
- Constellations
- Ground Stations
- Fields of observations
- Ground tracks
- Visibility inter-satellite
- Visibility station-satellite

Possibility to manage(V1.0):

- Satellite attitude
- 3D Models
- Interplanetary bodies
- Ellipsoid of covariance
- Satellite reference system
- Earth reference system
- Maneuvers

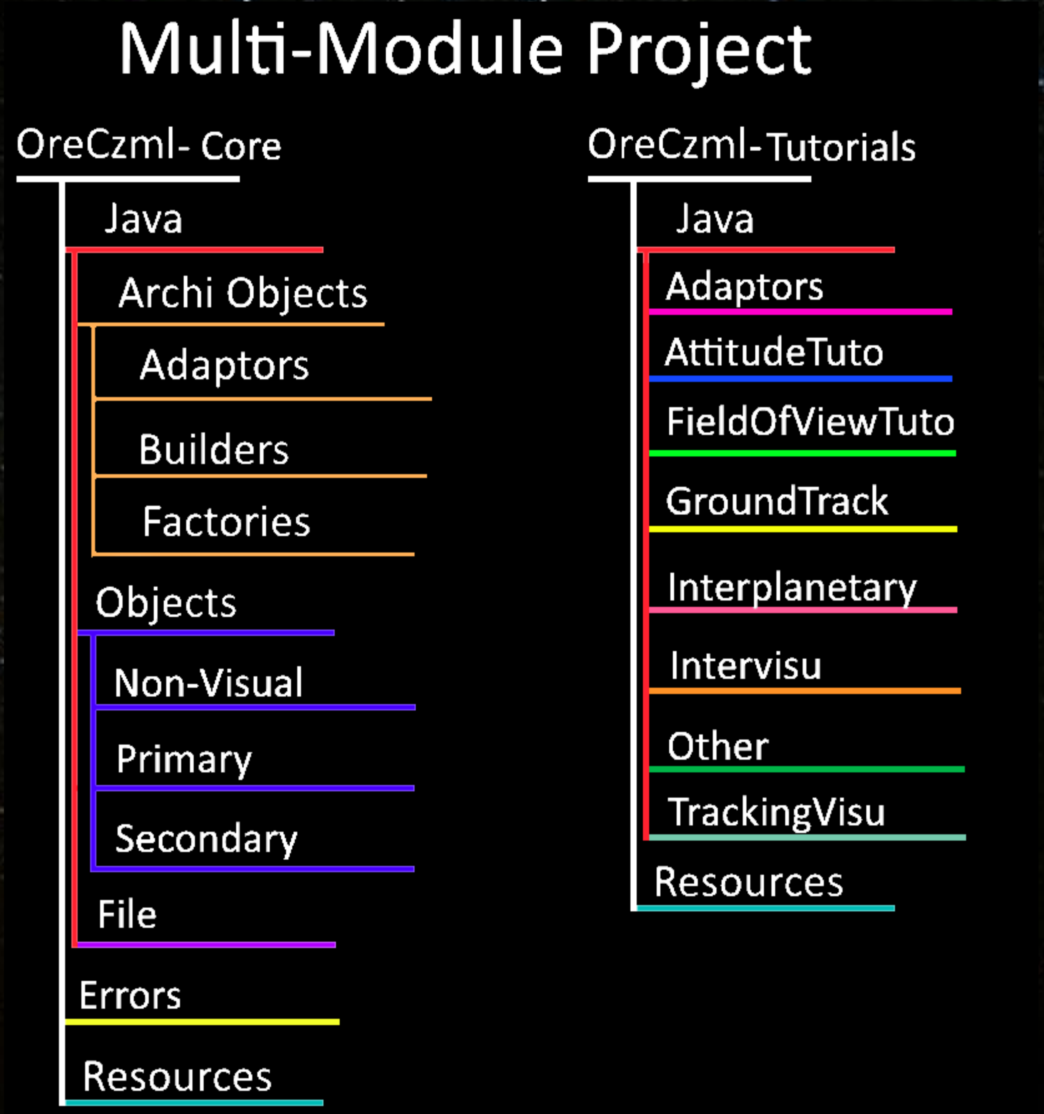
Architecture of OreCzml

OreCzml is composed of two modules:

- OreCzml-Core
- OreCzml-Tutorials

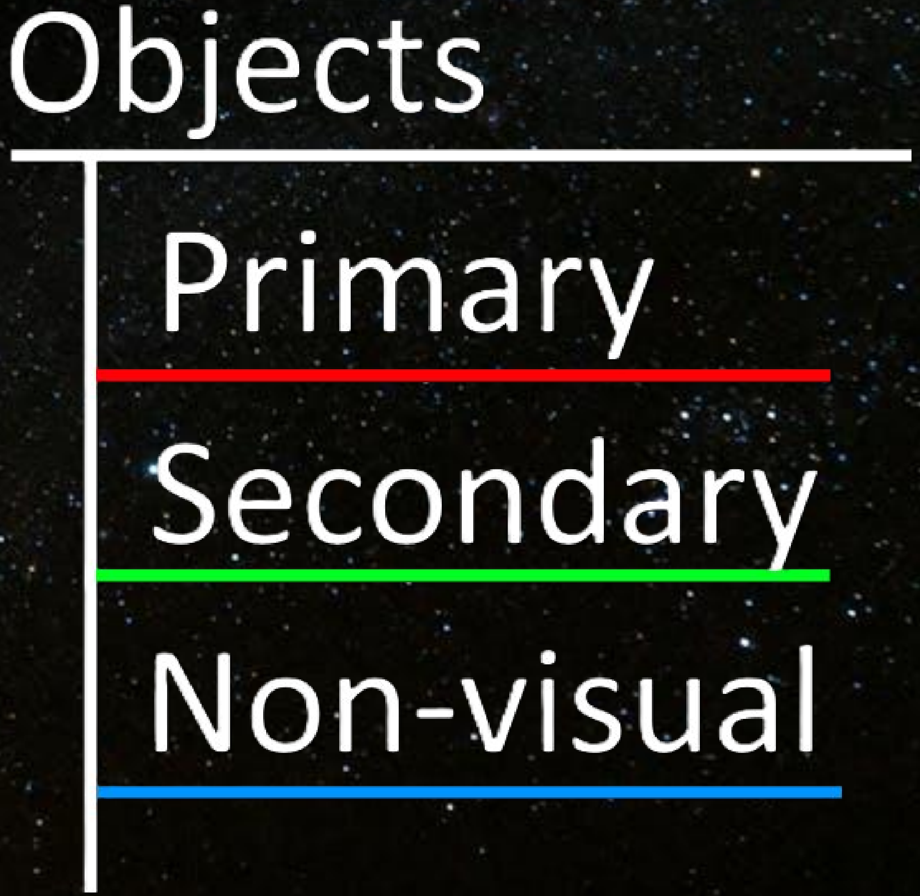
Core: All the classes related to the functionalities of the library

Tutorials: Several examples that users can run and understand how to use OreCzml



General information about objects

- **Primary objects:** Objects directly displayed on screen (Ex :Satellites)
- **Secondary objects:** Objects that need primary objects to exist (Ex : Attitude)
- **Non-visual objects:** Objects that do not depend a primary object but do not display on screen
- All primary objects have a builder class attributed



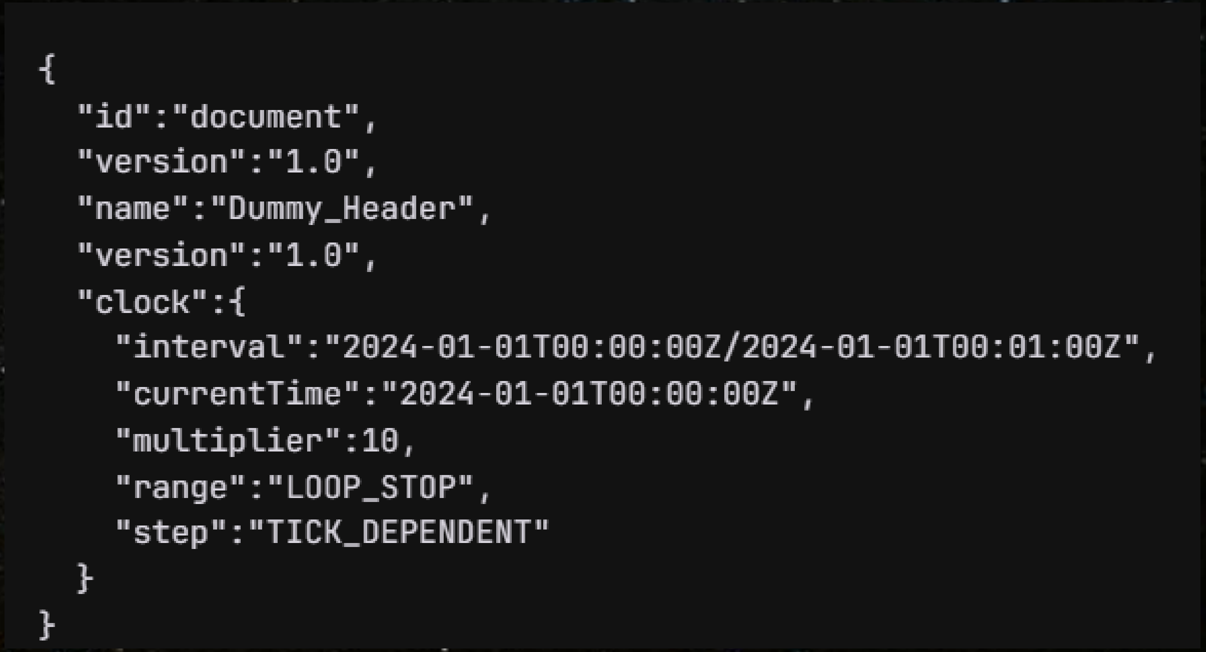
The header

Is the first object to instantiate when using OreCzml.

It defines:

- The time range of the simulation
- The default time step between each instant
- The time scale to use for the simulation

Several headers can be used simultaneously for different simulations.



```
{
  "id":"document",
  "version":"1.0",
  "name":"Dummy_Header",
  "version":"1.0",
  "clock":{
    "interval":"2024-01-01T00:00:00Z/2024-01-01T00:01:00Z",
    "currentTime":"2024-01-01T00:00:00Z",
    "multiplier":10,
    "range":"LOOP_STOP",
    "step":"TICK_DEPENDENT"
  }
}
```

Example of a Header object in the czml file.

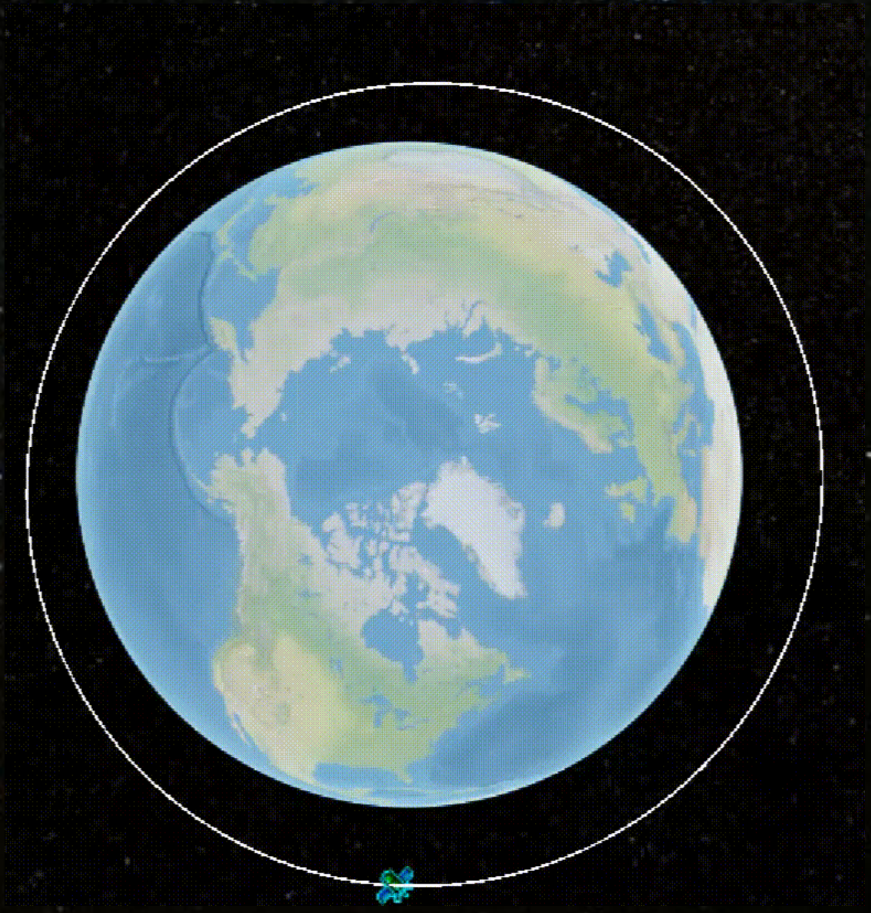
How to create Czml objects ?

Spacecrafts

Created from a BoundedPropagator object

Satellites objects have:

- An ephemeris
- An attitude
- A model (2D/3D)



Example of a satellite object on CesiumJS

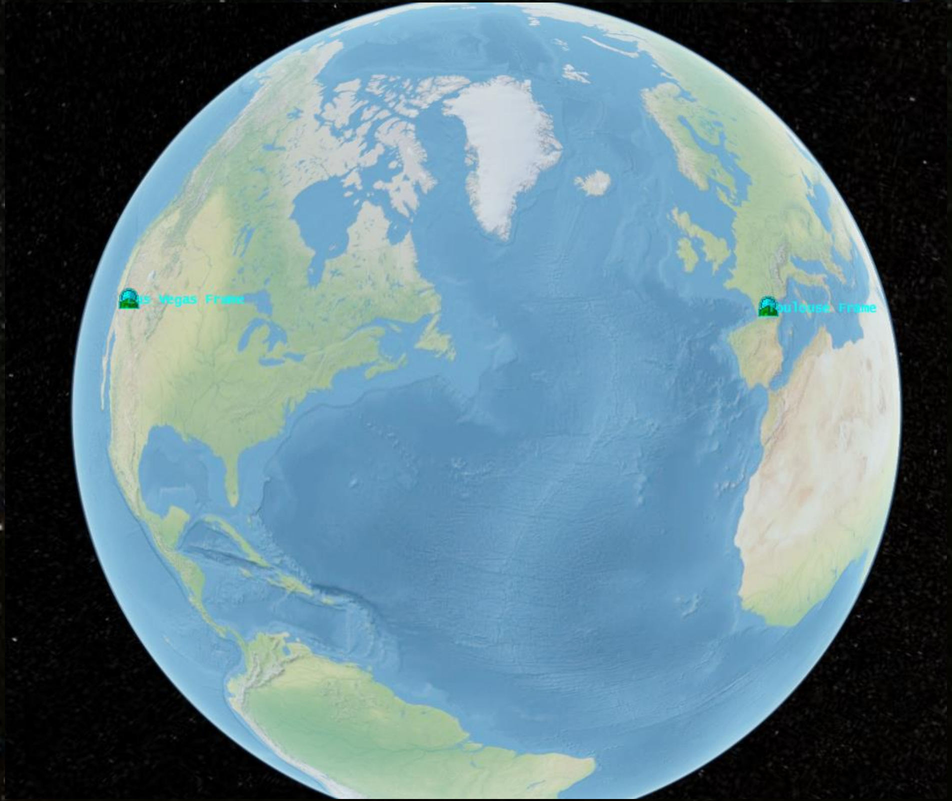
How to generate a Czml objects ?

Ground Stations

Created from a TopocentricFrame object

Ground station objects have:

- A position on earth
- A model (2D/3D)
- An angle of aperture



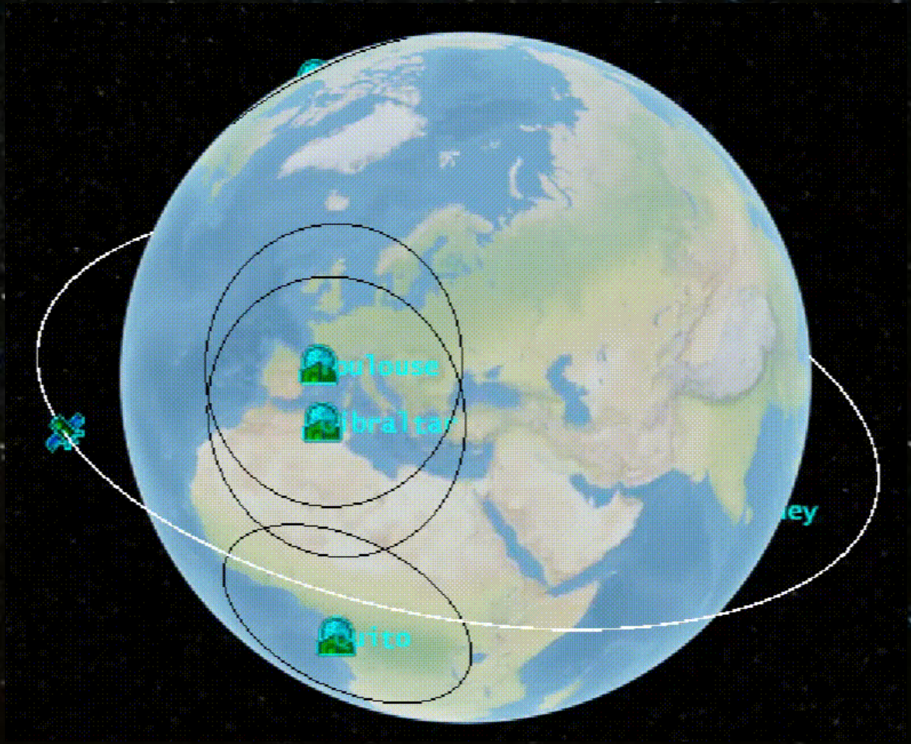
Example of two ground stations on CesiumJS

How to generate a Czml objects ?

Line of Visibility

Created from a Satellite and a TopocentricFrame

- They represent the visibility window of a satellite for a given station
- Can be applied to constellations
- Are computed with Elevation detectors from Orekit



Example of lines of visibility with the visibility circles of stations

Czml file object

A Czml file object **needs** to be built with the CzmlFileBuilder object.

A Czml file object contains:

- A header object
- All the primary objects
- A path where to output the file

The CzmlFile object is the bridge between the Czml objects and the Czml file created on output.

It contains all the information needed to build the output.

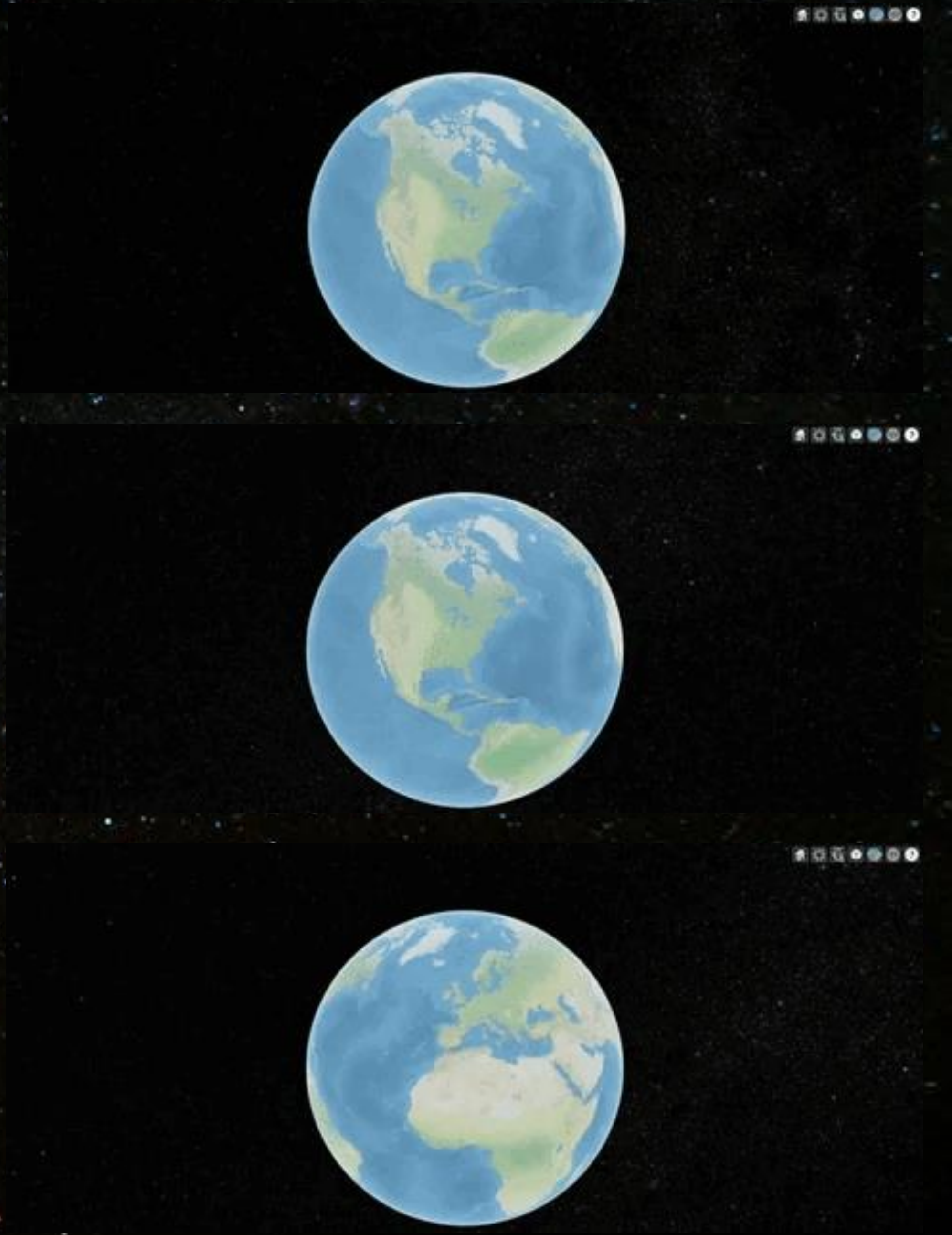
Demonstrator

And after ?

To better use OreCzml, install the local CesiumJs interface.

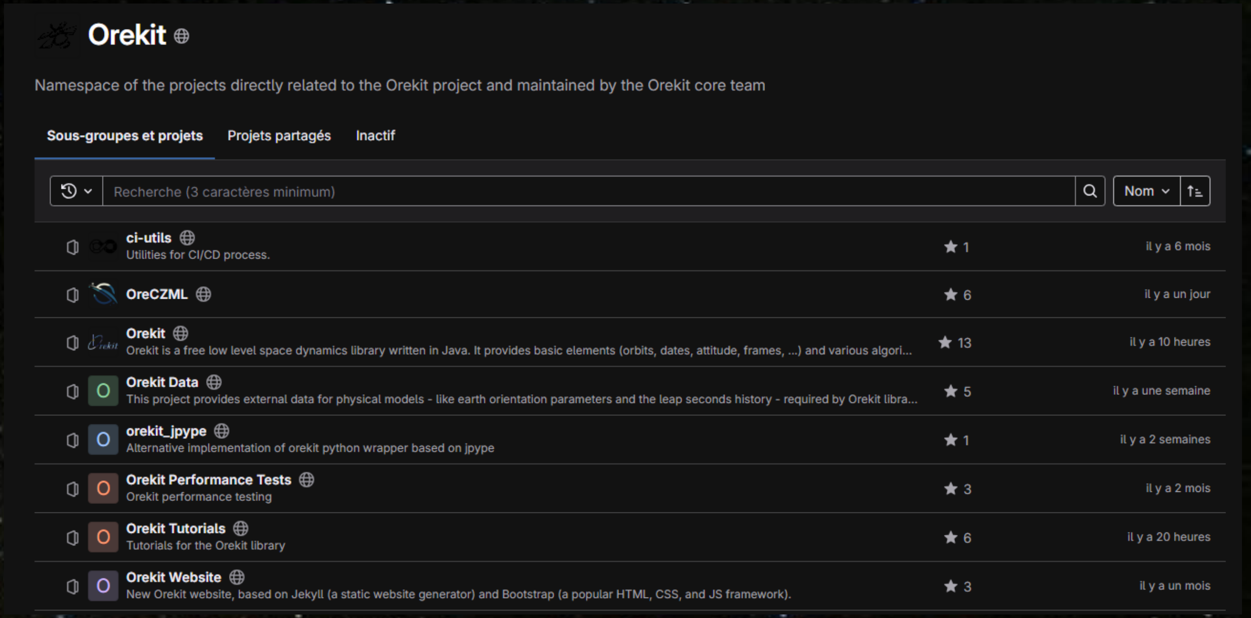
Additional capabilities I added :

- Objects selection
- Light management
- ITRF/GCRF view scene switch
- NavBall



And after ?

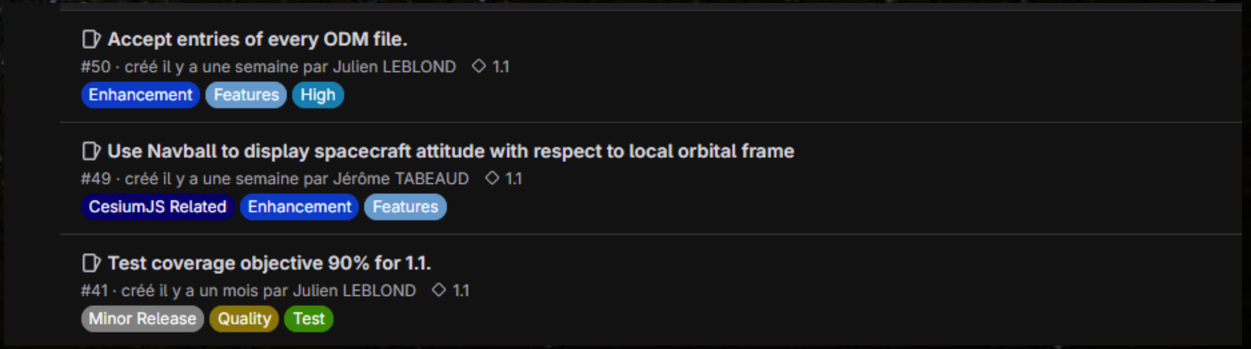
- OreCzml added to the GitLab Orekit Group.
- A wiki is available on this GitLab to fully explains how each class works.
- Feel free to contribute by opening tickets or giving solutions



Orekit

Namespace of the projects directly related to the Orekit project and maintained by the Orekit core team

ci-utils Utilities for CI/CD process.	★ 1	il y a 6 mois
OreCZML	★ 6	il y a un jour
Orekit Orekit is a free low level space dynamics library written in Java. It provides basic elements (orbits, dates, attitude, frames, ...) and various algori...	★ 13	il y a 10 heures
Orekit Data This project provides external data for physical models - like earth orientation parameters and the leap seconds history - required by Orekit libra...	★ 5	il y a une semaine
orekit_jpype Alternative implementation of orekit python wrapper based on jpype	★ 1	il y a 2 semaines
Orekit Performance Tests Orekit performance testing	★ 3	il y a 2 mois
Orekit Tutorials Tutorials for the Orekit library	★ 6	il y a 20 heures
Orekit Website New Orekit website, based on Jekyll (a static website generator) and Bootstrap (a popular HTML, CSS, and JS framework).	★ 3	il y a un mois



Accept entries of every ODM file.
#50 · créé il y a une semaine par Julien LEBLOND ◇ 1.1
Enhancement Features High

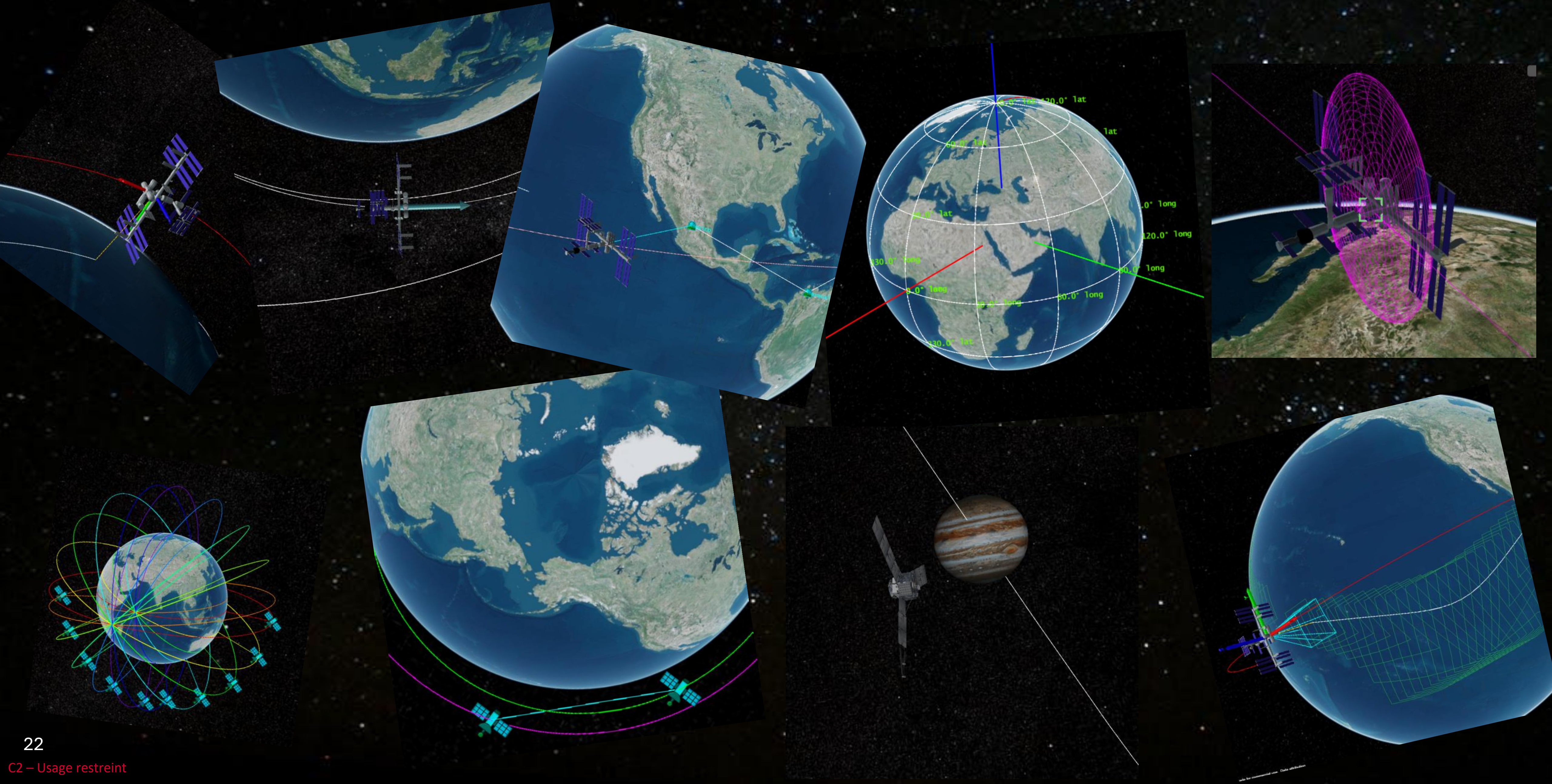
Use Navball to display spacecraft attitude with respect to local orbital frame
#49 · créé il y a une semaine par Jérôme TABEAUD ◇ 1.1
CesiumJS Related Enhancement Features

Test coverage objective 90% for 1.1.
#41 · créé il y a un mois par Julien LEBLOND ◇ 1.1
Minor Release Quality Test

Conclusion

- OreCzml is a real bridge between Orekit and Cesium, between computation and visualisation.
- OreCzml now released its first version V1.0
- It is still improving and will be better in time with the cooperation of the Orekit community.

Thank you for your attention



Questions