

JSatOrb: Simplified Mission Analysis REST-based Tool Dedicated to Education and Training

Thibault Gateau, Lucien Senaneuch,
Patrice Labedan



2019 May 23

JSatOrb

The screenshot displays the JSatOrb software interface in a browser window. The title bar shows the URL as localhost:4200. The main window is titled "Simulation_1" and is divided into several functional areas:

- File:** Contains buttons for "New", "Open", "Save", and "Quit".
- Display:** Includes a globe icon and a play/pause button.
- Simulation:** Shows the start and current dates as 18/21/2018 14:27:16 and 18/21/2018 16:57:16, respectively. It also features a "Step" control set to 180 and a "PARAM" button.
- Analysis:** Contains buttons for "Ephemeris", "Maneuvers", "RF Links", "Coverage", "Access", and "Attitude".
- Tools:** Includes a "Date Conversion" button and a "TLE Format" button.

The central part of the interface is a world map with a grid overlay, showing the trajectories of three satellites labeled SAT_1, SAT_2, and SAT_3. A ground station location, TOULOUSE-FRANCE, is marked on the map.

At the bottom, there are several panels for data management and display:

- Satellites:** A list containing SAT_1, SAT_2, and SAT_3, with SAT_3 selected.
- Constellations:** An empty panel with "New", "Mod", and "Rem" buttons.
- Ground Stations:** A list containing TOULOUSE-FRANCE, with "New", "Mod", and "Rem" buttons.
- Links:** An empty panel with "New", "Mod", and "Rem" buttons.
- Position/Access:** Displays the current coordinates for the selected satellite: Latitude -12.31°, Longitude -48.15°, and Altitude 8492.99 km. It also shows the current date and time: 18/21/2018 15:20:46. Below this are buttons for "XYZ", "Orb/Ek", and "LLA".

Memories Orekit Day 2017: conclusion on JSatorb Project

ISAE-SUPAERO Software Legacy
JSatorb: a Satorb possible evolution
Ground Segment & Operations
Conclusion & Questions

Nowadays academics requirements

- Open-Source
- Cross-platform
- Standardized



Next steps - Take home Message

- Still cover **teachings** requirements
- Still allow customization for **research**
- Required software suite for a whole nanosatellite project
 - Mission analysis
 - Simulation
 - Operation
- Intercompatibility - Input/Outputs Standardization

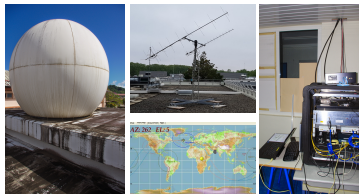
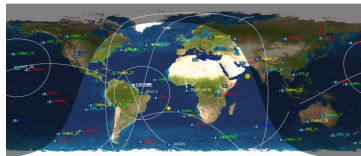
ISAE-SUPAERO: Doing Space Stuff

Research & Support

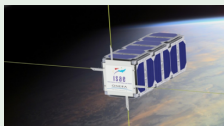
- Engineering Projects
- Research Projects

Facilities

- UHF/VHF antenna/station
- S-Band antenna/station
- Control Center
- Clean Rooms ...



Examples of 3U Nanosats projects on the way



- Entrysat
- Phase D
- Currently in the ISS

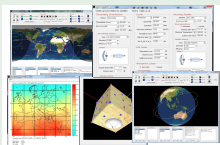


- Eyesat
- Phase D



- Nymph
- Phase C

Examples of software developments



- Satorb
Mission Analysis
> Used for teaching purpose

- SCC
Simple
Control
Center
Operations Management

- NSS
Nanostar
Software
Suite
Full Mission Pre-design

Nanostar SUDOE Project: <http://nanostarproject.eu>

NANOSTAR Consortium

- 7 Partners (Portugal, Spain, France)
- 2 aerospace clusters
- 2018-2020, 2 millions € budget



Nanostar SUDOE Project: <http://nanostarproject.eu>

NANOSTAR Goal

- Provide relevant training on nanosat technology
- To provide a formation tool for students... and also engineers
- To support the emergence of nanosat environment



uc3m

Universidad Carlos III de Madrid



POLITÉCNICA



TÉCNICO LISBOA

isae SUPAERO



UNIVERSIDADE BEIRA INTERIOR



Bordeaux INP AQUITAINE

Nanostar SUDOE Project: <http://nanostarproject.eu>

NANOSTAR work plan

- Setup a **collaborative platform**, with adapted software tools
- Setup geographically distant **Concurrent Design Facilities**
- Propose **student challenges** relevant for nanosats missions



CDF: Concurrent Design Facility



CDF: Concurrent Design Facility



Mission Analysis

- GMAT
- Orekit
- Poliastro
- Celestlab
- *Satorb*
- RTK
- SimuCIC

Mission Analysis

- GMAT
- Orekit
- Poliastro
- Celestlab
- *Satorb*
- RTK
- SimuCIC

ADCS

- Simulink
- Basile

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mass Budget

- **Excel**
- **IDM-CIC**

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mass Budget

- **Excel**
- **IDM-CIC**

LOS

- **Stella**

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mass Budget

- **Excel**
- **IDM-CIC**

LOS

- **Stella**

Radiation

- **Fastrad**

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mass Budget

- **Excel**
- **IDM-CIC**

LOS

- **Stella**

Radiation

- **Fastrad**

Link Budget

- **AmsatXLS**
- *Satorb*
- **Propa**

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mass Budget

- **Excel**
- **IDM-CIC**

LOS

- **Stella**

Radiation

- **Fastrad**

Link Budget

- **AmsatXLS**
- *Satorb*
- **Propa**

Dissipation Budget

- **Thermica**
- **Esatan**

Mission Analysis

- **GMAT**
- **Orekit**
- **Poliastro**
- **Celestlab**
- *Satorb*
- **RTK**
- **SimuCIC**

ADCS

- **Simulink**
- **Basile**

Structure

- **Catia**
- **Sketchup**
- **Blender**

Mass Budget

- **Excel**
- **IDM-CIC**

LOS

- **Stella**

Radiation

- **Fastrad**

Link Budget

- **AmsatXLS**
- *Satorb*
- **Propa**

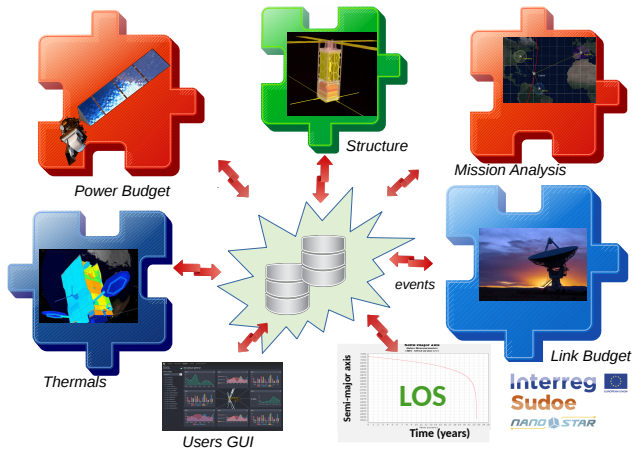
Dissipation Budget

- **Thermica**
- **Esatan**

Visualisation

- **Celestia**
- **VTS**
- **IDM view**

Nanostar Software Suite (One soft suite to bind them all)



Mission Analysis Module: JSatorb interface

The screenshot displays the JSatorb Mission Analysis Module interface. At the top, there are several control panels: **Project** (New, Open, Save, Quit), **Display** (Planisphere, From satellite, From space, From station, Display settings), **Simulation** (Start: 10/05/2017 00:00:00, Step: 60 s, Current date: 10/05/2017 04:58:09), **Analysis** (Ephemeris, Access, Maneuvers, RF links, Coverage, Attitude), and **Tools** (Date conversion, TLE format, About).

The central part of the interface is a 3D globe showing the Earth with various satellite constellations and ground stations. Labels on the map include CONG_1_1, CONG_1_2, CONG_1_3, CONG_1_4, CONG_1_5, CONG_1_6, CONG_1_7, CONG_1_8, CONG_1_9, CONG_1_10, HOHOLU, HI, SAT_1, and DARWIN.

At the bottom, there are five data panels: **Satellites** (listing CONG_1_1 through CONG_1_10), **Constellations** (listing CONG_1), **Ground stations** (listing TOULOUSE, DARWIN, HOHOLU, HI), **Links** (listing LINK_1 UL, LINK_2 UL), and **Position/Access** (showing orbital parameters: S-Major Axis 6978.1 km, Eccentricity 0.000, Inclination 66.0°, Arg Perigee 0.0°, RAAN 288.0°, Mean Anomaly 354.1°, and 0 visible satellite(s)).

Mission Analysis Module: JSatorb interface

Related works

- STAVOR (mobile)
<https://www.orekit.org/stavor/>
- Dromobil (HTML5, CSS, WebGL, js)
www.hayabusa.isas.jaxa.jp/kawalab/dromobile/
- Cesium
<https://cesiumjs.org/>
- Orbitalpredictor (Cesium)
<http://www.orbitalpredictor.com/>

Mission Analysis Module: JSatorb interface

Related works

- STAVOR (mobile)
<https://www.orekit.org/stavor/>
- Dromobil (HTML5, CSS, WebGL, js)
www.hayabusa.isas.jaxa.jp/kawalab/dromobile/
- Cesium
<https://cesiumjs.org/>
- Orbitalpredictor (Cesium)
<http://www.orbitalpredictor.com/>

YAVISO-Yet Another Visualization Interface for Spacecrafts Orbits

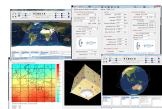
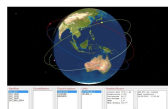
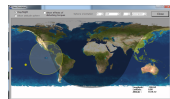
- 1 ISAE-SUPAERO Software Legacy
 - Satorb
 - Current Statement
- 2 JSatorb: short evolution story
 - JSatorb: Increasing Modularity
 - Full Java Solution
 - JSatorb: Service Oriented Architecture
- 3 Conclusion & Questions

- 1 ISAE-SUPAERO Software Legacy
 - Satorb
 - Current Statement
- 2 JSatorb: short evolution story
- 3 Conclusion & Questions

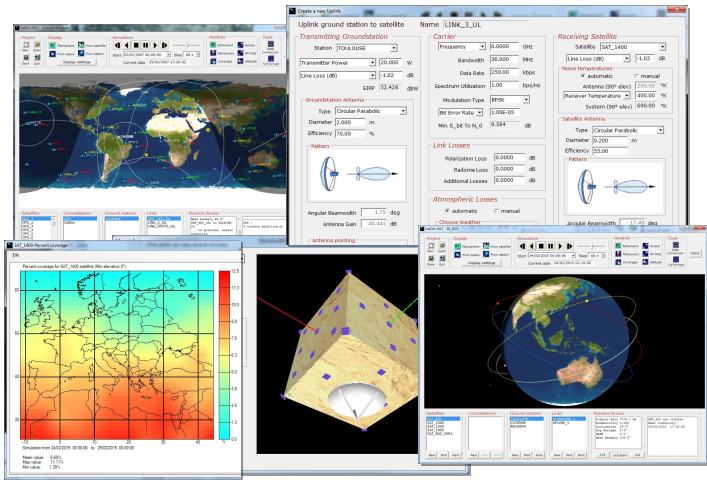
ISAE-SUPAERO Space Software Suite

People involved

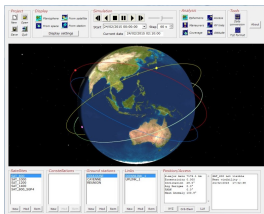
- Initiator (before 2001!):
 - Christian Colongo
- Current Dev Team:
 - Patrice Labedan
 - └ Guillaume Garrouste
 - └ Thibault Gateau
- Lot of support from:
 - Students Projects
 - Internships
 - PhD students
 - Collaborations (TUM)



Satorb



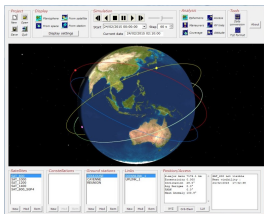
Satorb & Friends



Features: creating objects and links

- Satellites;
- Some satellites specs;
- Constellations;
- Ground stations;
- Upward, downward links;
- Inter-satellite links;

Satorb & Friends



Features: Obtaining reports

- Ground trace;
- 3D Orbital position;
- Evolution of the created elements;
- Coverage maps;
- Link budgets.

Kerbal Space Program before Kerbal Space Program...



ISAE-SUPAERO Software Legacy

Pros: Homemade

- Fit exactly to ISAE-SUPAERO needs
- Adapt what we want
- No intellectual property issue
- Short dev cycles

Cons: Homemade

- Not open-source, no community behind
- Costful for internal developers
- Not cross platform
- Validation by hand

- 1 ISAE-SUPAERO Software Legacy
- 2 JSatorb: short evolution story
 - JSatorb: Increasing Modularity
 - Full Java Solution
 - JSatorb: Service Oriented Architecture
- 3 Conclusion & Questions

Satorb: VBnet Heavy Client (evol. from vb6)

The image displays five screenshots from the JSatorb software interface:

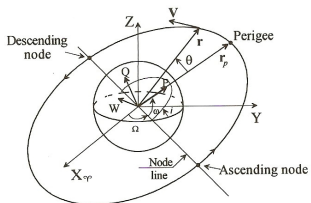
- Top-left:** A world map showing satellite coverage footprints and ground station locations.
- Top-center:** A configuration window titled "Create a new Uplink" for "LINK_3_UL". It includes sections for "Transmitting Groundstation" (Station: TDULOUSE, Transmitter Power: 20.000 W, Line Loss: -1.02 dB, EIRP: 52.428 dBW), "Groundstation Antenna" (Type: Circular Parabolic, Diameter: 2.000 m, Efficiency: 70.00%), "Carrier" (Frequency: 6.0000 GHz, Bandwidth: 26.000 MHz, Data Rate: 250.000 kbps, Modulation Type: BPSK, Bit Error Rate: 1.00E-03, Min. E_bit to H_0: 9.584 dB), "Link Losses" (Polarization Loss: 0.0000 dB, Radome Loss: 0.0000 dB, Additional Losses: 0.0000 dB), "Atmospheric Losses" (Automatic), and "Antenna pointing" (Angular Beamwidth: 1.75 deg, Antenna Gain: 40.443 dB).
- Top-right:** A configuration window for "Receiving Satellite" (SAT_1400). It includes "Carrier" (Frequency: 6.0000 GHz, Bandwidth: 26.000 MHz, Data Rate: 250.000 kbps, Modulation Type: BPSK, Bit Error Rate: 1.00E-03, Min. E_bit to H_0: 9.584 dB), "Receiving Satellite" (Satellite: SAT_1400, Line Loss (dB): -1.02 dB, Noise temperatures: Antenna (90° elev): 290.00 °K, Receiver Temperature: 400.00 °K, System (90° elev): 690.00 °K), and "Satellite Antenna" (Type: Circular Parabolic, Diameter: 0.200 m, Efficiency: 55.00%).
- Bottom-left:** A heatmap titled "SAT_1400 Percent coverage" showing coverage percentages over Europe. The color scale ranges from 0.0 (blue) to 2.0 (red). Statistics: Mean value: 0.95%, Max value: 11.11%, Min value: 0.36%.
- Bottom-center:** A 3D model of a satellite antenna pointing towards Earth.
- Bottom-right:** A 3D model of Earth showing satellite orbits and ground stations.

Create the germ of JSatOrb, a version of SatOrb in Java

Student-focused
learning tool

Professional software
for researchers

Implement a clear division in the coding



Calculations

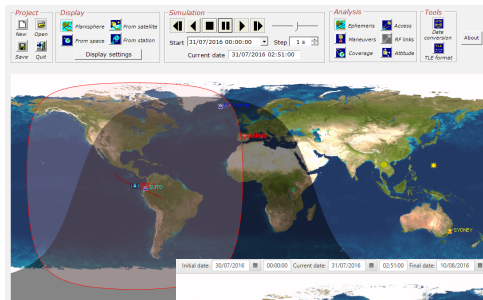


User interface

Choosing an Astrodynamics Library

Feature type	Software	SatOrb	OreKit	JAT	TUDAT	CelestLab
	Features					
Visualization	Terminal	✓	✓	✓	✓	✓
	2D (planisphere)	✓	-	✓	-	✓
	3D (Earth)	✓	-	✓	-	-
Ephemeris	Position/Velocity	✓	✓	✓	✓	✓
	Keplerian Parameters	✓	✓	✓	✓	✓
	Eclipses	✓	✓	✓	✓	✓
Manoeuvres	Impulse	✓	✓	✓	✓	✓
	Continuous	-	✓	✓	✓	✓
Time	UTC	✓	✓	✓	✓	✓
	TAI	-	✓	✓	✓	✓
	Julian	✓	✓	✓	✓	✓
	NORAD	✓	-	-	-	-
Propagators	Kepler	✓	✓	✓	✓	✓
	Brouwer	✓	-	-	-	-
	Mosaif	✓	-	-	-	-
	SGP4/SDP4	✓	✓	✓	-	-
	Central	-	✓	✓	-	✓
	Lyddane	-	-	-	-	✓
	Eckstein-Hescher	-	✓	✓	-	✓
	Cohessey Wiltshire	-	-	✓	✓	✓
Others	TLE Format	✓	✓	✓	✓	✓
	Coverage	✓	✓	✓	-	✓
	Constellations	✓	-	-	-	-
	Ground stations	✓	✓	✓	✓	✓
	Links	✓	-	-	-	-
	Language	VisualBasic	Java	Java	C++	Scilab

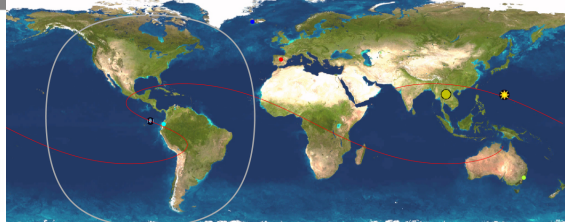
JSatorb: JavaFX UI (Julio Hernandez Gonzalez)



From Satorb...

Microsoft
VB.net

... To
JSatorb



Satellites

- CONTS_1_2
- CONTS_1_8
- CONTS_1_10

Constellations

- CONTS_1

Ground stations

- TOULOUSE
- DARWIN
- HONOLULU

Links

- LINK_1_UL
- LINK_2_UL

Position/Access

- S-major Axis 6978.1 km
- Eccentricity 0.000
- Inclination 65.0°
- Arg Perigee 0.0°
- RAAN 289.0°
- Mean Anomaly 354.1°

CONTS_1 :
0 visible satellite(s)

Feedback

Some objective reached...

- Increase modularity
- Cross Platform

Feedback

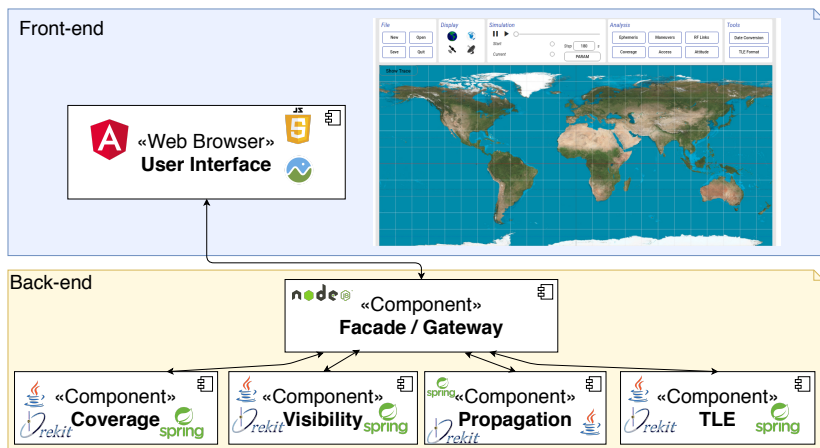
Some objective reached...

- Increase modularity
- Cross Platform

But...

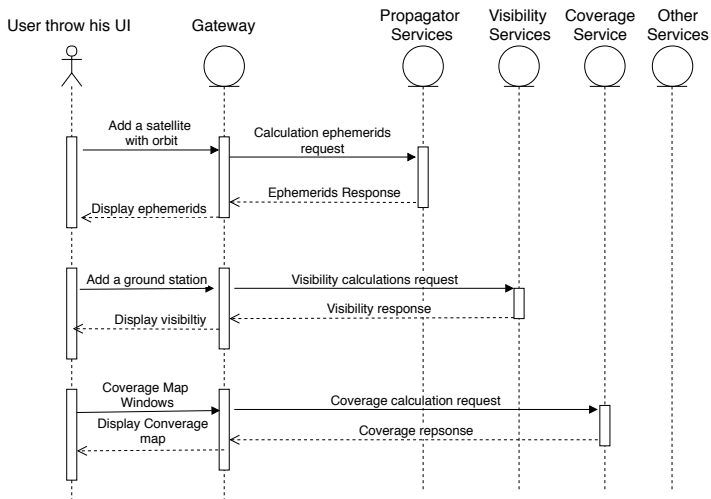
- Still a heavy client
- UI and domain specific code still dependent
- Standardized?

JSatorb: Service Oriented Architecture



Text

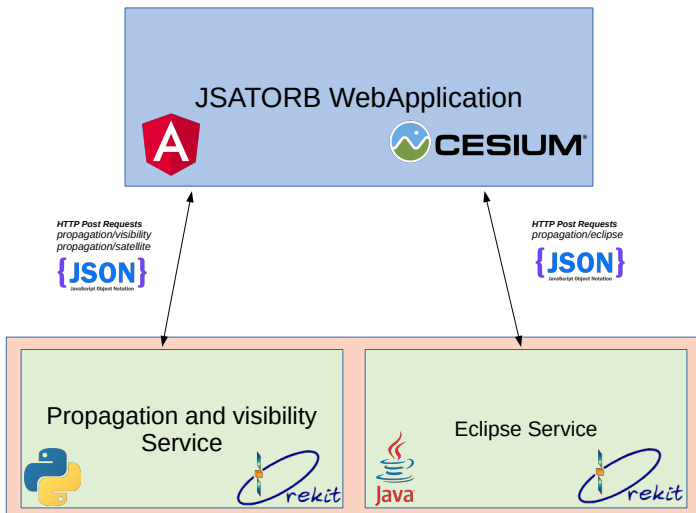
JSatorb: Typical Use Case Scenario



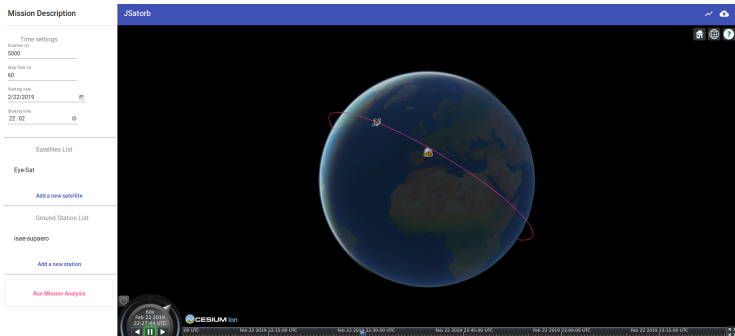
JSatorb: Angular UI (Theo Koudlanski)

The screenshot displays the JSatorb web application interface. At the top, a browser address bar shows 'localhost:4200' and a search bar contains 'Lima'. The application header 'JSatorb' is centered. Below the header, there are four main panels: 'File' (New, Open, Save, Out), 'Display' (Earth view icons), 'Simulation' (play, stop, and speed controls), and 'Analysis' (Ephemeris, Maneuvers, RF Links, Coverage, Access, Attitude). A 'Tools' panel on the right includes 'Date Conversion' and 'TLE Format'. The central area is a world map with a grid, showing satellite tracks. A red dot marks 'Lima' in South America, and another red dot marks 'Malaga' in Europe. A satellite icon labeled 'SAT_1' is visible in the Pacific Ocean. A dialog box titled 'Ephemeris tool for SAT_1 satellite' is open, featuring a 'Type Of Ephemeris' section with radio buttons for 'Position / Velocity Ep', 'Keplerian Ephemeris', 'Long. Lat. Alt Ephemeris', and 'Eclipse Times'. The 'Period Analyzed' section includes 'Start' (29/05/2018 00:00:00), 'End' (30/05/2018 00:00:00), and 'Interval (min)'. At the bottom of the dialog are 'Report', 'Graph', and 'Cancel' buttons. The bottom of the application shows a 'Satellites' table with 'SAT_1' listed, and other panels for 'Constellations', 'Ground Stations', and 'Access'.

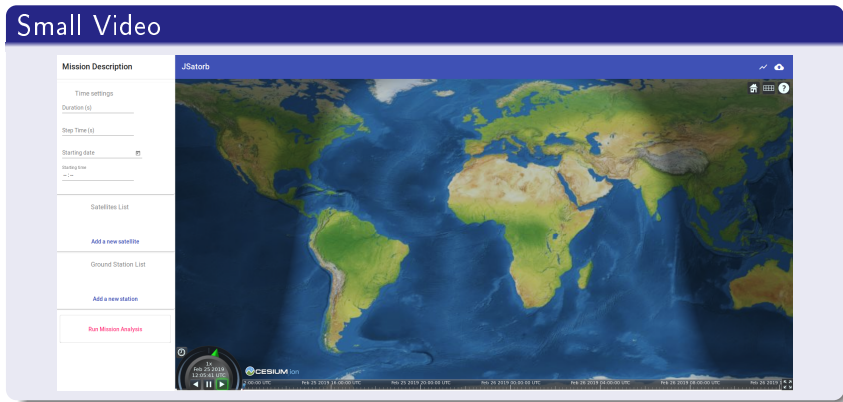
JSatorb: Cesium JS and RESTfull API (Lucien Senaneuch)



JSatorb: Cesium JS and RESTfull API (Lucien Senaneuch)



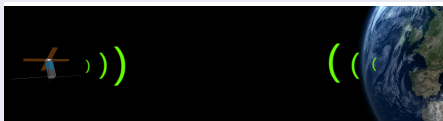
JSatorb: Demo (Lucien Senaneuch)



- 1 ISAE-SUPAERO Software Legacy
- 2 JSatorb: short evolution story
- 3 Conclusion & Questions

Nowadays academics requirements

- Open-Source
- Cross-platform
- Standardized



Take home Message

- Still cover **teachings** requirements
- Still allow customization for **research**
- Intercompatibility - Input/Outputs Standardization
- Open-Source under AGPL licence
(<https://sourceforge.isae.fr/projects/jsatorb/repository>)

Thank you for your attention !

Any question ?

