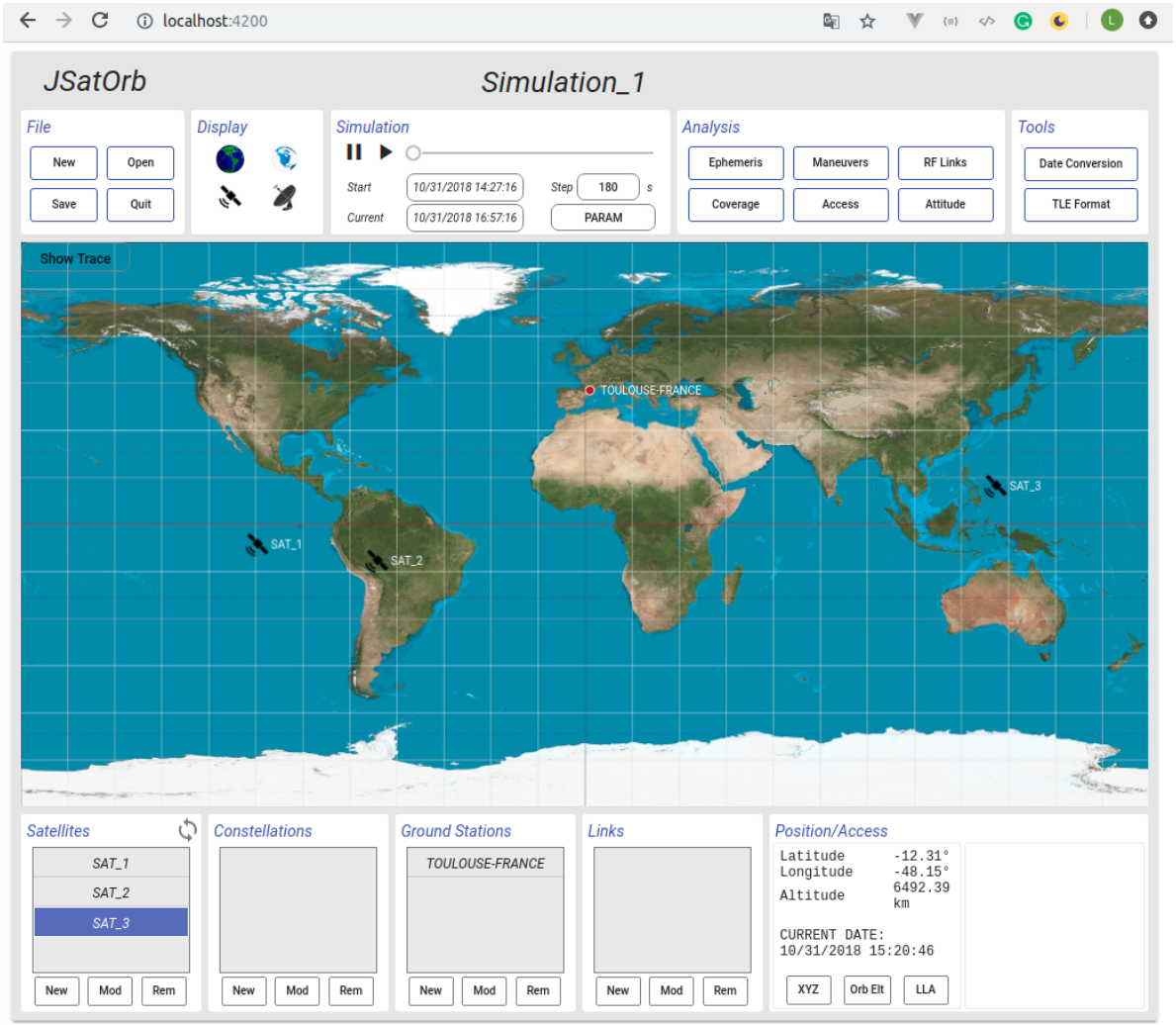
JSatOrb: Simplified Mission Analysis REST-based Tool Dedicated to Education and Training

Thibault Gateau, Lucien Senaneuch, Patrice Labedan

2019 May 23

JSatOrb


localhost:4200
JSatOrb
Simulation_1
File
New
Open
Save
Quit
Display
Simulation
Start
10/31/2018 14:27:16
Step
180
s
Current
10/31/2018 16:57:16
PARAM
Analysis
Ephemeris
Maneuvers
RF Links
Coverage
Access
Attitude
Tools
Date Conversion
TLE Format
Show Trace
TOULOUSE-FRANCE
SAT_1
SAT_2
SAT_3
Satellites
SAT_1
SAT_2
SAT_3
New
Mod
Rem
Constellations
Ground Stations
TOULOUSE-FRANCE
Links
Position/Access
Latitude -12.31°
Longitude -48.15°
Altitude 6492.39 km
CURRENT DATE:
10/31/2018 15:20:46
XYZ
Orb Elt
LLA

Memories Orekit Day 2017: conclusion on JSatorb Project

Nowadays academics requirements

- Open-Source
- Cross-platform
- Standardized

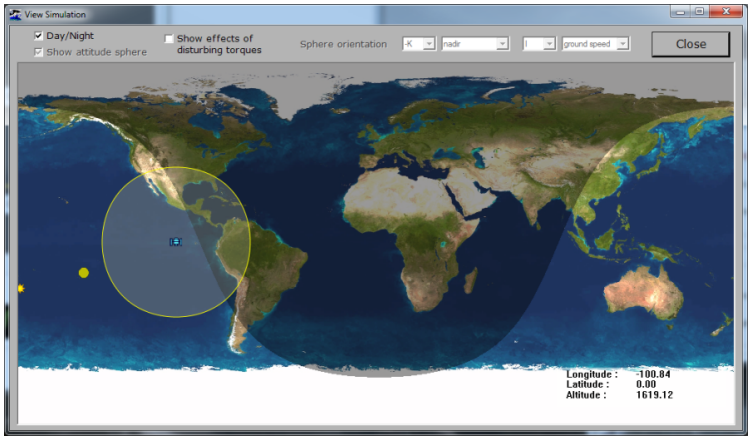
Next steps - Take home Message

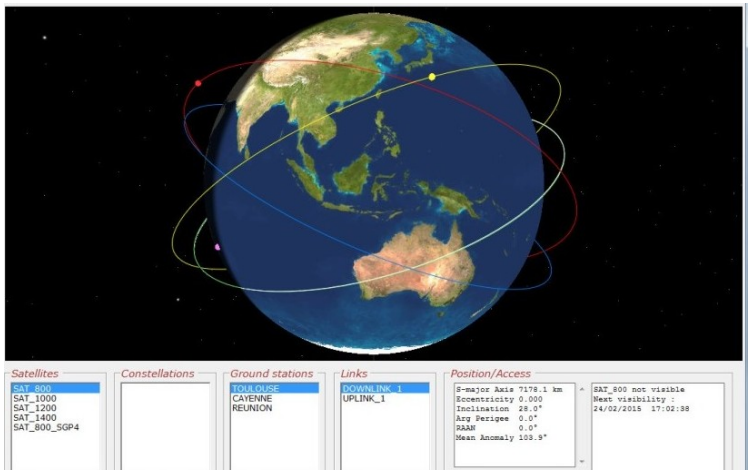
- Still cover **teachings** requirements
- Still allow customization for **research**
- Required software suite for a whole nanosatellite project
  - Mission analysis
  - Simulation
  - Operation
- Intercompatibility - Input/Outputs Standardization

ISAE-SUPAERO: Teaching Space Stuff

Teaching support

- Space Mechanics
- Mission Analysis
- Thermal Architecture
- Space Telecom
- Power system
- ADCS
- Launchers
- Project Management
- ...





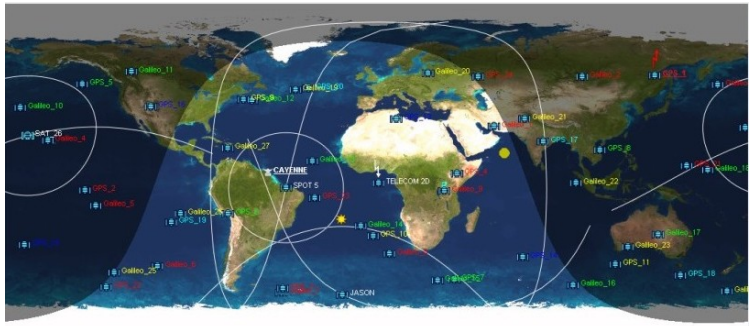
ISAE-SUPAERO: Doing Space Stuff

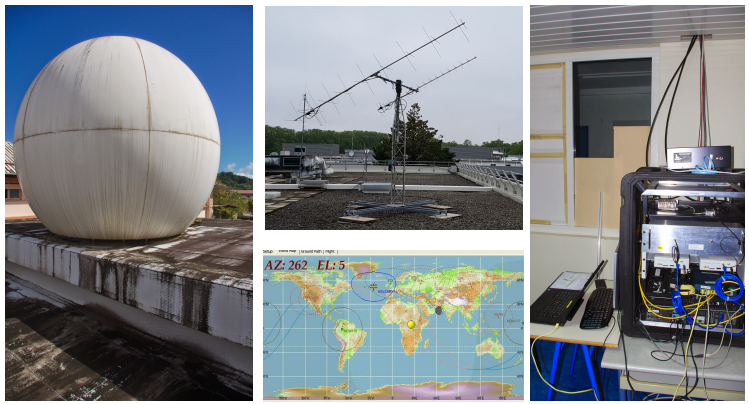
Research & Support

- Engineering Projects
- Research Projects

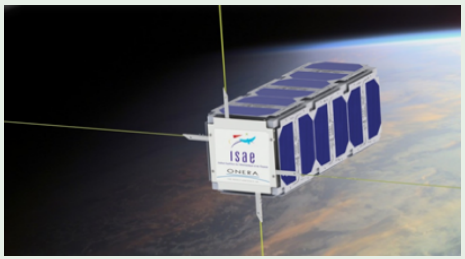
Facilities

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

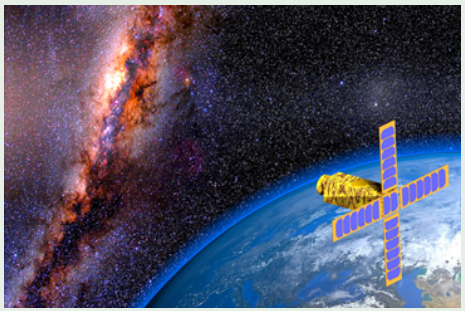




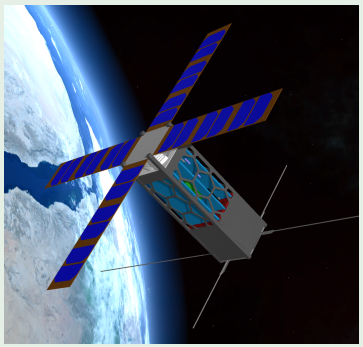
Examples of 3U Nanosats projects on the way



- Entrysat
- Phase D
- Currently in the ISS

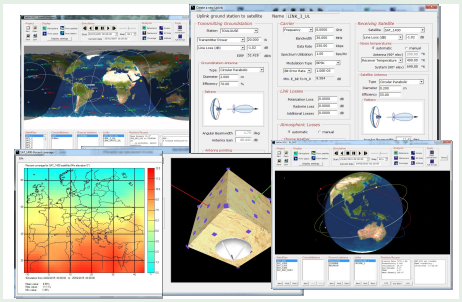


- Eyesat
- Phase D



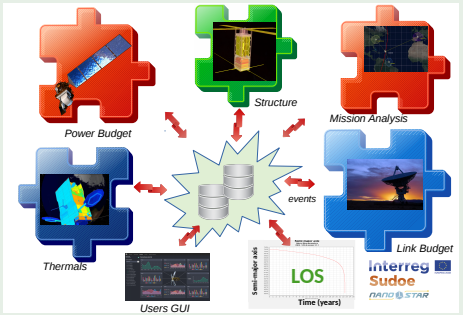
- Nimph
- Phase C

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

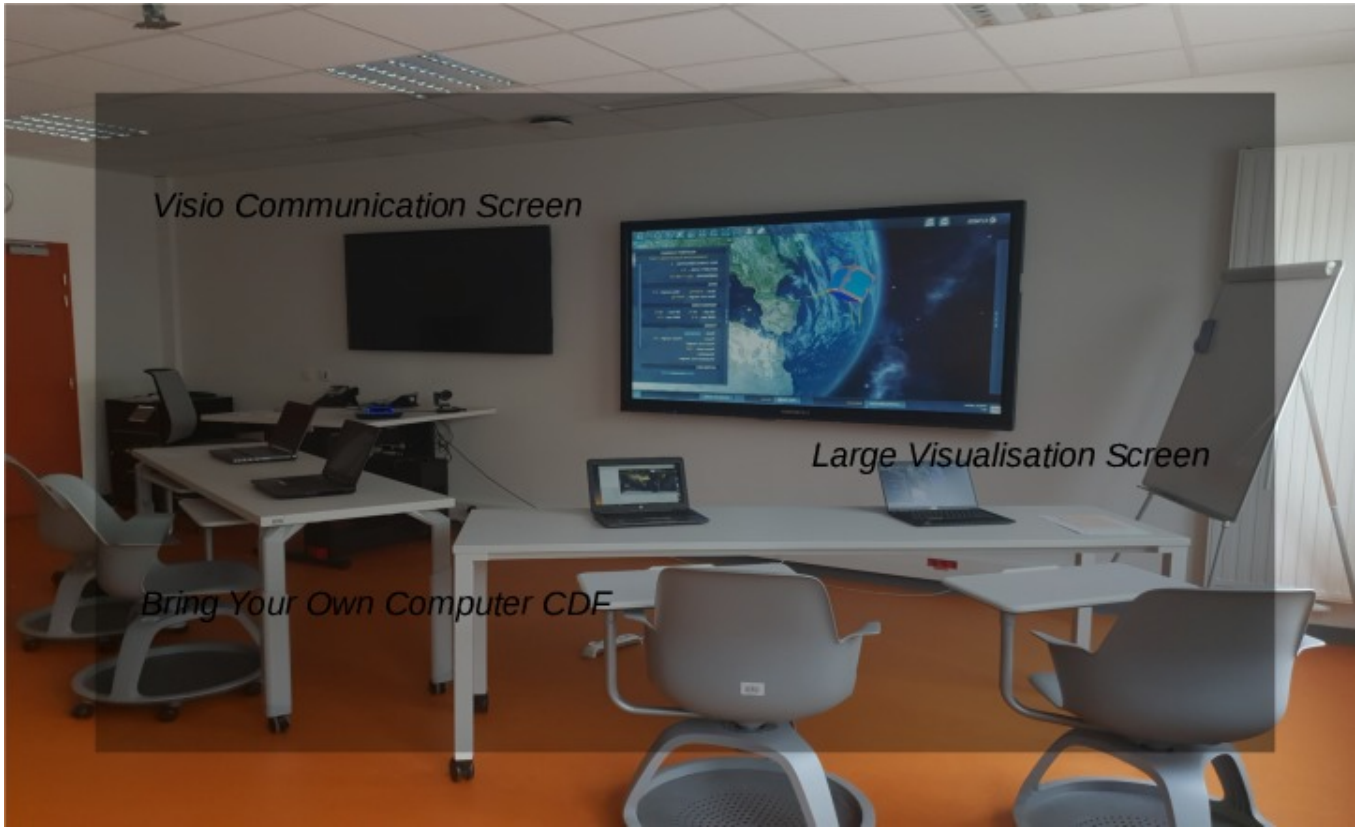
Nanostar SUDOE Project: http://nanostarproject.eu

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

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ADCS

- Simulink
- Basile

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Structure

- Catia
- Sketchup
- **Blender**

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LOS

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Radiation

- Fastrad

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Link Budget

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- *Satorb*
- Propa

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Dissipation Budget

- Thermica
- Esatan

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Dissipation Budget

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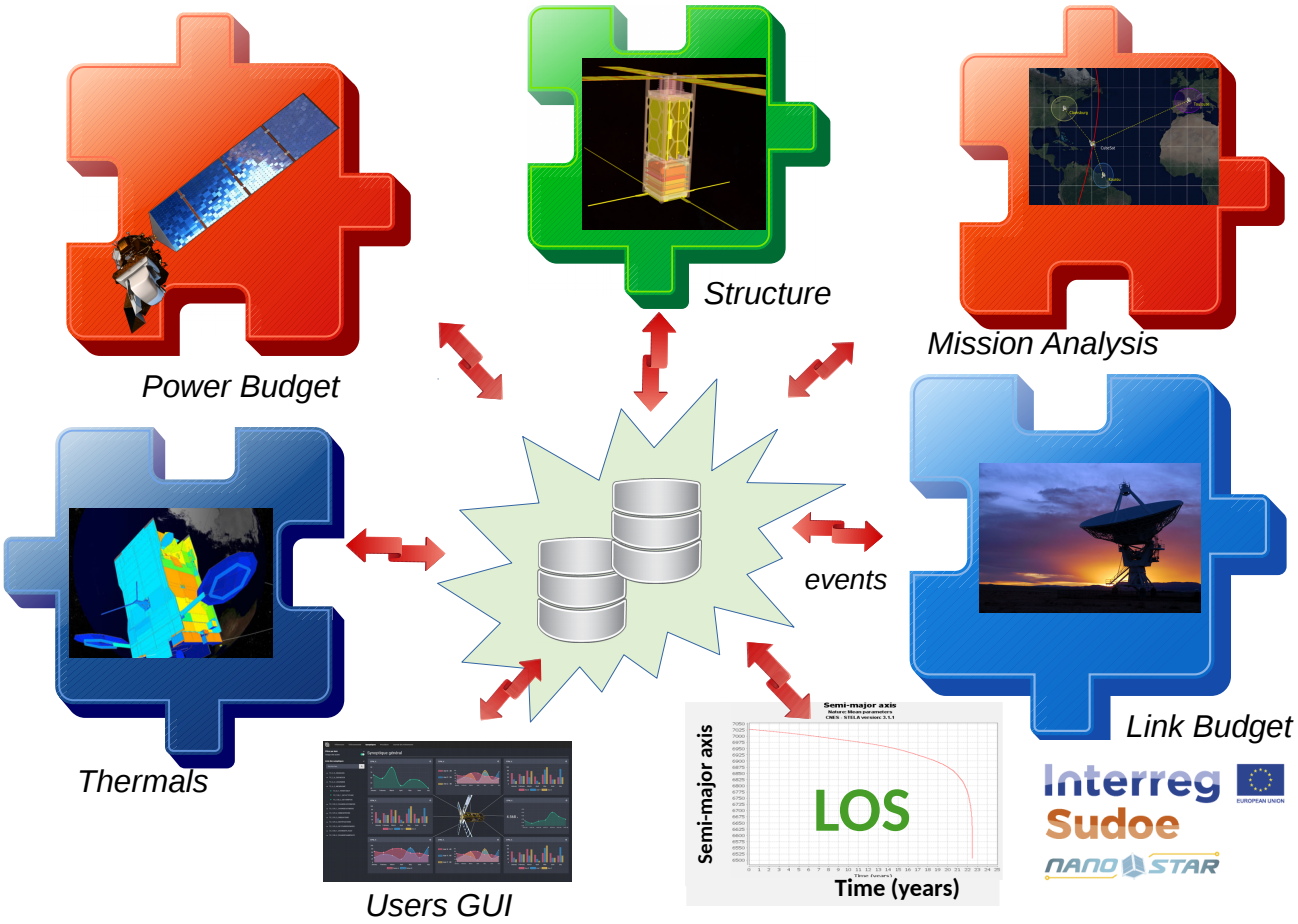
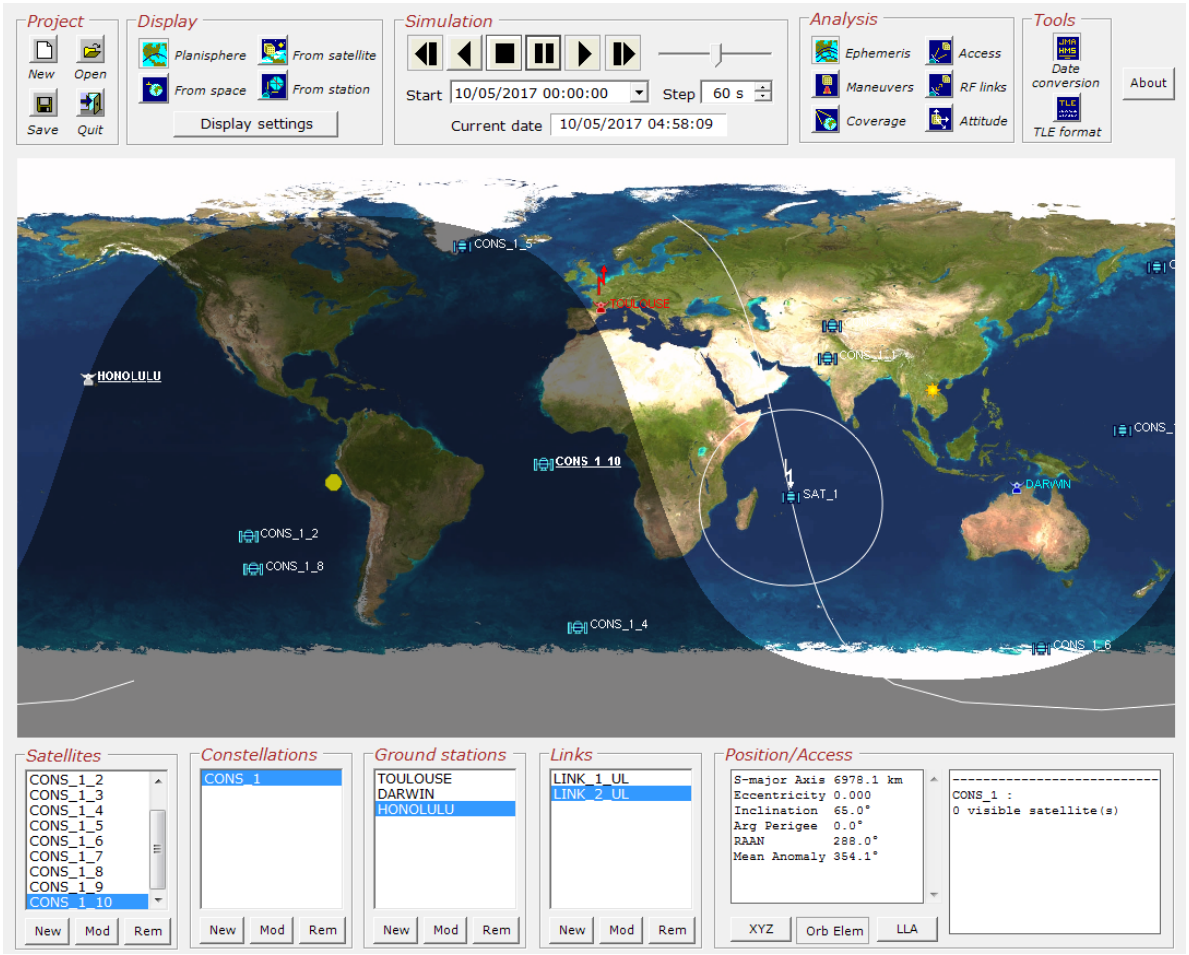
Visualisation

- Celestia
- VTS
- IDM view

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



Mission Analysis Module: JSatorb interface



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

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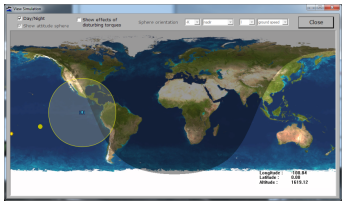
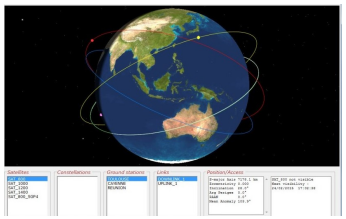
YAVISO-Yet Another Visualization Interface for Spacecrafts Orbits

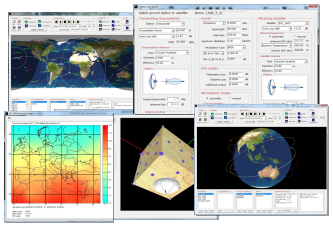
ISAE-SUPAERO Space Software Suite

People involved

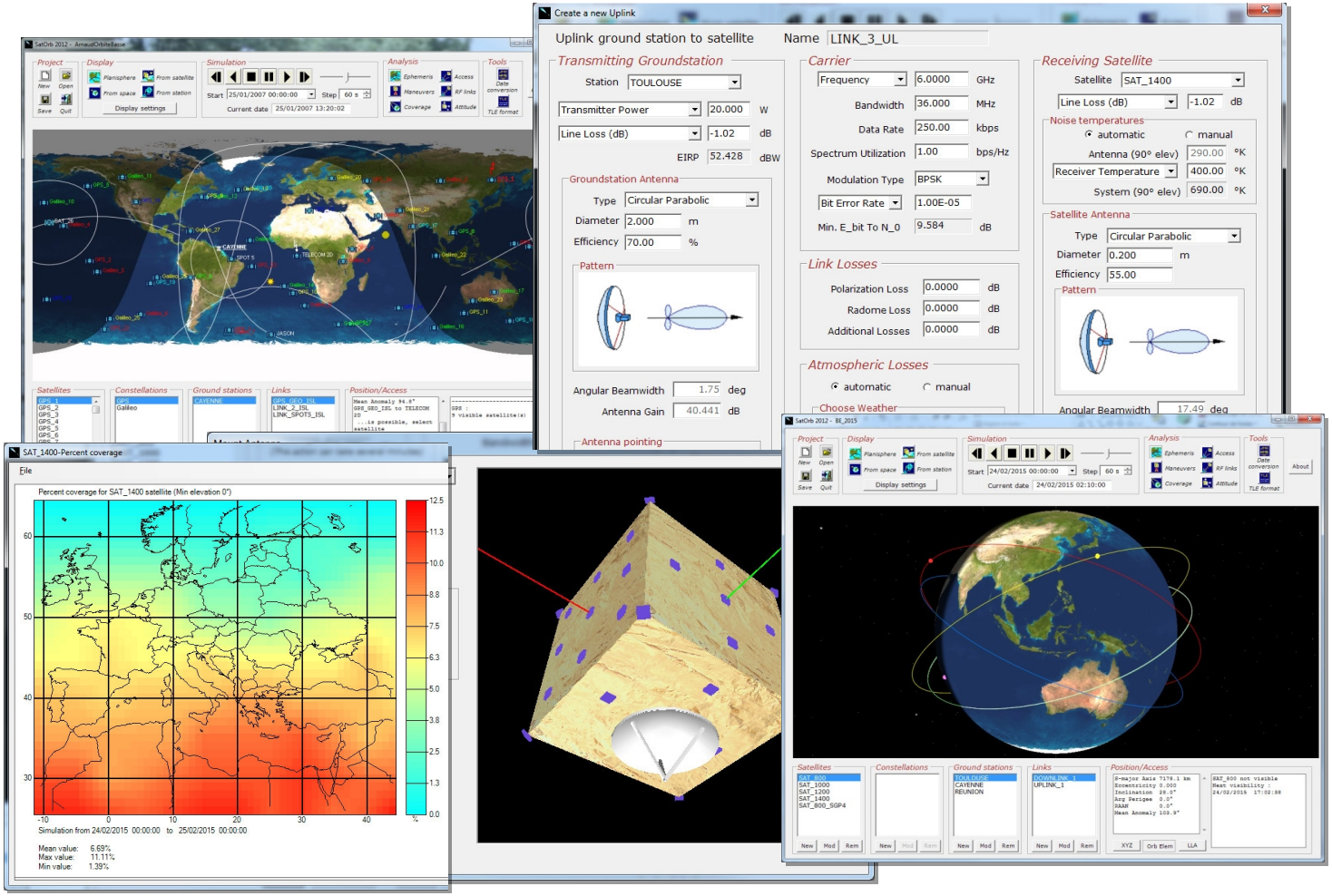
- Initiator (before 2001!):
  - Christian Colongo
- Current Dev Team:
  - Patrice Labedan
    - Guillaume Garrouste
    - Thibault Gateau
- Lot of support from:
  - Students Projects
  - Internships
  - PhD students
  - Collaborations (TUM)



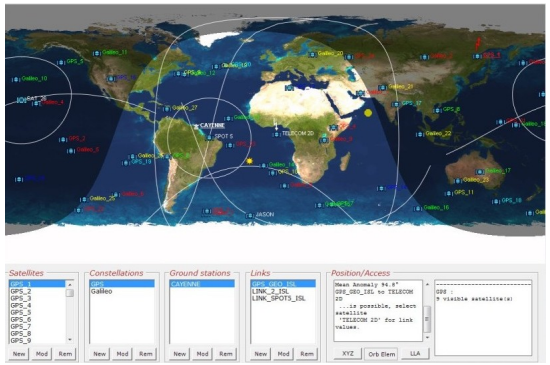


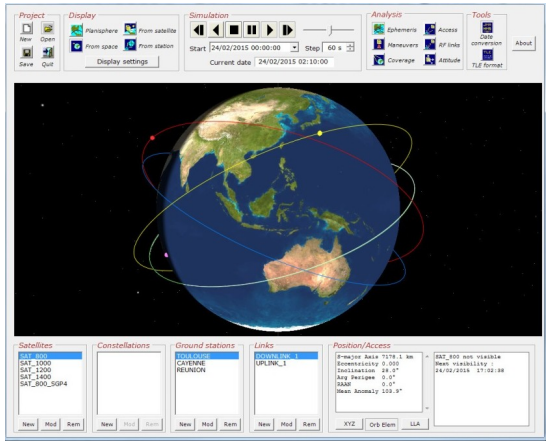


Satorb


Create a new Uplink
Uplink ground station to satellite
Name LINK_3_UL
Transmitting Groundstation
Station TOULOUSE
Transmitter Power 20.000 W
Line Loss (dB) -1.02 dB
EIRP 52.428 dBW
Groundstation Antenna
Type Circular Parabolic
Diameter 2.000 m
Efficiency 70.00 %
Pattern
Angular Beamwidth 1.75 deg
Antenna Gain 40.441 dB
Antenna pointing
Carrier
Frequency 6.0000 GHz
Bandwidth 36.000 MHz
Data Rate 250.00 kbps
Spectrum Utilization 1.00 bps/Hz
Modulation Type BPSK
Bit Error Rate 1.00E-05
Min. E_bit To N_0 9.584 dB
Link Losses
Polarization Loss 0.0000 dB
Radome Loss 0.0000 dB
Additional Losses 0.0000 dB
Atmospheric Losses
automatic
manual
Choose Weather
Receiving Satellite
Satellite SAT_1400
Line Loss (dB) -1.02 dB
Noise temperatures
automatic
manual
Antenna (90° elev) 290.00 °K
Receiver Temperature 400.00 °K
System (90° elev) 690.00 °K
Satellite Antenna
Type Circular Parabolic
Diameter 0.200 m
Efficiency 55.00
Pattern
Angular Beamwidth 17.49 deg
SAT_1400-Percent coverage
File
Percent coverage for SAT_1400 satellite (Min elevation 0°)
Simulation from 24/02/2015 00:00:00 to 25/02/2015 00:00:00
Mean value: 6.69%
Max value: 11.11%
Min value: 1.39%

Satorb & Friends

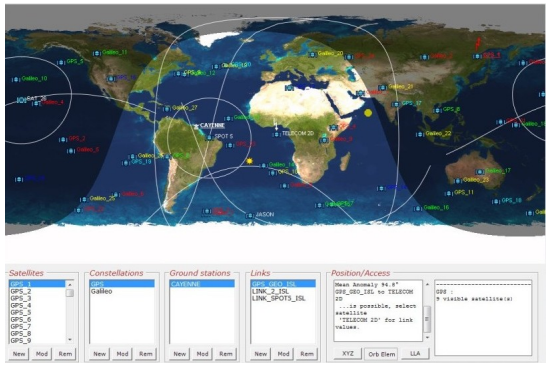


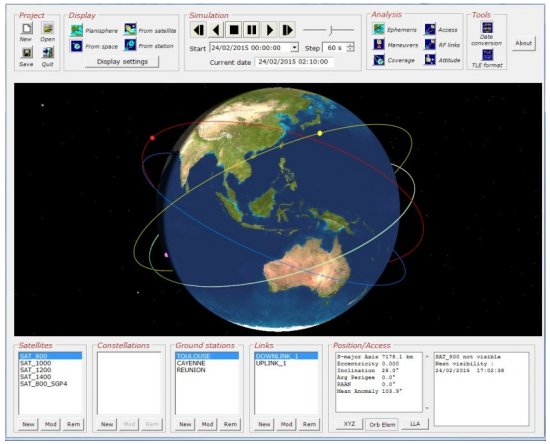


Features: creating objects and links

- 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

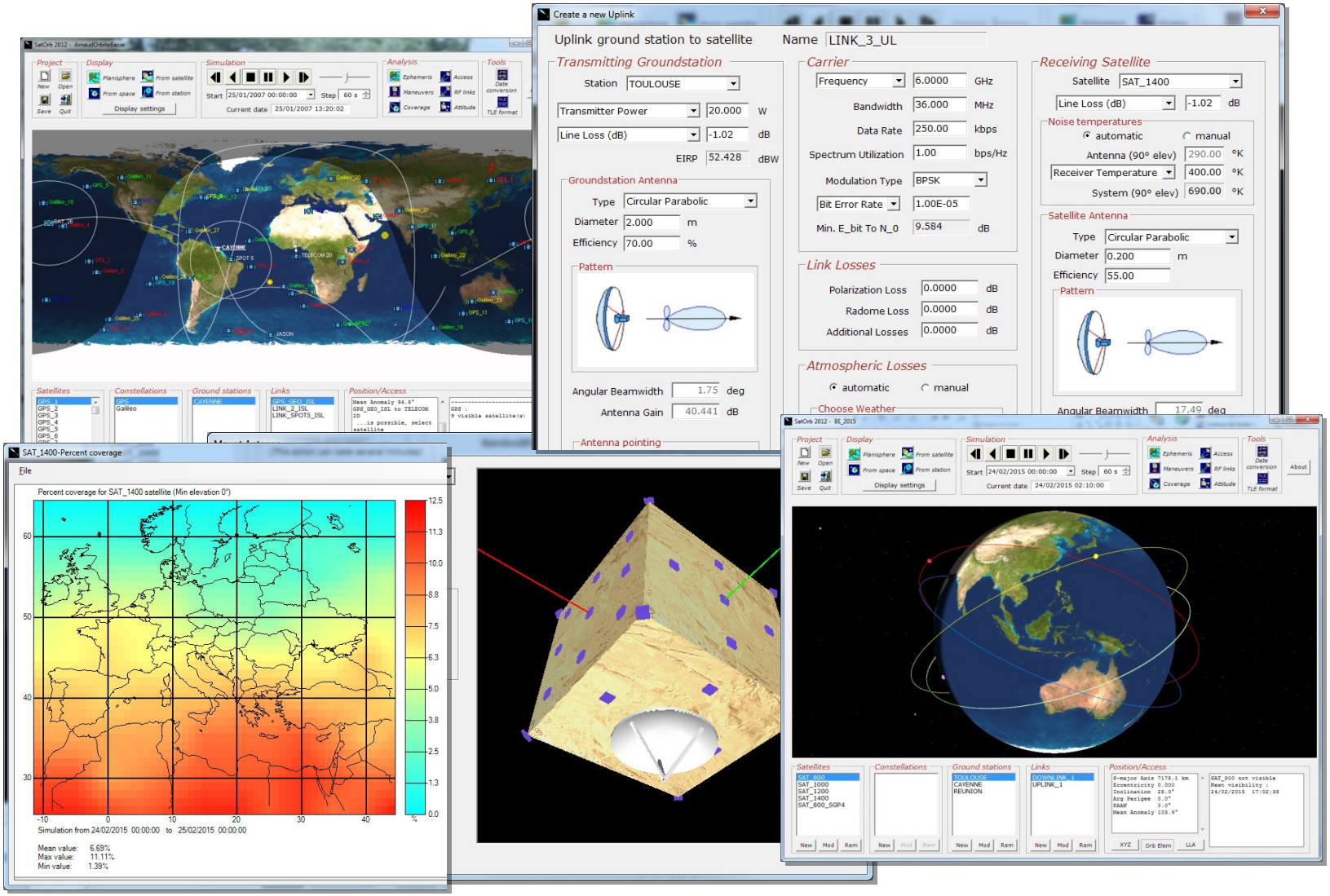
Pros: Homemade

- 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 developpers
- Not cross platform
- Validation by hand

Satorb: VBnet Heavy Client (evol. from vb6)

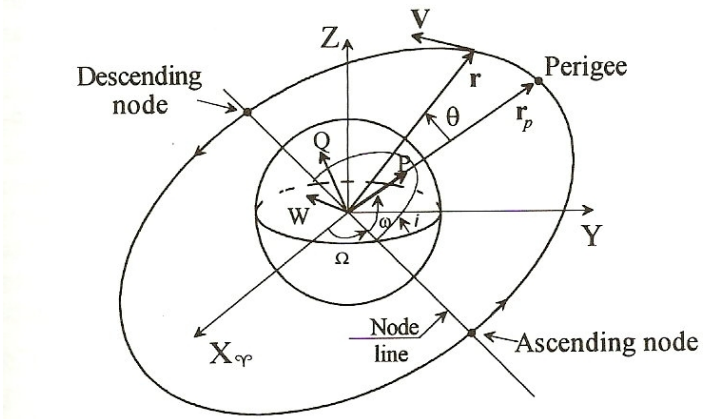


Create the germ of JSatOrb, a version of SatOrb in Java

Student-focused learning tool

Professional software for researchers

Implement a clear division in the coding



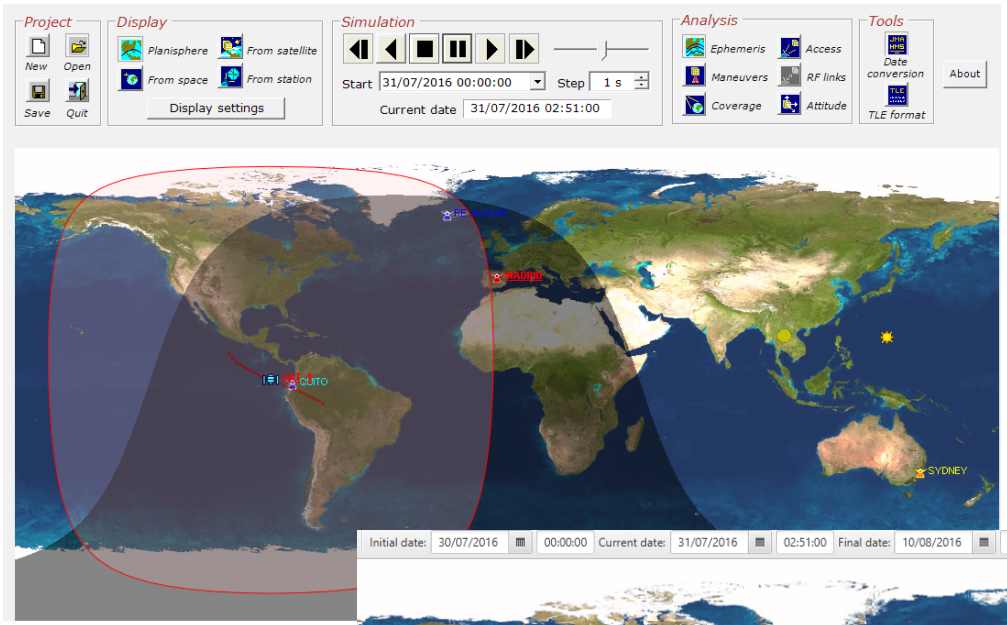
Calculations

User interface

Choosing an Astrodynamics Library

Feature type	Software / Features	SatOrb	OreKit	JAT	TUDAT	CelestLab
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	-	✓	✓	-	✓
	Cohessy Wiltshire	-	-	✓	✓	✓
Others	TLE Format	✓	✓	✓	✓	✓
	Coverage	✓	✓	✓	-	✓
	Constellations	✓	-	-	-	-
	Ground stations	✓	✓	✓	✓	✓
	Links	✓	-	-	-	-
	Language	VisualBasic	Java	Java	C++	Scilab

JSatorb: JavaFX UI (Julio Hernanz Gonzalez)



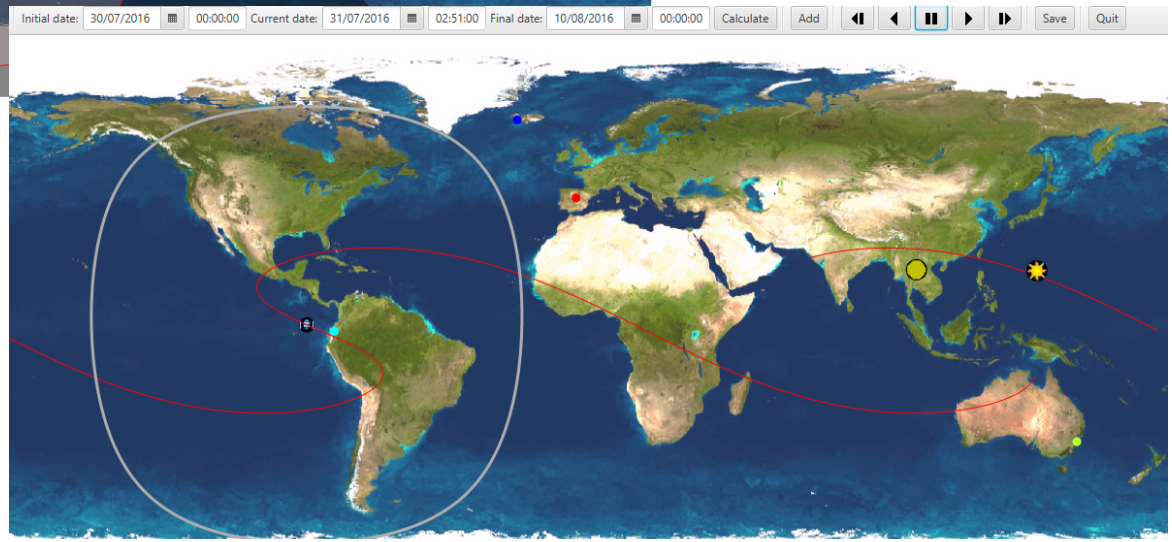
From Satorb...

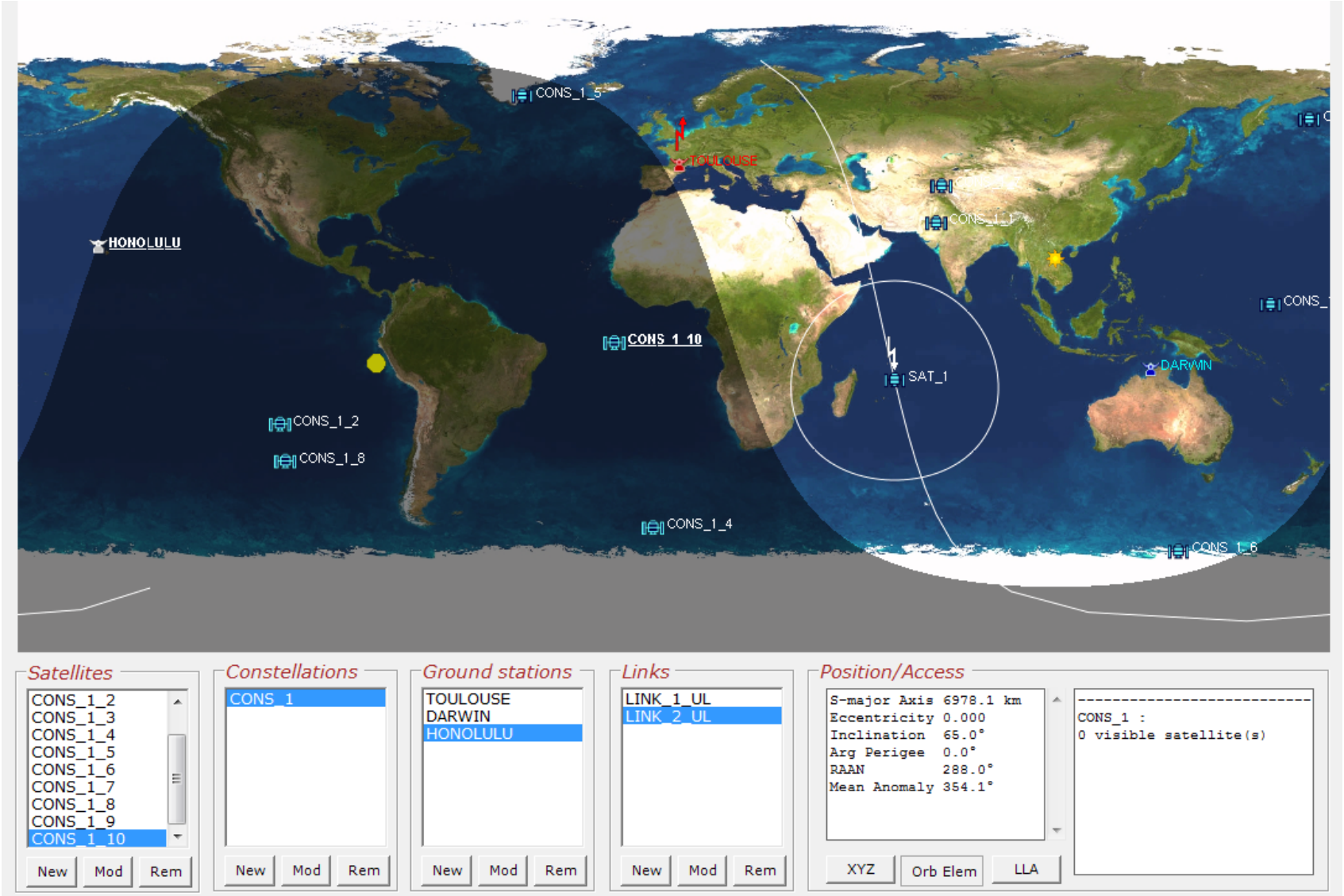
Microsoft VB.net

... To JSatorb

Orekit

Java




CONS_1_5
TOULOUSE
HONOLULU
CONS_1_10
SAT_1
DARWIN
CONS_1_2
CONS_1_8
CONS_1_4
CONS_1_6
Satellites
CONS_1_2
CONS_1_3
CONS_1_4
CONS_1_5
CONS_1_6
CONS_1_7
CONS_1_8
CONS_1_9
CONS_1_10
New
Mod
Rem
Constellations
CONS_1
New
Mod
Rem
Ground stations
TOULOUSE
DARWIN
HONOLULU
New
Mod
Rem
Links
LINK_1_UL
LINK_2_UL
New
Mod
Rem
Position/Access
S-major Axis 6978.1 km
Eccentricity 0.000
Inclination 65.0°
Arg Perigee 0.0°
RAAN 288.0°
Mean Anomaly 354.1°
XYZ
Orb Elem
LLA
CONS_1 :
0 visible satellite(s)

Feedback

Some objective reached...

- Increase modularity
- Cross Platform

Feedback

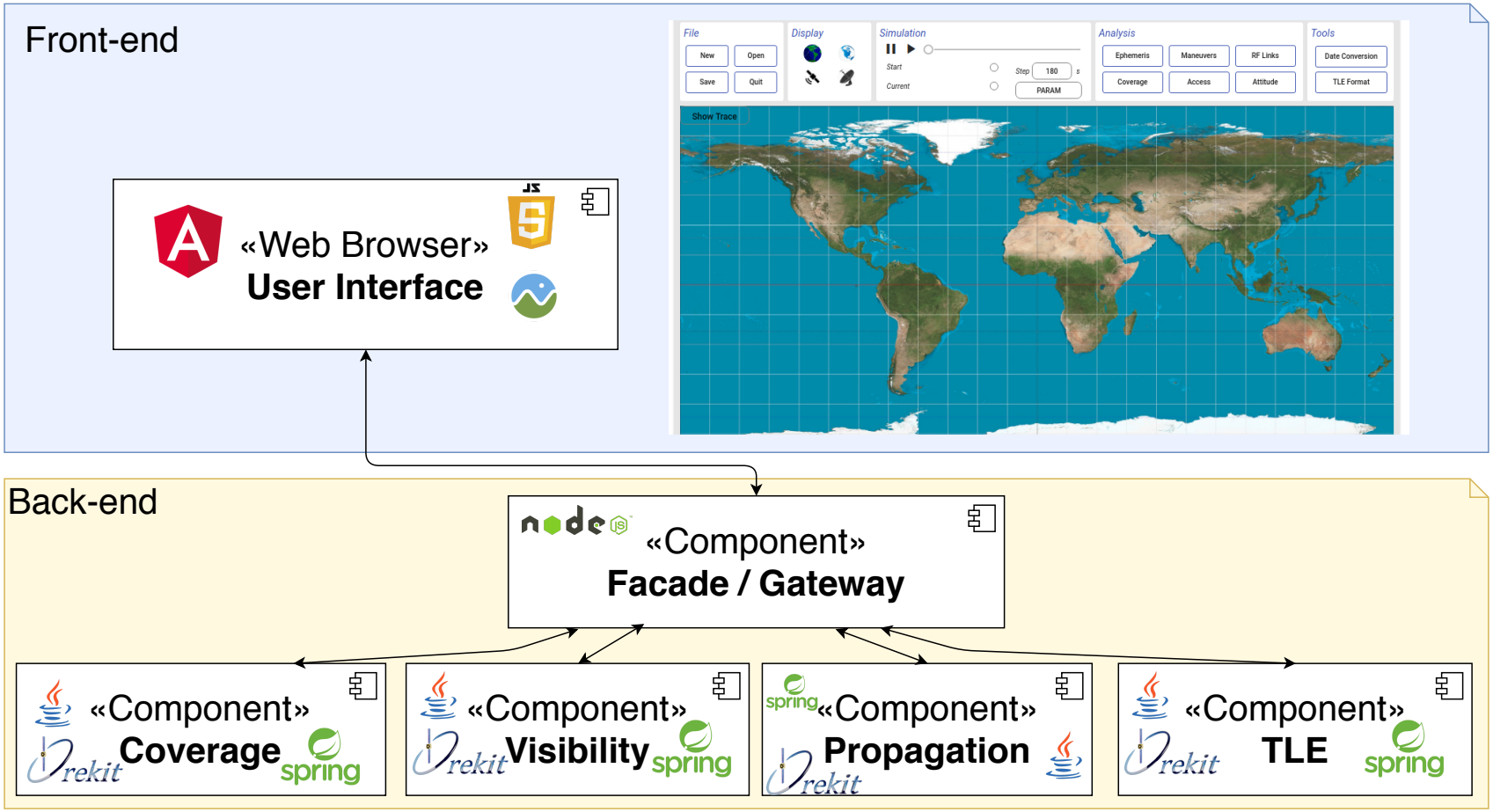
Some objective reached...

- Increase modularity
- Cross Platform

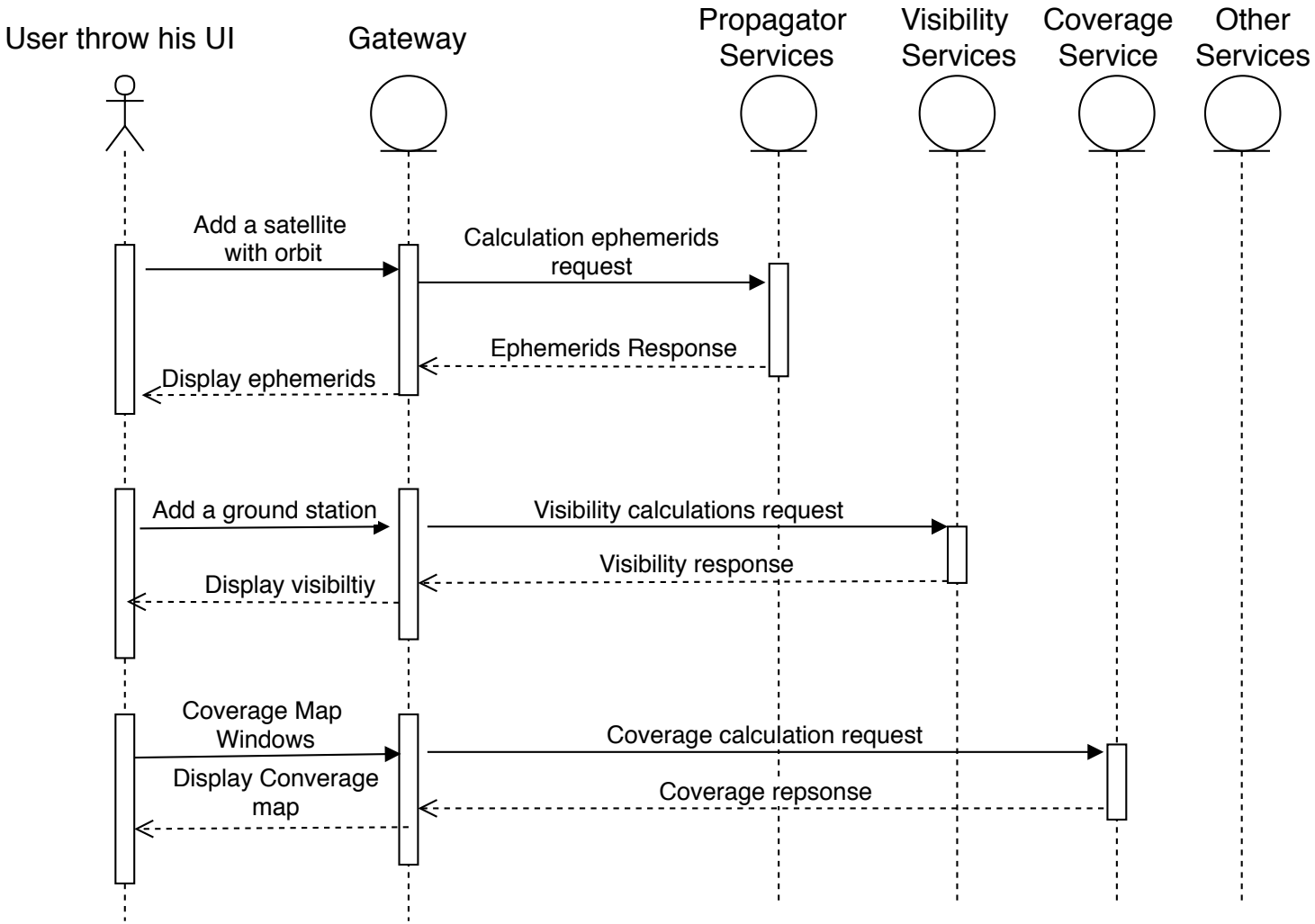
But...

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

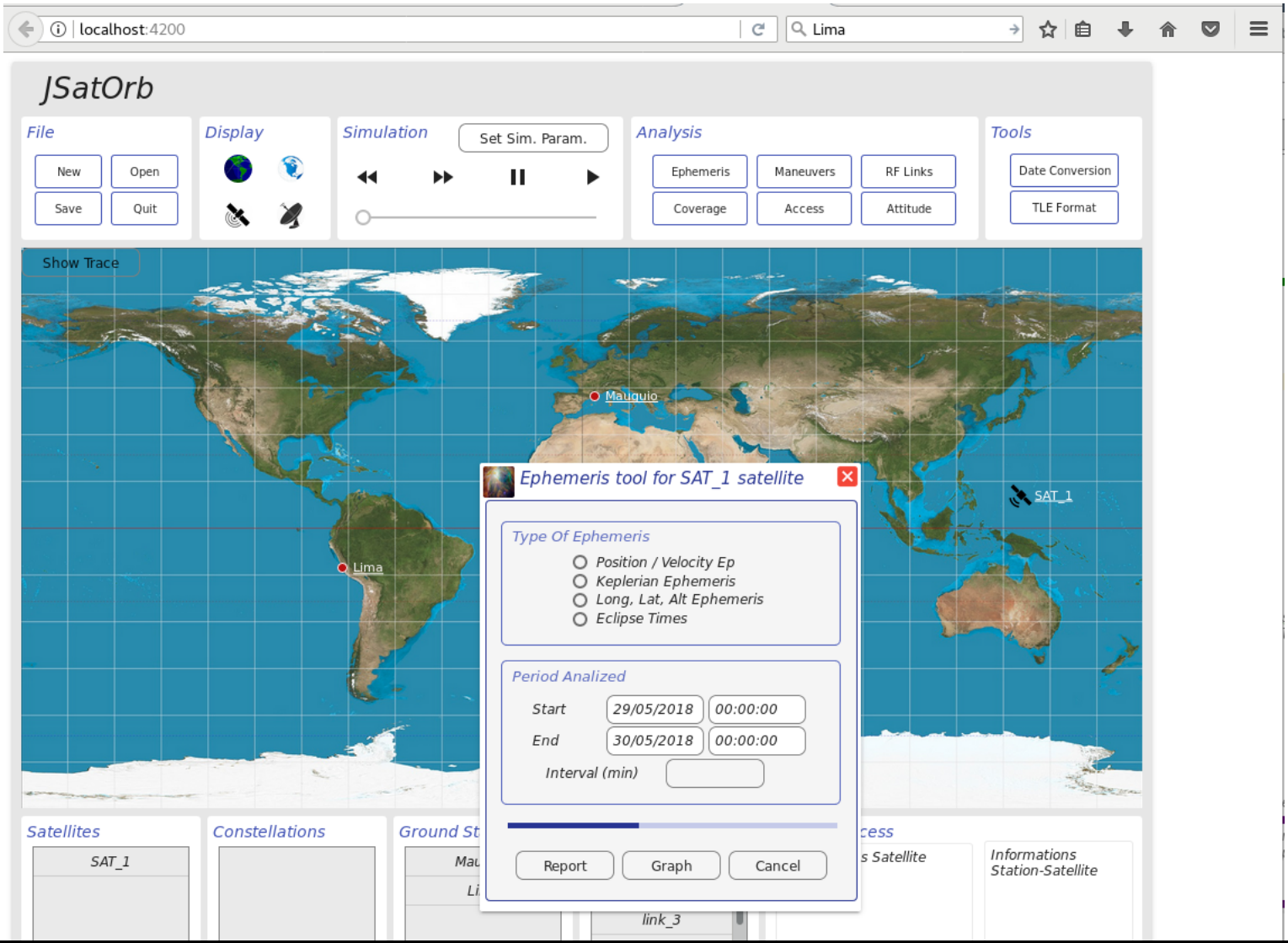
JSatorb: Service Oriented Architecture



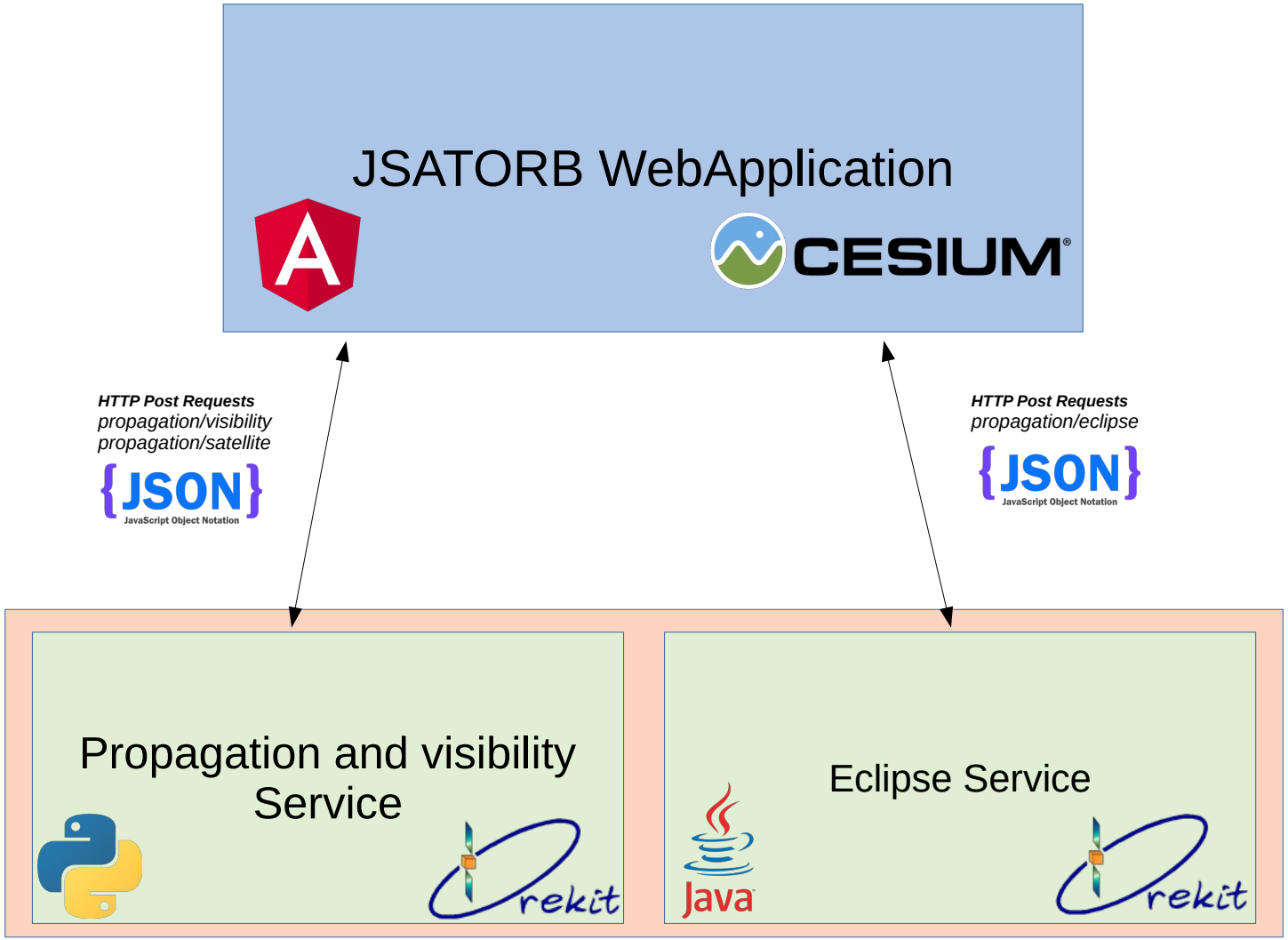
JSatorb: Typical Use Case Scenario



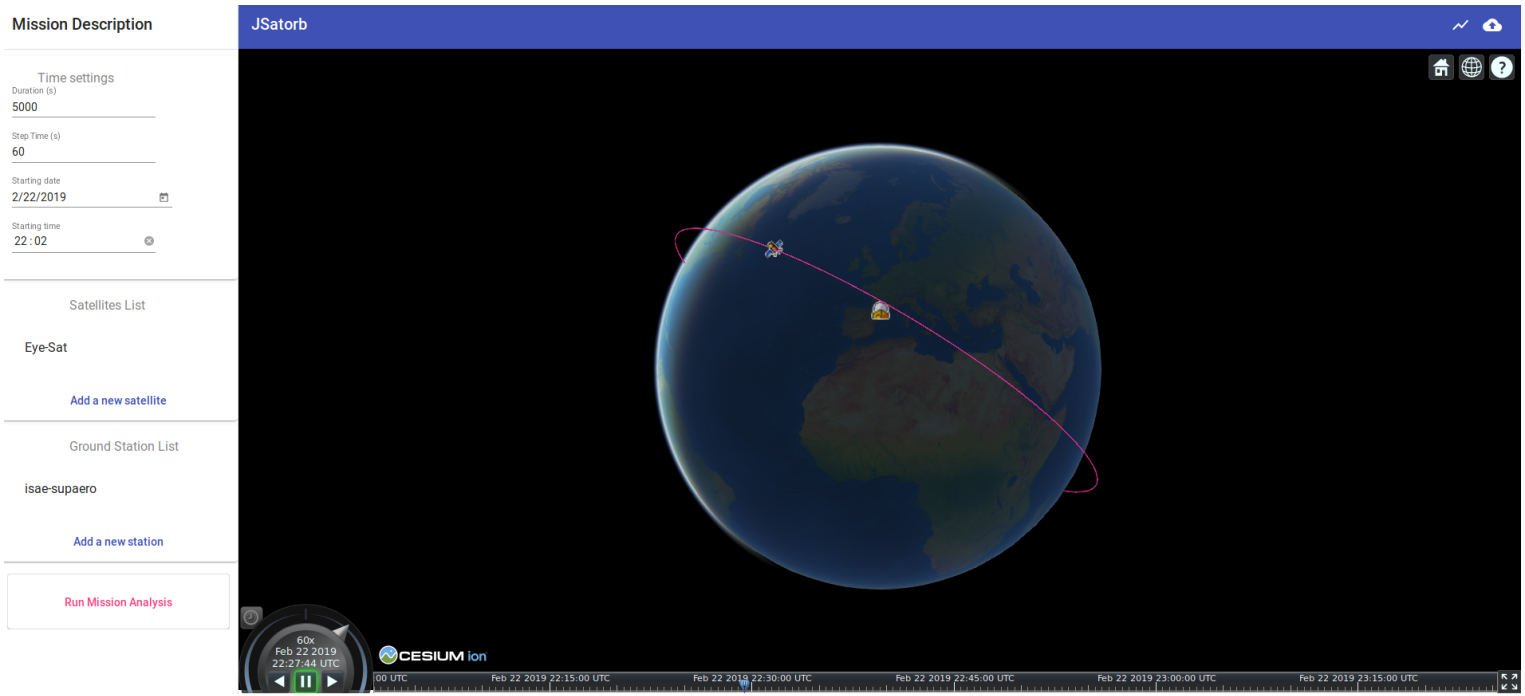
JSatorb: Angular UI (Theo Koudlanski)



JSatorb: Cesium JS and RESTfull API (Lucien Senaneuch)

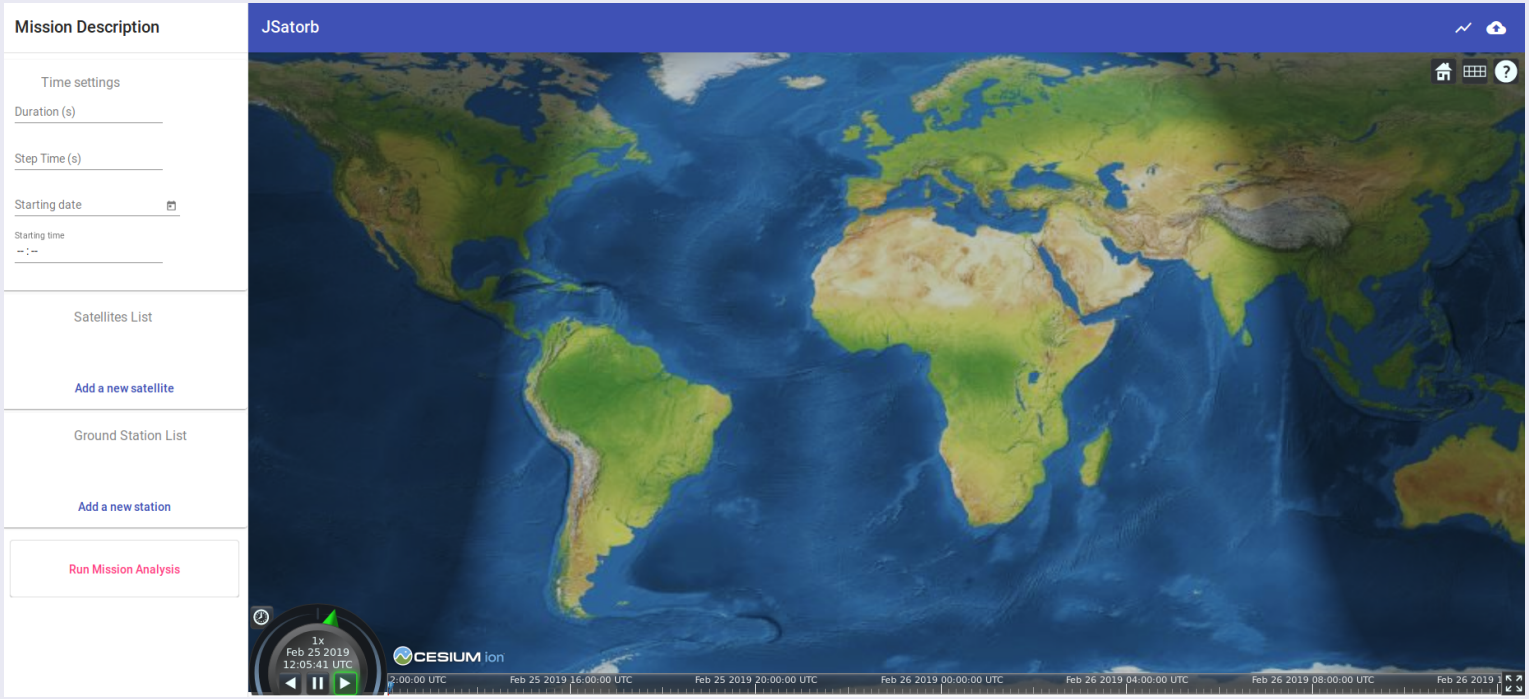


JSatorb: Cesium JS and RESTfull API (Lucien Senaneuch)



JSatorb: Demo (Lucien Senaneuch)

Small Video



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 ?