DOCKS, a growing software suite for space mission prototyping

Boris Segret, Sebastien Durand
C²ERES, the space pole of PSL University Paris

3rd OSCW, Athens, 14-16 oct. 2019
From LEO to Interplanetary CubeSats

Sources:
NAGA MarCO
JIVE VLBI
ESA ROSETTA
CNES MMX
Etude NOIRE
MAT
CelestiaMotherlode
DOCKS helps and structures your CubeSat project, for you to focus:
★ on the scientific coverage
★ on the engineering sizing
… from the early design up to AIT/AIV
Concept Maturity Level (CM.), 2009, Gregg Vane / JPL at the Planetary Science Decadal Survey Steering Group
DOCKS: 2 modules for trajectories

Deep space trajectories

- Cruise / RdV / ProxOps
  - Forward / Backward propagation
  - Adaptive time-step
    - Runge-Kutta or Runge-Kutta-Fehlberg
    - Accuracy-driven adaptive step
  - Continuous propulsion

- Proximity Operations
  - Spherical Harmonics or other
  - Cross-check scientific models
  - Drag / comets...

- Validations
  - Based on planets and asteroids
  - Still some issues in special contexts
  - Cross-checking welcome!

Earth-vicinity: link to CNES’ STELA
Keplerian engine: “CONIC”
DOCKS: Energy and Datalink

Intervisibilities with...
- Sun, Ground station(s)
- Output = “Event File” (EVTF)
- Adaptive time accuracy

EPS module
- Solar arrays mounting, cells & battery techno
- Mode strategy
- Quaternions & Intervisibilities
- GUI

Datalink (to come)
- Primitive modeling with intervisibilities
- Mode strategy
- Output = “Datavolume on board”
- Quaternions (if relevant), Atmospheric loss
“Easy-Quaternions” module
- (to be released)
- 3-degree simple pointing strategies
- Output
  - “directions” or “quaternions” in VTS formats
  - slew-rates

“Non-easy quaternions” module
- 4th degree of freedom
- Coupling with Mode strategy

Generic ADCS simulator
- Not “Earth-limited”
- Standard control laws and filtering to be tuned
- Library of known actuators and sensors
- Coupling with continuous propulsion
DOCKS: development

What is done yet

★ Free licenses
★ Modular architecture
  ▶ Python 3.x / Anaconda 3
    - astropy / polyastro / calceph
  ▶ “docks-tools” module
★ Multi-OS
  ▶ Ubuntu 18.04
  ▶ MS-Windows 10
★ Distribution
  ▶ public Gitlab
  ▶ releases with install routines
  ▶ support by mail

What we will do next

★ Multi-OS:
  ▶ Mac OS & Debian
  ▶ Intensive testing in all OS
★ Trajectories
  ▶ Sensitivity analyses => Accuracy-driven
  ▶ Propulsion arcs
★ Energy: Initial GUI
★ MBSE management
  ▶ Timeline, Links and updates in the models
  ▶ User’s configuration management
★ “drop & run” service for heavy computation
  ▶ Propagations (~50 it./s, per basic perturbation)
  ▶ ADCS

(.../...)

Segret, DOCKS @ CCERES, 3rd OSCW, Athens 10/2019
### Skills

<table>
<thead>
<tr>
<th></th>
<th>A - Top Priority</th>
<th>B - High Priority</th>
<th>C - Interesting!</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USER</strong></td>
<td>Report bugs</td>
<td>Report boring use</td>
<td>Request features</td>
</tr>
<tr>
<td><strong>Scientist / Engineer</strong></td>
<td>Challenge Propagator’s or EPS’ performances</td>
<td>Add a model (Propagator or Datalink)</td>
<td>Module for Thermal analysis</td>
</tr>
<tr>
<td><strong>IT enthusiast</strong></td>
<td>User-friendly GUI</td>
<td>Reading from GMAT/STK</td>
<td>Wizards</td>
</tr>
<tr>
<td><strong>Open Source enthusiast</strong></td>
<td>Tutorials &amp; Citations</td>
<td>“Modules’ datasheet”</td>
<td>Templates</td>
</tr>
</tbody>
</table>

- **Contact / Support (Gitlab):** docks.contact@obspm.fr
- **Partnering:** cceres.psl@obspm.fr
- **Keep in touch:** subscribe to “cceres.news@obspm.fr”
### Skills

<table>
<thead>
<tr>
<th>User</th>
<th>A - Top Priority</th>
<th>B - High Priority</th>
<th>C - Interesting!</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>Report bugs</td>
<td>Report boring use</td>
<td>Request features</td>
</tr>
<tr>
<td>Scientist/Engineer</td>
<td>Challenge Propagator’s or EPS’ performances</td>
<td>Add a model (Propagator or Datalink)</td>
<td>Module for Thermal analysis</td>
</tr>
<tr>
<td>IT enthusiast</td>
<td>User-friendly GUI</td>
<td>Reading from GMAT/STK</td>
<td>Wizards</td>
</tr>
<tr>
<td>Open Source enthusiast</td>
<td>Tutorials &amp; Citations</td>
<td>“Modules’ datasheet”</td>
<td>Templates</td>
</tr>
</tbody>
</table>

**Contact / Support (Gitlab):** docks.contact@obspm.fr  
**Partnering:** cceres.psl@obspm.fr  
**Keep in touch:** subscribe to “cceres.new@obspm.fr”
Récapitulatif : UKF, 3 objets d’avant-plan

- Départ de la Terre
- Milieu de croisière
- Arrivée à Mars