En masse, on demand, on orbit: Interplanetary Pocket Spacecraft licensing and regulatory challenges

Michael Johnson

michael@PocketSpacecraft.com

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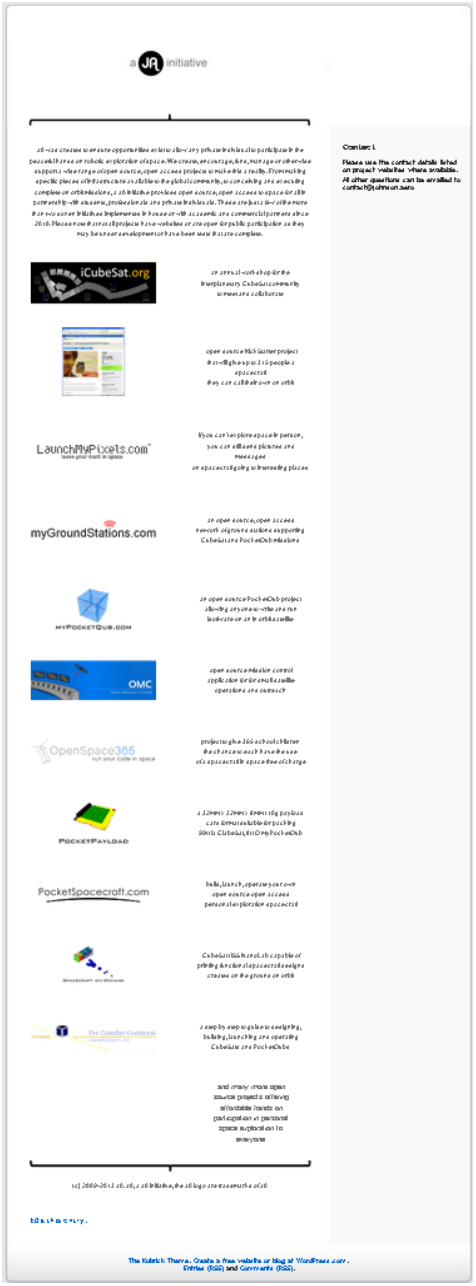
About JA

- Founded 2010
- Ops in China, IoM, UK & USA
- Creates, encourages, funds, manages or otherwise supports more than two dozen open source open access space exploration infrastructure projects
- Seven flight projects
- Collaborate with academia, enthusiasts, government, industry and non-profits
- >300 volunteers, >30 countries



goal

send spacecraft to orbit and/or land on the surface of every body in the solar system over the next ~~25~~ 21.1 years

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$>10^1 >$ ~ 5000km radius

$>10^2 >$ ~ 100 km radius

$>10^4 >$ ~ 20 km radius

$>10^6 >$ ~ 0.5km radius in asteroid belt alone

Graphics courtesy: Alan Taylor, kokogiak.com

pocket spacecraft

a spacecraft that an individual can afford to buy, launch and operate with little or no technical expertise

personal space age

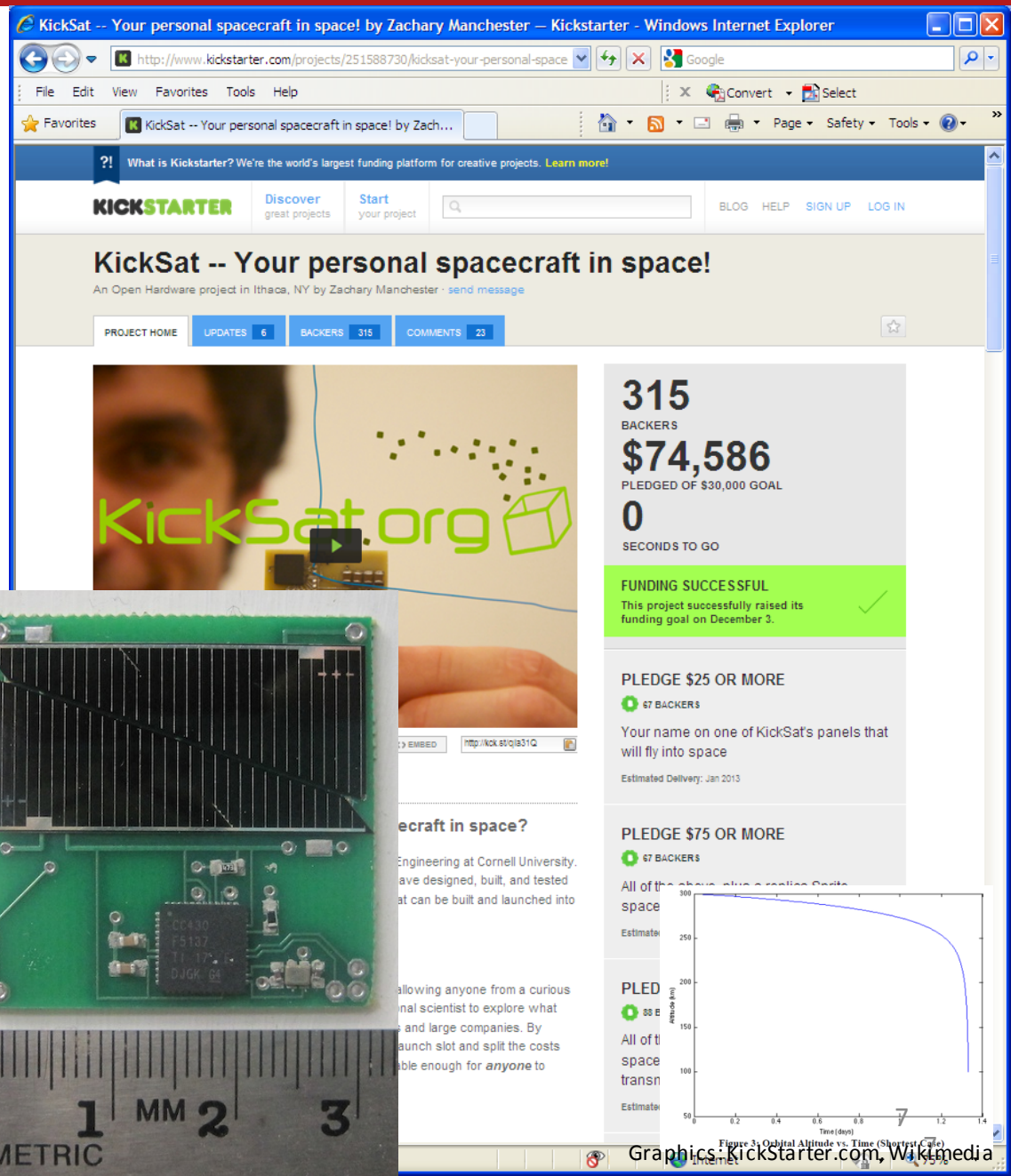
the era of exploration of space by private individuals for science, general interest and profit

Graphics courtesy: JA / PocketSpacecraft.com

- science goals
  - be useful, be responsible
  - work within existing frameworks and systems where possible
  - enable many of the >95% of missions not down selected
- consumer goals
  - support 10^6 participating explorers
  - video game size quantum of exploration
  - instant gratification and mass customisation
  - appeal to everyone from collectors to citizen space engineers
- easy to use for everyone
  - point and click/touch design, collaboration and autonomous operation
- sustainable
  - fun, interactive, immersive for years or decades
  - spread risk, be comfortable not knowing where it may lead
  - legal, honest, decent and truthful
  - make affordable - crowd source, fractionate and automate everything
- symbiotic and respectful
  - scientists need explorers, explorers need scientists
  - everyone needs engineers
  - all skill levels can contribute something – apps/money both ways

KickSat mission

- Crowd sourced funding via 315 KickStarter backers
  - 67 @ $25
  - 67 @ $75
  - 88 @ $300 ←
  - 26 @ $1000 ←
  - 0 @ $5000
  - 1 @ $10000
- NASA ELaNa 5 launch April 2014
- Student labour
- Reuse existing open source systems
- Very inexpensive
- Very short lived



Graphics: KickStarter.com, Wikimedia

Photos courtesy: JA / OpenMissionControl.org

Pocket Spacecraft

TF-SLR Scout prototype v0.4

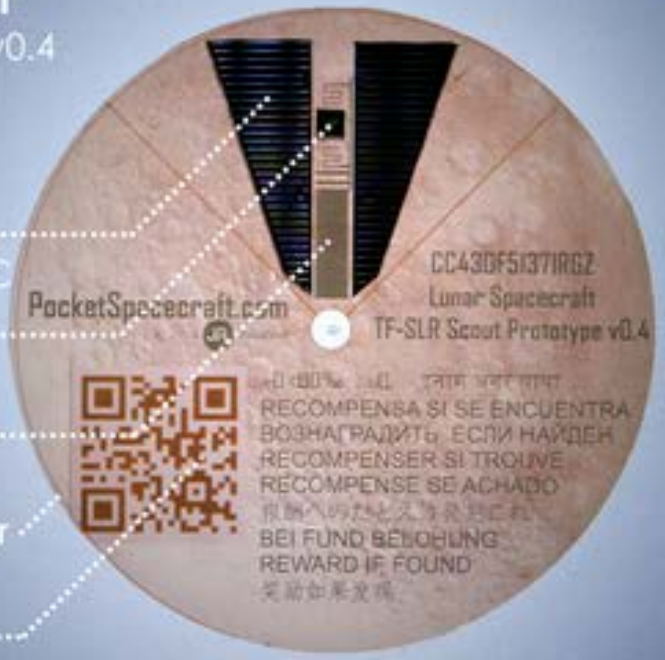
Solar cell
CIGS or Spectrolab TASC

SoC lapped to <50µm
TI CC430F5137IRGZ die

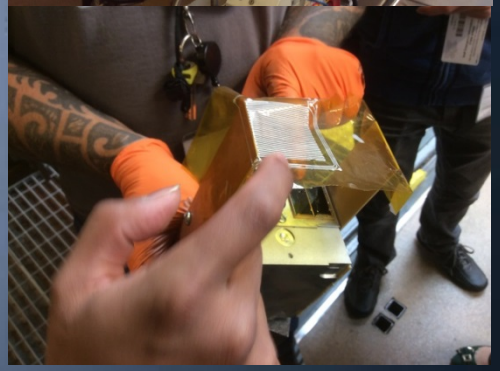
Printed passives (RCL)
e.g. Cabot CCI-300 ink

Antenna bustle/actuator
NiTi memory metal

Custom graphics
Laser marked



<8cm
<3.2"



Graphics courtesy: JA / PocketSpacecraft.com

Resistance:

- ‘They will never work’
- ‘You can’t do anything useful’
- ‘They are just for students’
- ‘You can’t do real science’
- ’You can’t fit real instruments’
- ‘You can’t do useful imaging with such small apertures’
- ‘They don’t have enough power’
- ‘They’re unreliable’

It’s hard to imagine [ChipSats and TF-SLRs] will be capable enough

Graphics: M. Santer, Imperial College London

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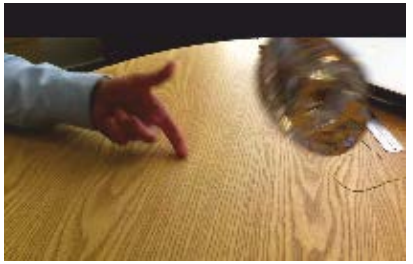
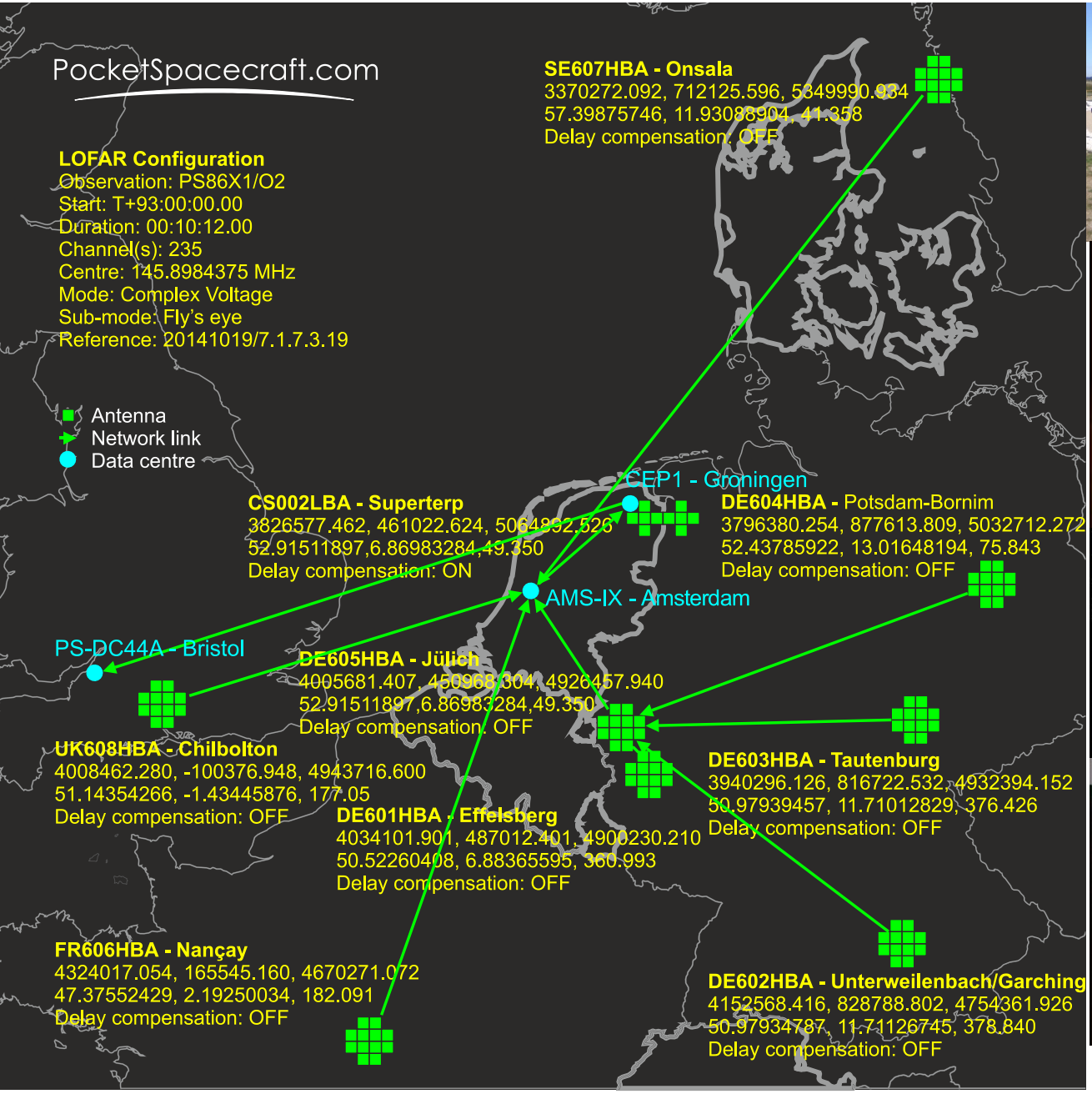
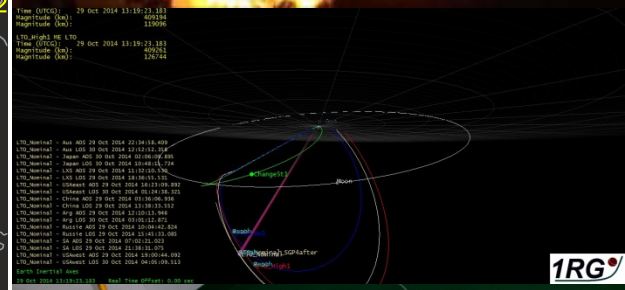


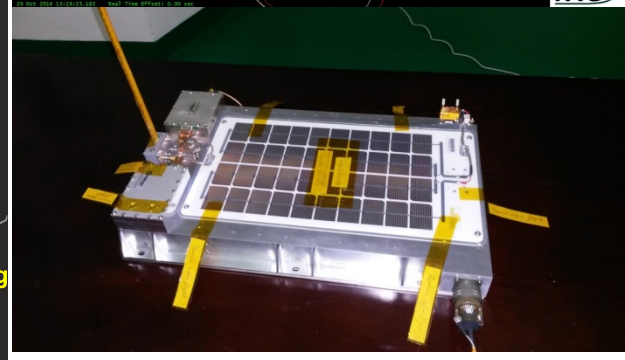
"It's hard to imagine [ChipSats and TF-SLRs] will be capable enough, but that's exactly what people said about CubeSats."

Therese Moretto Jorgensen, Program Director, National Science Foundation
*Nature **508**, 300-301 (17 April 2014)*

Graphics: M. Santer, Imperial College London

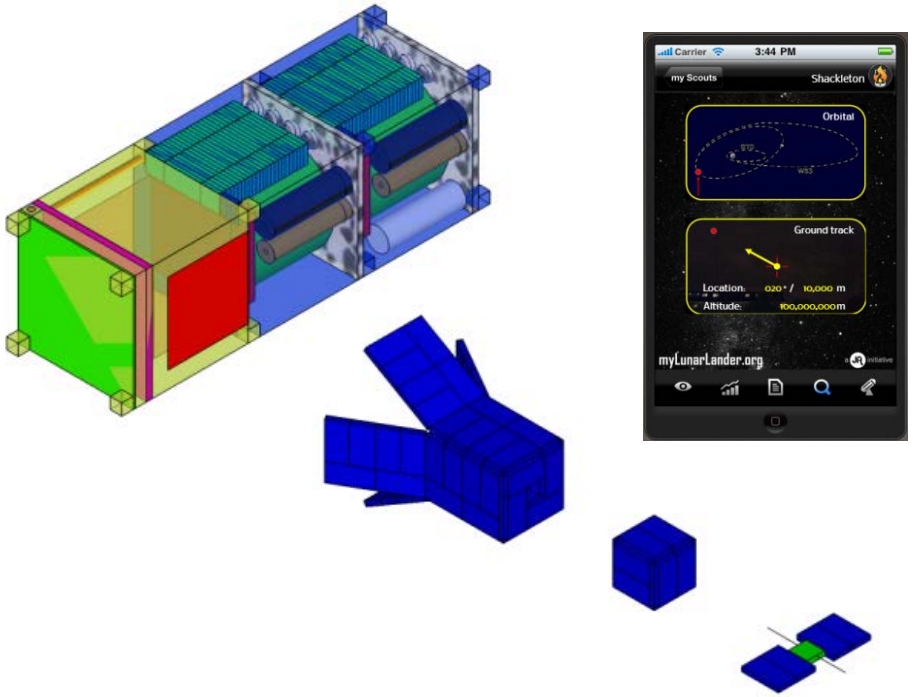






Graphics courtesy: ASTRON, JA, LuxSpace, STFC

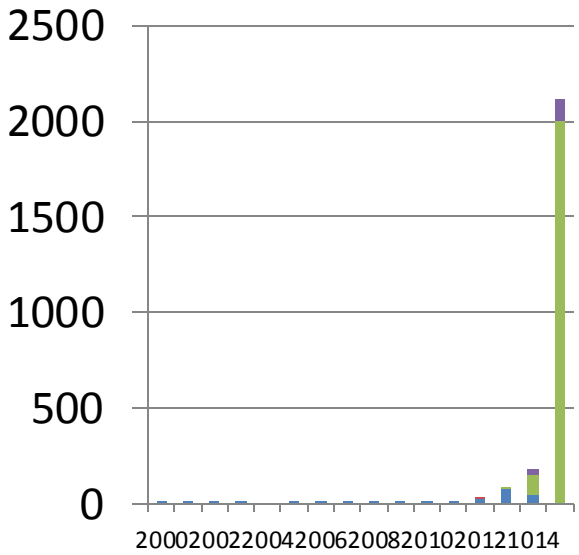
- Purpose may not be known at launch
- Spacecraft can be launched speculatively
- Potential clashes with existing frameworks (e.g. amateur vs scientific vs commercial)
- Design to deployment can be <u>minutes</u>



Graphics courtesy:JA, M.Travis - YouTube

Challenges – number of spacecraft

- 3881 payloads catalogued on orbit by U.S. Space Surveillance Network
- KickSat proof of concept low earth orbit mission launched 2014: >100 spacecraft
- Pocket Spacecraft interplanetary proof of concept mission 2015/16: >1000 spacecraft
- Potentially >1 million TF-SLRs to come over next two decades
- Number of spacecraft printed per mothership may be unknown at launch and could vary by orders of magnitude



Graphics: Ben Bishop, JA

Challenges – economics

- Current regulatory fees for spacecraft that can profitably be manufactured, launched and operated for less than $99 each can be disproportionate (>$10,000 per spacecraft)
- License application fee (no guarantee of success):
  UK: £6,500- £13,000 per mission
  (£0 in China, Spain, USA, etc.)
- €60 million third party insurance cover per mission:
  UK: €600,000 per year indefinitely
  (£0 in China, Spain, USA, etc.)

Graphics: UKSA

Challenges – international and fluid ownership

- Pocket Spacecraft interplanetary proof of concept mission has spacecraft backed by participants from >40 countries
- Spacecraft could be designed, manufactured, launched, deployed, managed or operated by different children and adults with multiple citizenships with ownership changing at every step and over time

Graphics: Twitter

michael@PocketSpacecraft.com

* if your question is about an open source project:
  - no restrictions

* if your question is about a closed source project and we're at JPL:

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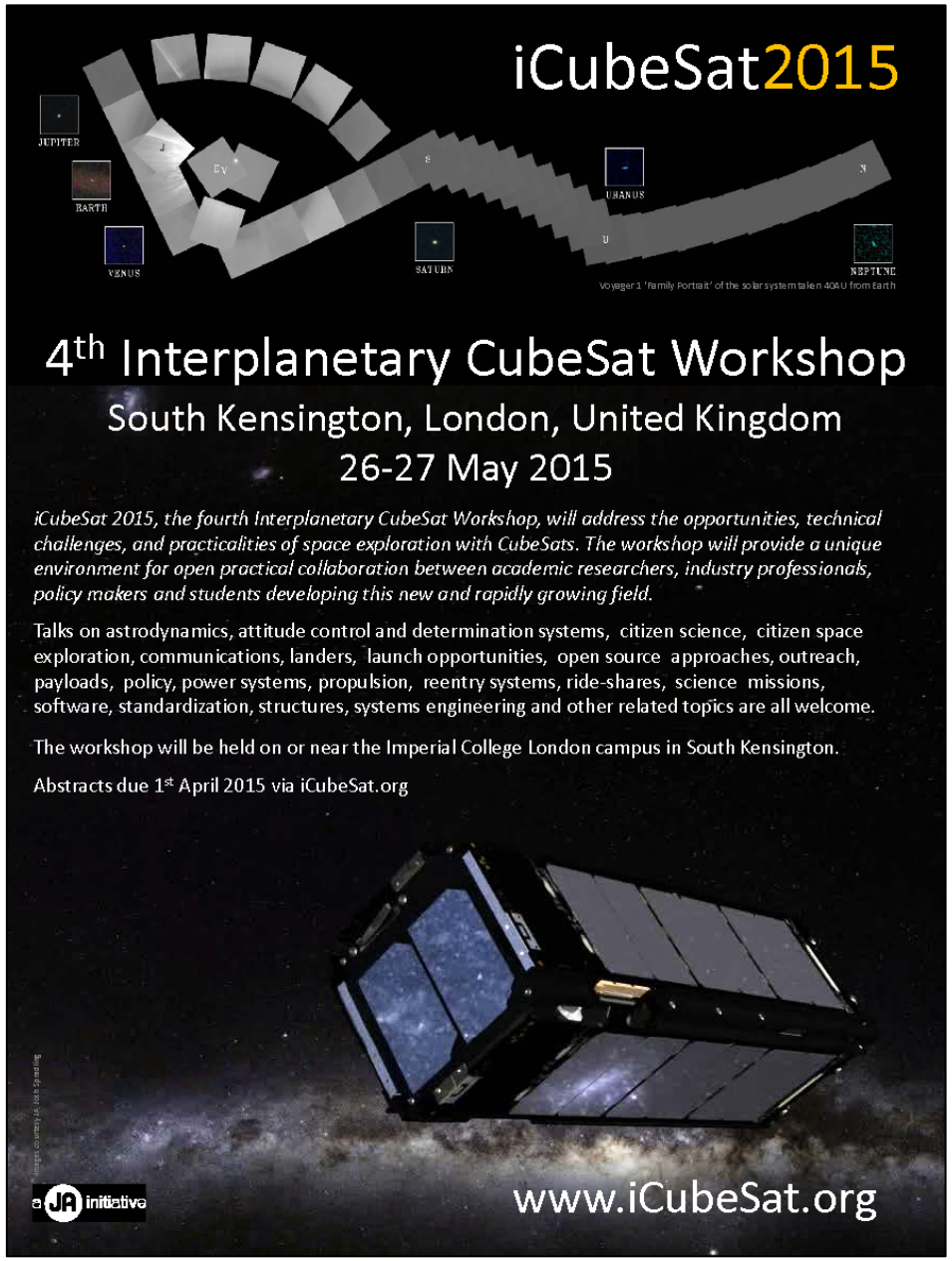

Graphics courtesy: iCubeSat.org